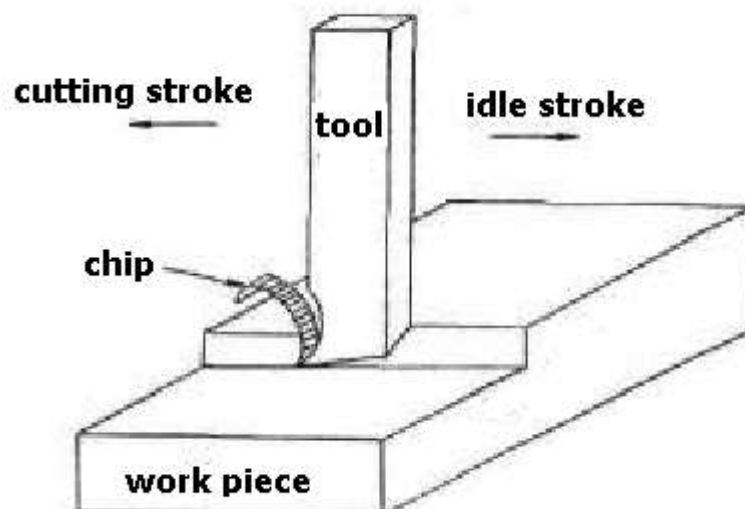

SHAPING MACHINES**3.1 Shaping Machines****Introduction**

The shaper is a machine tool having a reciprocating cutting tool of the lathe type, which takes a straight line cut. It is primarily intended to produce flat surfaces. These surfaces may be horizontal, vertical or inclined. The main significance of this machine lies in its greater flexibility on account of ease in work holding, quick adjustment and use of tools of relatively simple design. In the light of above fact it is almost an indispensable machine in tool rooms die making shops and general repair shops for the production of a few identical shapes of jobs. It can also be adopted for producing curved and irregular surfaces.

3.2 Working Principle

The working principle of a shaper is illustrated in the Fig.



On a shaper the job is usually fixed in a vice on the machine table. The tool is held in the tool post, mounted on the ram of the machine. As the ram reciprocates to and for the cutting tool cuts the material in forward stroke only except in case of draw cuts shaper, in which the tool cuts in backward stroke of the ram. The other stroke in both the cases remains idle, as there is no cutting action in this stroke and hence termed as idle strokes.

Types of Shapers

Shapers are classified in a number of ways depending upon the general features of design or the purpose for which they are intended. Shapers are classified under the following headings.

1) According to the type of mechanism used for giving reciprocating motion to the ram

(a) Crank type (b) Geared type (c) Hydraulic type

2) According to the position and travel of ram

(a) Horizontal type (b) Vertical type (c) Traveling head type

3) According to the type of design of the table:

(a) Standard shaper (b) universal shaper

4) According to the type of cutting stroke

(a) Push type (b) Draw type

Crank Shaper

This is the most common type of shaper in which a single point cutting tool is given a reciprocating motion equal to the length of the stroke desired while the work is clamped in position on an adjustable table. In construction, the crank shaper employs a crank mechanism to change circular motion of a large gear called "bull gear" incorporated in the machine to reciprocating motion of the ram. The bull gear receives power either from an individual motor or from an overhead line shaft if it is a belt driven shaper.

Geared type

The reciprocating motion of the ram in some type of shaper is affected by means of a rack and pinion. The rack teeth, which are cut directly below the ram, mesh with a spur gear. The pinion meshing with the rack is driven by a gear train. The speed and the direction in which the machine will traverse depend on the number of gears in the gear train. This type of shaper is not very widely used.

Hydraulic Shaper

In a hydraulic shaper reciprocating movement of the ram is obtained by hydraulic power. Oil under high pressure is pumped in to the operating cylinder fitted with a piston. The end of the piston rod is connected to the ram. The high-pressure oil first acts on one side of the piston and then on the other causing the piston to reciprocate and the motion is transmitted to the ram. The piston speed is changed by varying the amount of liquid delivered by the pump. One of the most important advantages of this type of shaper is that the cutting speed and force of the ram drive are constant

from the very beginning to the end of the cut. It also offers great flexibility up of motion when the cutting tool is overloaded. Protecting the parts or the tools from breakage. Another advantages is that the machine does not make any noise and operates very quietly.

Horizontal Shaper

In a horizontal shaper, the ram holding the tool reciprocates in a horizontal axis. Horizontal shapers are mainly used to produce flat surfaces.

Vertical Shaper

In a vertical shaper, the ram holding the tool reciprocates in a vertical axis. In some of the vertical machines provision is made to allow adjustment of the ram to an angle of about 10 degrees from the vertical position. Vertical shapers may be crank driven, rack driven, screw driver or hydraulic power driven. The work table of a vertical shaper can be given cross, longitudinal, and rotary movement. The tool used on a vertical shaper is entirely different from that used on a horizontal shaper. Vertical shapers are very convenient for machining internal surfaces, keyways, slots or grooves; large internal and external gears may also be machined by indexing arrangement of the rotary table. There are vertical shapers, which are specially designed for machining internal keyways. They are then called keys eaters.

Travelling Head Shaper

In a travelling head shaper, the ram carrying the tool while it reciprocates moves crosswise to give the required feed. Heavy and un widely jobs, which are very difficult to hold on the table of standard shaper and fed past the tool are, held static on the basement of the machine while the ram reciprocates and supplies the feeding movements.

Standard or Plain Shaper

A shaper is termed as standard or plain when the table has only two movements, vertical and horizontal, to give the feed. The table may or may not be supported at the outer end.

Universal Shaper

In a universal shaper in addition to the two movements provided on the table of a standard shaper, the table can be swivelled about an axis parallel to the ram ways, and the upper portion of the table can be tilted about a second horizontal axis perpendicular to the first axis. As the work mounted on the table can be adjusted in different planes, the machine is most suitable for different

types of work and is given the name "universal". A universal shaper is mostly used in tool room work.

Push Type Shaper

This is the most general type of shaper used in common practice. The metal is removed when the ram moves away from the column, i.e., pushes the work.

Draw Type Shaper

In a draw shaper, the metal is removed when the ram moves towards the column of the machine, i.e., draws the work towards the machine. The tool is set in a reversed direction to that of a standard shaper. The ram is generally supported by an overhead arm which ensures rigidity and eliminates deflection of the tool. In this shaper the cutting pressure acts towards the column which relieves the cross rail and other bearings from excessive loading and allows to take deep cuts. Vibration in these machines is practically eliminated.

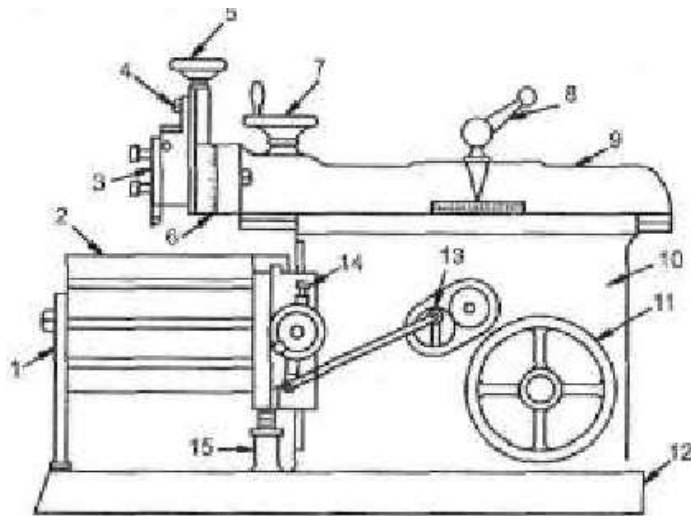
3.3 Principal parts

Base

The base is the necessary bed or support required for all machine tools. The base may be rigidly bolted to the floor of the shop or on the bench according to the size of the machine. It is so designed that it can take up the entire load of the machine and the forces set up by the cutting tool over the work. It is made of cast iron to resist vibration and take up high compressive load.

Column

The column is a box like casting mounted upon the base. It encloses the ram driving mechanism. Two accurately machined guide ways are provided on the top of the column on which the ram reciprocates. The front vertical face of the column contains levers, handles, etc, for operating the machine.



1) Table support 2) Table 3) Clapper box 4) Apron clamping bolts 5) Down feed hand wheel 6) Swivel base degree graduations 7) Position of stroke adjustment hand wheel 8) Ram block locking handle 9) Ram 10) Column 11) Driving pulley 12) Base 13) Feed disc 14) Pawl mechanism 15) Elevating screw.

Cross rail

The cross rail is mounted on the front vertical guide ways of the column. It has two parallel guide ways on its top in the vertical plane that is perpendicular to the ram axis. The table may be raised or lowered to accommodate different sizes of jobs by rotating an elevating screw which causes the cross rail to slide up and down on the vertical face of the column. A horizontal cross feed screw which is fitted within the cross rail and parallel to the top guide ways of the cross rail actuates the table to move in a crosswise direction.

Saddle

The saddle is mounted on the cross rail which holds the table firmly on its top. Crosswise movement of the saddle by rotating the cross feed screw by hand or power causes the table to move sideways.

Table

The table, which is bolted to the saddle, receives cross wise and vertical movements from the saddle and cross rail. It is a box like casting having T-slots both on the top and sides for clamping the work. In a universal shaper the table may be swivelled on a horizontal axis and the upper part of the table may be tilted up or down. In a heavier type shaper, the front face of the table is clamped with a table support to make it more rigid.

Ram

The ram is the reciprocating member of the shaper. This is semi-cylindrical in form and heavily ribbed inside to make it more rigid. It slides on the accurately machined dovetail guide ways on the top of the column and is connected to the reciprocating mechanism contained within the column. It houses a screwed shaft for altering the position of the ram with respect to the work and holds the tool head at the extreme forward end.

Tool head

The tool head of a shaper holds the tool rigidly provides vertical and angular feed movement of the tool and allows the tool to have an automatic relief during its return stroke. The vertical slide of the tool head has a swivel base, which is held on a circular seat on the ram. The swivel base is graduated in degrees, so that the vertical slide may be set perpendicular to the work surface or at any desired angle. By rotating the down feed screw handle, the vertical slide carrying the tool

executes down feed or angular feed movement while machining vertical or angular surface. The amount of feed or depth of cut may be adjusted by a micrometer dial on the top of the down feed screw. Apron consisting of clapper box, clapper block and tool post is clamped upon the vertical slide by a screw. By releasing the clamping screw the apron may be swivelled upon the apron swivel pin either towards left or towards right with respect to the vertical slide. This arrangement is necessary to provide relief to the tool while making vertical or angular cuts. The two vertical walls on the apron called clapper box houses the clapper block, which is connected to it by means of a hinge pin. The tool post is mounted upon the clapper block on the forward cutting stroke the clapper block fits securely to the clapper box to make a rigid tool support on the return stroke a slight frictional drag of the tool on the work lifts the block out of the clapper box a sufficient amount preventing the tool cutting edge from dragging and consequent wear. The work surface is also prevented from any damage due to dragging. Fig.9.3 illustrates the tool head of a shaper.

1) Down feed screw micrometer dial 2) Down feed screw

3) Vertical slide 4) Apron 5) Apron clamping bolt

6) Clapper block 7) Tool post 8) Washer

9) Apron swivel pin 10) Swivel base.

Shaper Size and Specification

The size of shapers is classified according to the maximum length of stroke. Push-cut shapers can accept work sizes from 102-to 915 mm. Pull-cut shapers are made for work regiments up to 1.82 m. The maximum cross-feed distance is generally equivalent. The maximum ram stroke, distance. Therefore, a shaper with a 406mm maximum stroke, for example, is capable of machining a part with a plane surface that measures at least 406 mm x 406 mm square.

3.4 Specifications of a shaper

Maximum ram stroke 700mm

Maximum tool overhang 840 mm

Distance between table surface and ram Maximum 400mm

Minimum 80 mm

Dimensions of table working surface 700 mm x 450 mm

Maximum travel of table Horizontal 700 mm

Vertical 320 mm

Horizontal feed per double stroke 0.25-5 mm

Principal movement motor power 7 kW

Overall dimensions 2785 x 1750 x 1780 mm.

Shaper Driving Mechanism

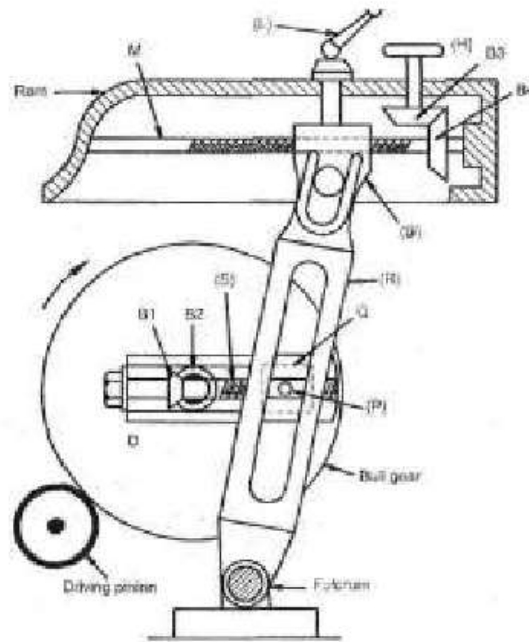
In a shaper, rotary movement of the drive is converted into reciprocating movement by the mechanism contained within the column of the machine. The ram holding the tool gets the reciprocating movement. In a standard shaper the metal is removed in the forward stroke and the return stroke is idle. The time taken by idle stroke is merely waste and should be minimised as far as possible. This can be achieved by making the shaper to complete its return stroke quicker than the forward one. Thus the shaper mechanism should be so designed to perform the cutting stroke at a comparatively slower speed than the return stroke and this mechanism is known as quick return mechanism.

The reciprocating movement of the ram and the quick return mechanism of the machine are usually obtained by any one of the following.

- 1) Crank and slotted lever mechanism
- 2) Whitworth quick return mechanism
- 3) Hydraulic shaper mechanism

Crank and Slotted Lever Mechanism

The crank and slotted lever mechanism is shown in the Fig. It consists of a slotted link called a rocker arm. The rocker arm is pivoted at its bottom end which forms the fulcrum. At its upper end it carries another short link which is attached to the ram block (B). The ram block (B) can be clamped at the desired position by a hand lever (L). The rocker arm is provided with a sliding block (Q) in which the crank pin (P) revolves. The sliding block can freely slide in the slot provided in the rocker arm. At the back of the rocker arm a large gear wheel known as a bull gear is provided. The motion of the power is transmitted to the bull gear through a pinion, which receives its motion from an individual motor or overhead line shaft through a speed control mechanism. A slotted disc (D), carrying a T-slot, is fitted to the bull gear at its front; the crank pin 'P' is fitted in this slot and can be moved to any desired position along the slot by means of the bevel gears (B₁ and B₂) and an adjusting screw (S). The bevel gear (B₂) is concentric with the bull gear and the other bevel gear (B₁) is attached to the lead screw (S) at its one end as shown in the Fig. The axes of bevel gears (B₁ and B₂) are at right angles to each other and are called as miter gears.

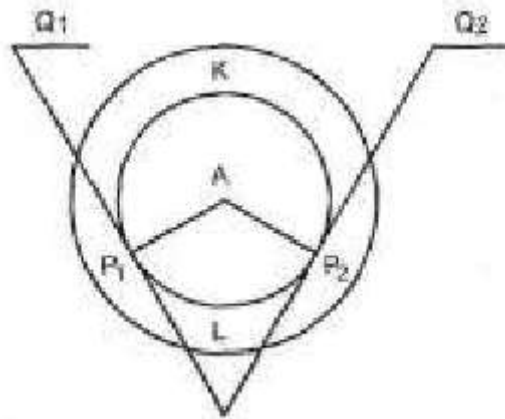


As the bull gear rotates causing the crank pin (P) to rotate, the sliding block (Q) fastened to the crank pin (P) will rotate on the crank pin circle and at the same time will move up and down the slot in the rocker arm giving it rocking movement which makes the rocker arm to swing about the fulcrum. Thus in turn the rocker arm moves the ram to and fro.

Principle of Quick Return Mechanism

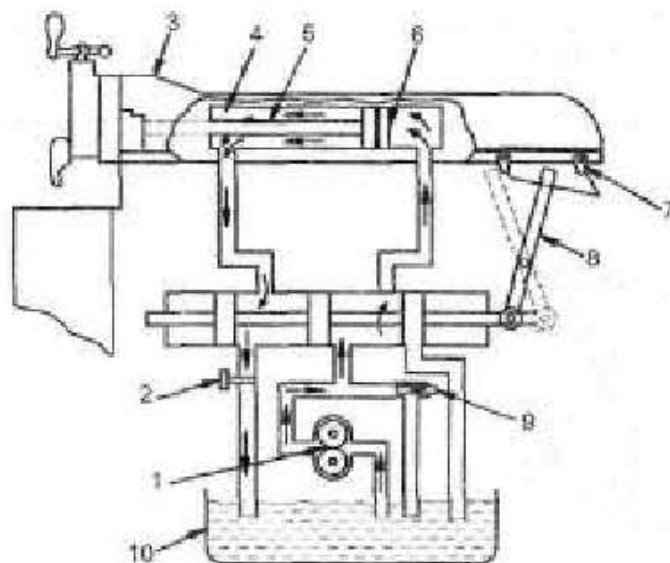
The principle of quick return mechanism is illustrated in Fig. When the link is in the position OQ2, the ram will be at the extreme backward position of the stroke and when it is at OQ1, it has reached the extreme forward position. Therefore the forward cutting stroke takes place when the crank rotates through the angle $\angle P_1 A K P_2$, and the return stroke takes place when the crank rotates through the angle $\angle P_2 L P_1$.

It is very clear that the angle $\angle P_1 A K P_2$ made by the cutting stroke (forward stroke) is greater than the angle $\angle P_2 L P_1$ made by the return stroke. The angular velocity of the crank pin is constant. Therefore the return stroke is completed within a shorter time than the cutting stroke for which it is known as quick return motion. The ratio between these two angles, and hence between the corresponding times is approximately 3:2.



Hydraulic Mechanism

The simple mechanism of a hydraulic drive is shown in the Fig. In a hydraulic shaper the ram is moved forward and backward by a piston moving in a cylinder placed under the ram. The machine mainly consists of a constant discharged oil pump, a valve chamber, a cylinder and a piston. A constant speed motor drives the pump, which delivers oil at a constant pressure to the line. The regulating valves located in valve chamber, actuated by the machine and timed to the stroke; admit oil under pressure to each end of piston alternately and at the same time allowing oil from the opposite end of the piston to return to the reservoir. As the piston moves it. Although it is a constant pressure system under varying load condition the tool moves with different velocities. One end of the piston is having larger area and the other end has less area due to piston rod. Therefore it moves in one stroke at low speed (cutting stroke) and in opposite stroke (Return stroke) it moves at high speed. The velocity can also be controlled regulating the quantity of oil by feed handle as shown in Fig.



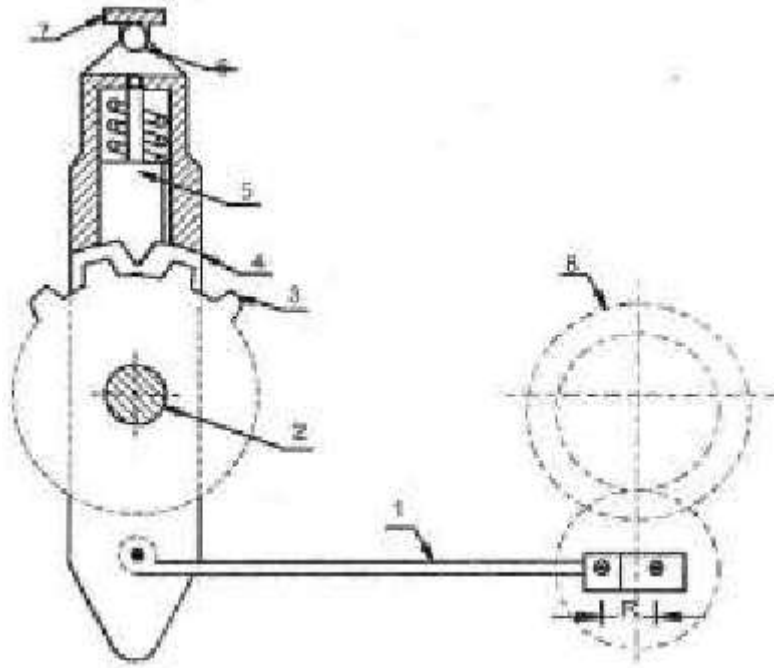
Advantages of Hydraulic Shaper over Mechanical Shaper

The hydraulic mechanisms are becoming popular because of the following advantages.

- 1) Ability to slip in case of over load
- 2) Smoother operation
- 3) Ability to withstand shock without damage to the tool or the machine
- 4) Infinite number of cutting speeds can be obtained from zero to the maximum value and the control easier.
- 5) Possibility of changing speed and feed during operation.

Table Feed Mechanism

The automatic cross feed mechanism incorporated to the shaper table is shown in the Fig. The cross feed of table may be obtained manually or by power. In the latter case the table cross feed screw is rotated through certain degrees with the help of a ratchet wheel mounted on the cross feed screw. The complete mechanism is as follows. It consists of a slotted disc which carries a T slot as shown in the Fig. In this slot an adjustable pin is fitted and to which the connecting rod is attached. The other end of the connecting rod is attached to the lower end of the rocker arm of the pawl mechanism. The rocker arm swings about the cross feed screw and at its upper end carries a spring loaded pawl. The adjustable pin is set eccentric with slotted link disc centre. The slotted disc at its back carries a spur gear, which is driven by the bull gear. As the disc rotates through gear the adjustable pin that is eccentric to the disc centre, causes the connecting rod to reciprocate. This in turn makes the pawl over one or more teeth and thus transmits an intermittent motion to the cross feed screw which moves the table. The lower end of the pawl is bevelled on one side. This facilitates the power feed to operate in either direction. The feed can be varied by varying the distance or between the disc centre and the centre of the adjustable pin. The larger the said distance, greater will be the feed and vice-versa.

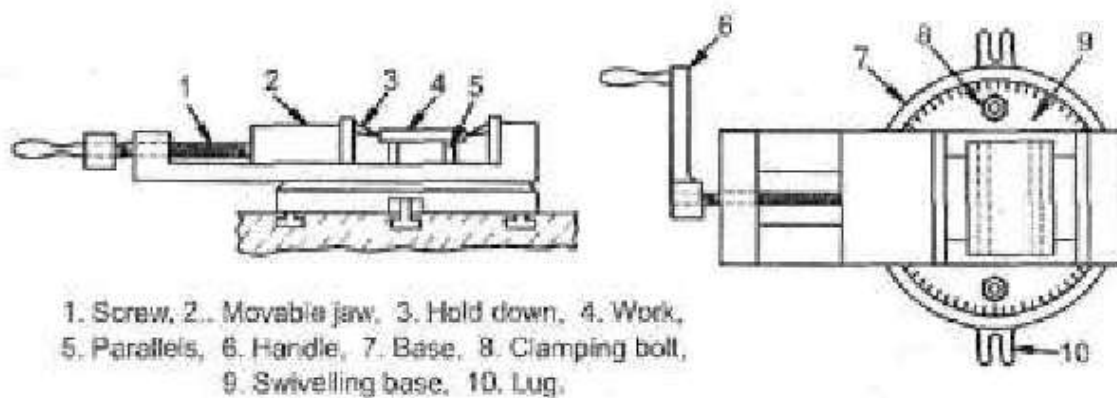


Work Holding Devices

The top and sides of the table of a shaper have T-slots for clamping the work. The work may be supported on the table by the following methods depending on the nature of the work-piece.

Shaper Vises

A vise is a quick method of holding and locating relatively small and regular shaped work-pieces. It consists of a base, table, screw, fixed and movable jaws. The base has a projection or tongue which fits in to the slot of the machine table. For properly securing it to the table lugs are provided for clamping the vise by T-bolts. The work is clamped between fixed and movable jaws by rotating the screw. Wherever possible the vise is so placed on the table that the tool while cutting exerts direct pressure upon the jaws. A machine vise may be classified under following headings.



- 1) Plain vise
 - a) Single screw
 - b) Double screw
- 2) Swivel vise
- 3) Universal vise.

Plain Vise

A plain vise is the most simple of all the types. The vise may have a single screw or double screws for actuating the movable jaw. The double screws add gripping strength while taking deeper cuts or handling heavier jobs.

Swivel Vise

In a swivel vise the base is graduated in degrees and the body of the vise may be swivelled at any designed angle on a horizontal plane. The swivelling arrangement is useful in bevelling the end of work-piece.

Universal Vise

A universal vise may be swivelled like a swivel vise. In addition to that, the body may be tilted in a vertical plane up to 90 degrees from the horizontal. An inclined surface may be machined by a universal vise.

Parallels

When the height of the job is less than the height of the jaws of the vise, parallels are used to raise and seat the work-piece above the vise jaws and parallel with the vise bottom. Parallels are square or rectangular bars of steel or cast iron, hardened and ground with opposite sides parallel. They are available in various sizes for seating work-pieces of different heights and are always used in pairs.

Hold Downs

Hold downs or grippers are used for holding thin pieces of work in a shaper vise. Hold downs are also used for holding work of smaller height than the vise jaws where suitable parallels are not available. The hold down is a hardened wedge shaped piece with its two working edges tapered at an angle of 5°. Hold downs are placed between two jaws of the vise and the work piece. When the screw is tightened the typical shaped of the hold down exerts down ward pressure on the work to hold it tight on the parallels or on the vise table.

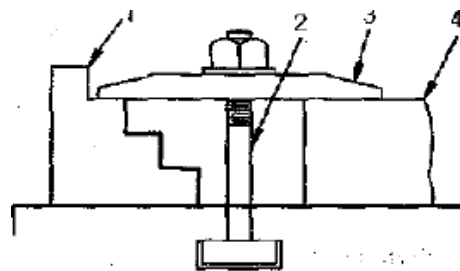
Clamping Work on the Table

When the work-piece is too large to be held in a vise it must be fastened directly on the shaper table. In holding work on the table, clamping bolts should not be unduly tightened to produce distortion of the work. The different methods employed to clamp different types of work on a shaper table are:

- 1) T-bolts and clamps
- 2) Stop pins
- 3) Stop pins and toe dogs
- 4) Strip and stop pins.

T-Bolts and Clamps

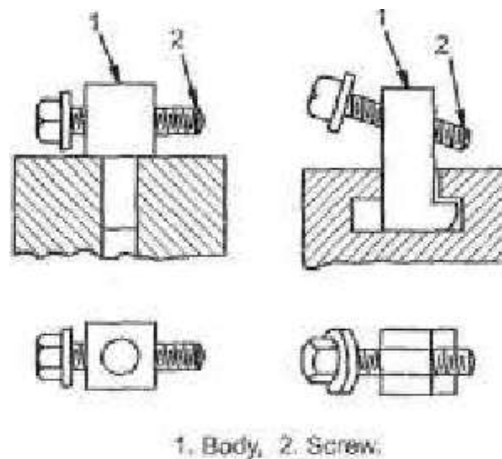
Fig. illustrates the use of T-bolts and clamps for holding the work. T-bolts having T-heads are fitted in the T-slots of the table. The length of the threaded portion is sufficiently long in order to accommodate different heights of work. The clamps are made of steel having slots at the centre for fitting the bolt. One end of the clamp rests on the side of the work while the other end rests on a fulcrum block. The fulcrum block should be of the same height as the part being clamped. The bolt is placed as near to the work as possible and the nut is then tightened. To hold a large work on the table a series of clamps and T-bolts are used all round the work.



Step block, 2. T-Bolt, 3. Clamp, 4. Work.

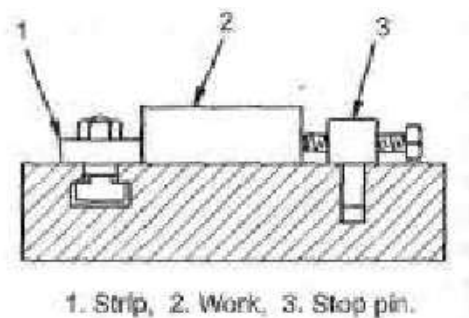
Stop Pins

A stop pin is a one-leg screw clamp. As the tool moves forward to perform cutting stroke the work tends to be pushed out of its position under the pressure of the cutting tool. Stop pins are used to prevent the work from coming out of position. The body of the stop pin is fitted in the hole or slot on the table and the screw is tightened till it forces against the work.



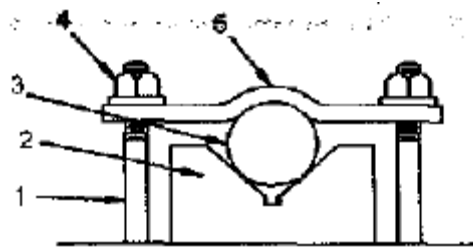
Strip and stop pins

Fig. illustrates the working of strip and stop pins for holding the work. Work having sufficient thickness is held on the table by strip and stop pins. A strip is a long bar having a tongue with holes for fitting the T-bolts. The strip with bolts is fitted in the T-slot of the table, the tongue of the strip fitting within the slot. The nuts are then tightened so that the strip plate may rest on one side of the work. The stop pin screws are then tightened end of the work so that the work may be clamped between stop pins and strip plate.



V-Block

Fig. illustrates the use of a V-block. For holding round rods V-block are used. Work may be supported on two V-blocks at its two ends and is clamped to the table by T-bolts and clamps. The tool may be made to reciprocate between the two clamps for cutting grooves or key ways. V-blocks are made of cast iron or steel and are accurately machined.



T-bolt, 2. V-block, 3. Work, 4. Nut, 5. Clamp

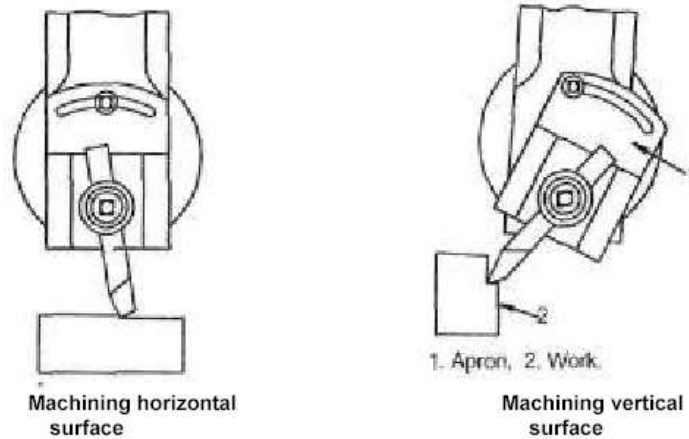
3.5 Operations performed on Shaper

A shaper is a versatile machine tool primarily designed to generate a flat surface by a single point cutting tool. But it may also be used to perform many other operations. The different operations, which a shaper can perform are as follows:

- 1) Machining horizontal surface
- 2) Machining vertical surface
- 3) Machining angular surface
- 4) Cutting slots, grooves, and key ways
- 5) Machining irregular surface
- 6) Machining splines or cutting gears.

Machining horizontal surface

Fig illustrates machining horizontal surface on a workpiece. A shaper is mostly used to machine a flat, true surface on a work-piece held in a vise or other holding devices. After the work is properly held on the table, a planing tool is set in the tool post with minimum overhang. The table is raised till there is a clearance of 25 to 30 mm between the tool and the work-piece. The length and position of stroke are then adjusted. The length of stroke should be nearly 20mm longer than the work and the position of stroke is so adjusted that the tool begins to move from a distance of 12 to 15 mm before the beginning of the cut and continues to move 5 to 8mm after the end of the cut. Proper cutting speed and feed is then adjusted. Short, strokes should be given with high speed while long strokes with slow speed. Both roughing and finishing cuts are performed to complete the job. For roughing cut speed is decreased but feed and depth of cut is increased. Depth of cut is adjusted by a micrometer dial. The depth of cut for roughing work usually ranges from 1.5 to 3mm, while for finishing work it ranges from 0.075 to 0.200 mm. Feed is adjusted about one half the width of the cutting edge of the tool so that each cut will overlap the last cut giving a smooth surface finish.

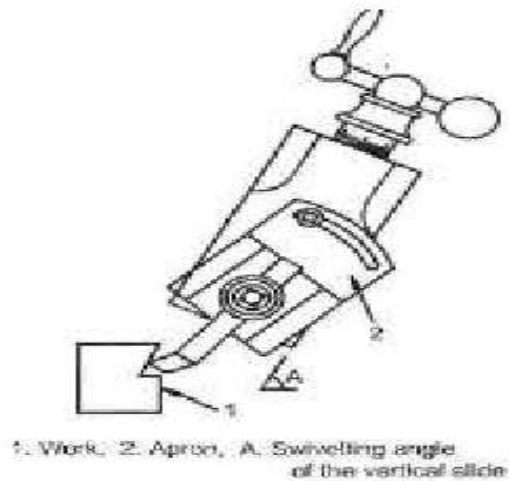


Machining vertical surface

A vertical cut is made while machining the end of a work-piece, squaring up a block or cutting shoulder. The work is mounted in the vise or directly on the table and the surface to be machined is carefully aligned with the axis of the ram. A side-cutting tool is set on the tool post and the position and length of stroke is adjusted. The vertical slide is set exactly at zero position and the apron is swiveled in a direction away from the surface being cut. This is necessary to enable the tool to move upwards and away from the work during return stroke. This prevents the side of the tool from dragging on the planed vertical surface during return stroke. The down feed is given by rotating the down feed screw by hand. The feed is about 0.25mm given at the end of the each return stroke. Both roughing and finishing cuts are performed to complete the job.

Machining angular surface

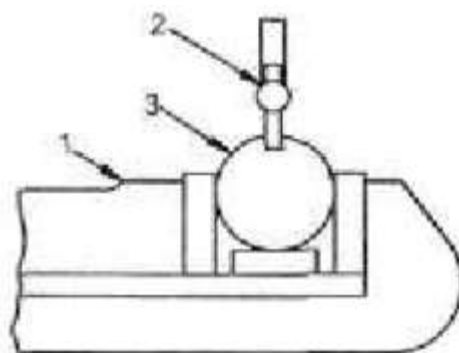
An angular cut is made at any angle other than a right angle to the horizontal or to the vertical plane. The work is set on the table and the vertical slide of the tool head is swiveled to the required angle either towards left or towards right from the vertical position. The apron is then further swivelled away from the work so that the tool will clear the work during return stroke. The down feed is given by rotating the down feed screw. Angular surface can also be machined in a universal shaper by using a universal vise without swivelling the tool head.



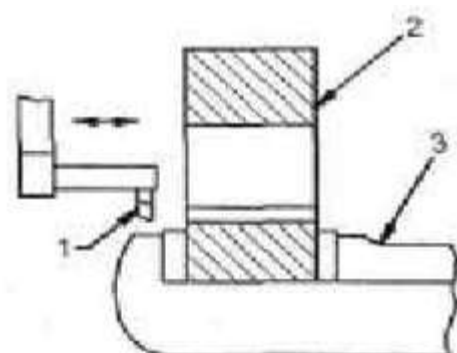
Machining angular surface

Cutting slots and keyways

With suitable tools a shaper can very conveniently machine slots or grooves on a work or cut external keyways on shafts and internal keyways on pulleys or gears. For cutting slots or keyways a square nose tool similar to a parting tool is selected. Fig.9.22 illustrates cutting of external keyways and Fig. shows cutting of internal keyways in a shaper. External keyways are cut on a shaft by first drilling a hole at the blind end of the keyway. The diameter of the holes should be 0.5 to 0.8mm over size than the width of the keyways and the depth should be about 1.55mm larger than the depth of keyway. This is necessary to leave a clearance on the tool at the end of the stroke. The length and position of stroke is carefully adjusted so that the stroke will terminate exactly at the clearance hole. The speed is reduced while cutting a keyway. Internal keyways are cut by holding the tool on a special tool holder so that the tool post will not hit against the work at the end of the stroke. The clapper block is locked in the clapper box to prevent the tool from lifting during return stroke. Lubrication is necessary on the work to prevent the cutting edge of the tool from wear due to dragging.



1. Vise, 2. Tool, 3. Work.
Cutting external keyway



1. Tool bit, 2. Work, 3. Vise.
Cutting internal keyway

Machining Irregular Surface

A shaper can also produce a contoured surface i.e. a convex or concave surface or a combination of any of the above surfaces. To produce a small contoured surface a forming tool is used. If the curve is sufficiently large power. Cross feed in conjunction with manual down feed is so adjusted that the tool will trace the required contour. If the contour has too many ups and downs both the feeds are operated by hand. A round nose tool is selected for machining irregular surfaces. For a shallow cut the apron may be set vertical but if the curve is quite sharp, the apron is swiveled towards right or left away from the surface to be cut. Fig. Shows machining of a concave surface using a round nose tool.

3.6 Machining time calculations

3.7 Slotting machines

Introduction

The slotting machine falls under the category of reciprocating type of machine tool similar to a shaper or a planer. It operates almost on the same principle as that of a shaper. The major difference between a slotter and shaper is that in a slotter the ram holding the tool reciprocates in a vertical axis, whereas in a shaper the ram holding the tool reciprocates in a horizontal axis. A vertical shaper and a slotter are almost similar to each other as regards to their construction, operation, and use. The only difference being, in the case of a vertical shaper, the ram holding the tool may also reciprocate at an angle to the horizontal table in addition to the vertical stroke. The ram can be swivelled not more than 5° to the vertical. The slotter is used for cutting grooves, key ways and slots of various shapes, for making regular and irregular surfaces both internal and external, for handling large and awkward work pieces, for cutting internal or external gears and many other operations which cannot be conveniently machine in any other machined tool described before. The slotting machine was developed by Brunei in the year 1800 much earlier than a shaper was invented.

3.8 Principles of working

3.9 Principal parts of slotting machine

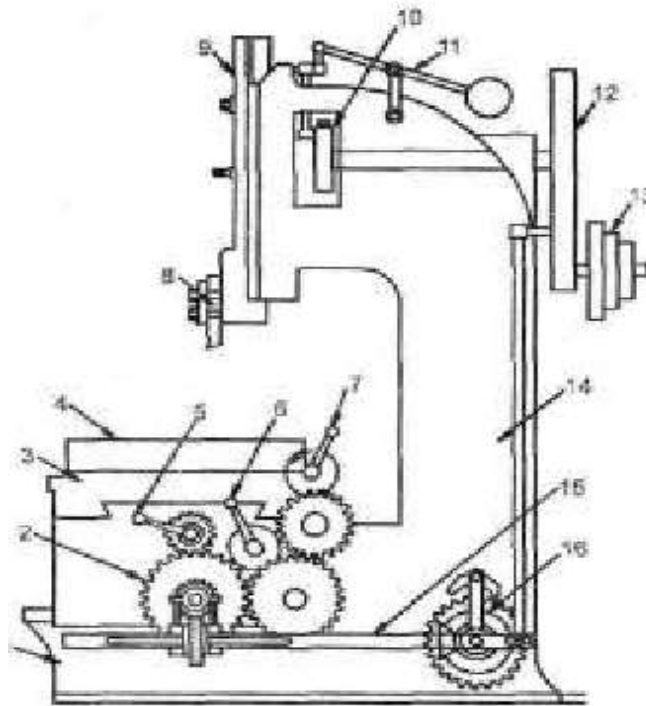


Fig. illustrates a slotting machine. The different parts of a slotting machine are:

- 1) Base
- 2) Column
- 3) Saddle
- 4) Cross-slide
- 5) Rotating table
- 6) Ram and tool head assembly
- 7) Ram drive mechanism
- 8) Feed mechanism

Base or Bed

The base is rigidly built to take up all the cutting forces and entire load of the machine. The top of the bed is accurately finished to provide guide ways on which the saddle is mounted. The guide ways are perpendicular to the column face. **Column** The column is the vertical member, which is cast integral with the base and houses driving mechanism of the ram and feeding mechanism. The front vertical face of the column is accurately finished for providing ways on which the ram reciprocates.

Saddle

The saddle is mounted upon the guideways and may be moved toward or away from the column either by power or manual control to supply longitudinal feed to the work. The top face of the saddle is accurately finished to provide guide ways for the cross-slide. These guide ways are perpendicular to the guide ways on the base.

Cross-Slide

The cross-slide is mounted upon the guide ways of the saddle and may be moved parallel to the face of the column. The movement of the slide may be controlled either by hand or power to supply cross-feed.

Rotary Table

The rotary table is a circular table which is mounted on the top of the cross-slide. The table may be rotated by rotating a worm which meshes with a worm gear connected to the underside of the table. The rotation of the table may be effected either by hand or power. In some machines the table is graduated in degrees that enable the table to be rotated for indexing or dividing the periphery of a job in equal number of parts. T-slots are cut on the top face of the table for holding the work by different clamping devices. The rotary table enables a circular or contoured surface to be - generated on the work piece.

Ram and Tool head Assembly

The ram is the reciprocating member of the machine mounted on the guide-ways of the column. It supports the tool at its bottom end on a tool head. A slot is cut on the body of the ram for changing the position of stroke. In some machines, special type of tool holders is provided to relieve the tool during its return stroke.

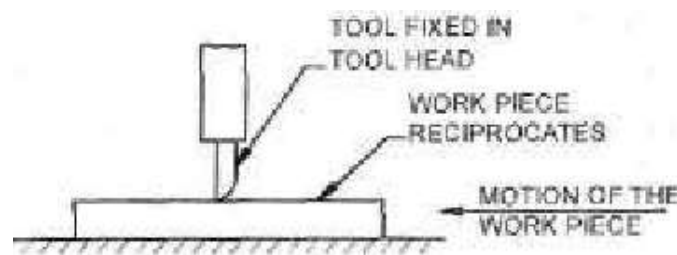
3.10 Specifications

3.11 Operations performed

3.12 PLANNING MACHINES & Principles of working

Introduction

A planer is a machine having reciprocating work and fixed tool. The work traverses the tool and feeds over at the end of each stroke the tool is clamped in the tool holder and the work on the table. Fig. shows the working principle of a planer. The type of work is very similar to that done on a shaper except that a plane is adapted to much large work. The cuts are all plain surfaces, but they may be horizontal, vertical or at any angle. Both the planer and shaper employ single-point cutting tools for machining. The planer is very heavy in construction and had long table travel. It can take multi-cuts at various places in a single stroke, because it can accommodate more than one tool holding stations. It is also possible to machine large number of smaller parts by setting them properly on the table usually, two tool heads are mounted on the overhead cross rail and one each on either of the column. Like all reciprocating machine tools, the planer is quipped with a clapper box to raise the tool on the return stroke.



Difference between Planer and shaper

Although both the planer and shaper employ single-point cutting tools for machining flat surfaces, they are not similar in their field of usefulness: they differ widely in construction and in method of operation when the two machines are compared in construction, operation and use, the following difference may be seen.

- 1) The planer is very heavy and robust machine in construction the shaper is smaller one.
- 2) On planer the work is moved against the stationary tool, on shaper the tool is moved against the stationary work.
- 3) On planner the feed is given to the tool, on shaper the feed is given to the work.
- 4) In planer the work table is drive either by gears or by hydraulic means. The shaper ram can also be driven in this manner, but in most cases the quick return mechanism is used.
- 5) Most planers differ from shapers in that they approach constant velocity cuts.
- 6) The planer is specially adopted to large work; the shaper can do only small work.
- 7) In a planer the tool is rigidly supported when the work moves on precision ways and maximum accuracy on the machined surface is assured. In a shaper, due to overhanging of the ram during the cutting stroke, and the machine being not very robust the accuracy cannot be expected up to the mark.
- 8) High rate of power consumption and overall rigidity in a planer enables it to take deep cuts and apply heavy feeds to rough finish a job quickly. A planer can consume up to 150 h.p. Whereas a shaper can consume 15 to 20 h.p.
- 9) A planer is not suitable for machining relatively small, and medium size work or few at a time that a shaper can do, but a planer is more economical and faster when large quantities are machined. A large number of jobs of identical shapers can be machined in one setting on a planer table.
- 10) Multiple tooling with double or four tool heads in a planer makes it possible to machine more than one surface together, thus reducing cutting time.
- 11) In a planning machine, work setting requires much of skill and takes along time, whereas in a shaper the work may be clamped easily and quickly.
- 12) Tools used in a planer are much more robust than that used in a shaper.
- 13) In modern planes wide range of cutting and return speeds are available and they may
 - 1) be changed independently.
- 14) Planers are larger and costlier machines compared to shapers.
- 15) 11.3 Planer Size

The size of a planer is determined by the maximum length of material the tool can machine in one stroke. It includes the table size, (length and width) and its distance from the rail. Other details are also mentioned to complete the specifications like type of drive, type of speed reduction, power input, cutting to return stroke ratio etc.

3.13 Principal parts

The principle parts of a planer are as follows:

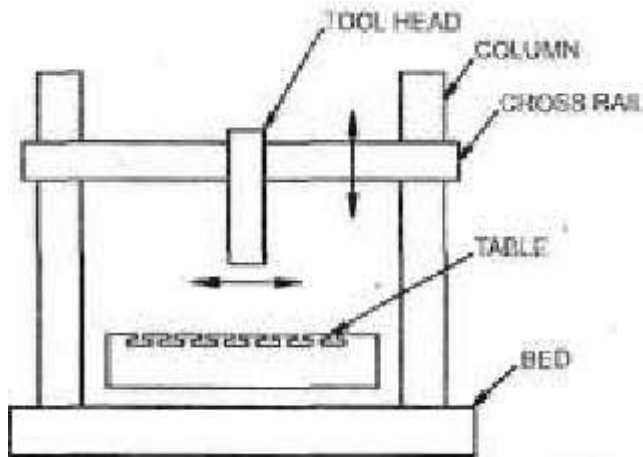
Bed

It is a very strong and robust structure. It is made of cast iron. Cross ribs are provided to make it more strong and stable. The length of the bed is usually-twice the length of the table, so that

the table may have complete stroke on the bed surface. For, supporting and permitting the table to reciprocate in constrained form, ways are provided on the top of the bed. Mechanisms for driving the table are accommodated inside the bed.

Table

The table is supported on the bed ways. T-slots are provided through out the length of the table for tightening the work-piece by T-bolts. A trough is provided at either end of the table to collect chips. Adjustable dogs are provided at aside of the table, which operate some mechanism for reversing the table automatically at the end of each the stroke. Some arrangements are also made to avoid the running away of the moving, loaded table. The table is usually cast in one piece; long table, may be cast in several pieces and bolted together.



Column or Uprights

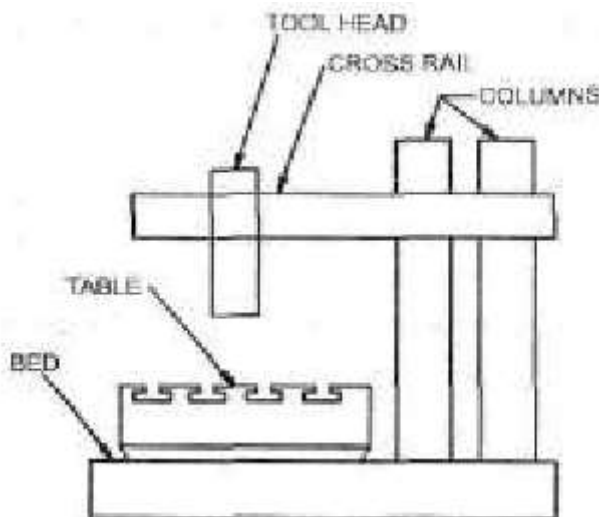
A planer has to columns one at each side of the bed at its centre and opposite to each other. The columns support a horizontal cross rail across the length of the bed. The cross rail may slide up or down on the columns and may be clamped in any position. Within the body of the columns, the vertical feed shaft, elevating screw for cross rail, end feed bar, etc. are accommodated within the body of the columns. The column may also support a tool head for side machining.

Cross-Rail

It is supported horizontally by the two vertical column at the centre of the bed and across it. The cross rail may be operated manually, hydraulically. It may be clamped horizontally in any position on the columns. It carries tool heads usually two in number. For feeding the tool, the feed screws are enclosed in the cross rail.

Tool Head

Usually two tool heads are mounted on the horizontal cross rail and one on each column. The tool head carries a tool post to hold the cutting tool. The tool post is hinged on the tool head for lifting the tool in the return stroke. The tool may be adjusted at an angle also, if desired.



Control

The controls for governing the various actions of different parts of a planer are provided in a centralised panel. From this central location the operator is able to obtain very close control of all cutting tools. These controls are start, stop, automatic cut, automatic return, speed reduce, etc.

Classification of Planer

According to the general construction the planers are of five types:

- 1) Double housing planer
- 2) Open-side planer
- 3) Universal planer
- 4) Pit type planer
- 5) Edge or plate planer.

Each of the above types may vary according to the method of drive as follows:

- 1) Gear drive
- 2) Hydraulic drive
- 3) Screw drive
- 4) Belt drive
- 5) Variable-speed motor drive
- 6) Crank drive.

Gear driven planers are generally used in the workshops. They have several times more inertia force to overcome than the hydraulic drive planers. Overcoming inertia consumes energy and with rapid short strokes, the difference in power consumption is noticeable. Hydraulic drives are highly satisfactory for planers. Advantages of hydraulic drives are uniform cutting pressure, quick table reversal, rapid means of varying the stroke and less noise in operation. Screw drive is employed principally on plate planers. Belt drive is the oldest system in which the power is taken from an overhead line shaft. Crank drive is found only on some small planers.

Double Housing Planer

It consists of a long heavy base on which the table or platen is reciprocated. The upright housing is located at the side of the base near the centre to support the cross rail. The cross rail supports the tool heads. The tool may be feed manually or by power in either a vertical or a crosswise direction. The motor drive usually at one side of the planer near the centre, and the drive mechanism is located under the table. The controls for operation are all at the upright housing. The stroke length of the table is controlled by the adjustable dogs at the side of the bed. The accuracy of the planer depends upon the rigidity and the manner in which the bed ways are machined.

Open-Side Planer

The open side planer has housing on one side only. It is hydraulically driven and used to handle wide work. It can be equipped with duplicating attachments for machining irregular surfaces. On one side of the table, a master form is mounted so that as the tracer moves over the surface, the cutting tool is moved accordingly. Such device are usually hydraulically operated and are similar in operation to duplicating units used on other machine tools.

Pit-Type Planer

It is very heavy and huge in construction. It differs from an ordinary planer in that the bed is stationary and the tool is move over the work. The work piece up to 12 m long and 5m wide may easily be machined on this planer. The cross-rail is mounted with two ram-type hands equipped with double clapper block tool holders for two-way planing. Two reversing housing supporting the cross-rail, slide on ways and are screw- driven from an enclosed worm drive at one end of the bed. All feeds are automatic reversible, and can be operated at both ends of the planning stroke.

Plate or Edge Planer

It is special type of planer devised for fabrication of heavy steel plates for pressure vessels armor plate. It may have the plate with capacity up to 15m. On one side of the housing the plate is clamped to the long bed. The carriage holding the cutting tool is supported on the heavy ways of the planer. The carriage carrying the tools and operator is moved along the work by the large screw drive. The size of the plates that can be edge-machined is limited by the width and height of the machine opening but there is no limit to the length, the plate may extended behind the machine.

3.14 Machining time calculations

3.15 DRILLING&BORINGMACHINES

DRILLING

Drilling is the process of originating holes in the work piece by using a rotating cutter called drill. The machine used for this purpose is called drilling machine. 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. As the machine tool exerts vertical pressure to originate a hole it is also called drill press. Holes were drilled by the Egyptians in 1200 B.C. by bow drills. The bow drill is the mother of present day metal cutting drilling machine.

Types of drilling machine

The different types of drilling machine which are most commonly used are:

- ✓ Portable drilling machine.
- ✓ Sensitive drilling machine (Bench mounting table top and Floor mounting
- ✓ Upright drilling machine (Pillar or Round column section and Box column section)
- ✓ Radial drilling machine (Plain, Semi-universal and Universal)
- ✓ Gang drilling machine.
- ✓ Multiple spindle drilling machine.
- ✓ Deep hole drilling machine.
- ✓ Turret type drilling machine

But in working principle all are more or less the same.

3.10.1.1 Portable drilling machine or hand drilling machine

Unlike the mounted stationary drilling machines, the hand drill is a portable drilling device which is mostly held in hand and used at the locations where holes have to be drilled. The small and reasonably light hand drilling machines are run by a high speed electric motor. In fire hazardous areas the hand drilling machine is often rotated by compressed air. The maximum size of the drill that it can accommodate is not more than 12 to 18 mm. Fig. 3.109 illustrates a hand drilling machine.



Fig. 3.109 Hand drilling machine Fig. 3.110 Table top sensitive drilling machine

Bench mounting or table top sensitive drilling machine

This small capacity (≤ 0.5 kW) upright (vertical) single spindle drilling machine is mounted on rigid table and manually operated using usually small size ($\phi \leq 10$ mm) drills. Fig. 3.110 illustrates a table top sensitive drilling machine.

Floor mounting sensitive drilling machine

The floor mounting sensitive drilling machine is a small machine designed for drilling small holes at high speed in light jobs. The base of the machine is mounted 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 is no arrangement for any automatic feed of the drill spindle. The drill is fed into the work by purely hand control. High speed is 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 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. 3.111 illustrates a floor mounting sensitive drilling machine.

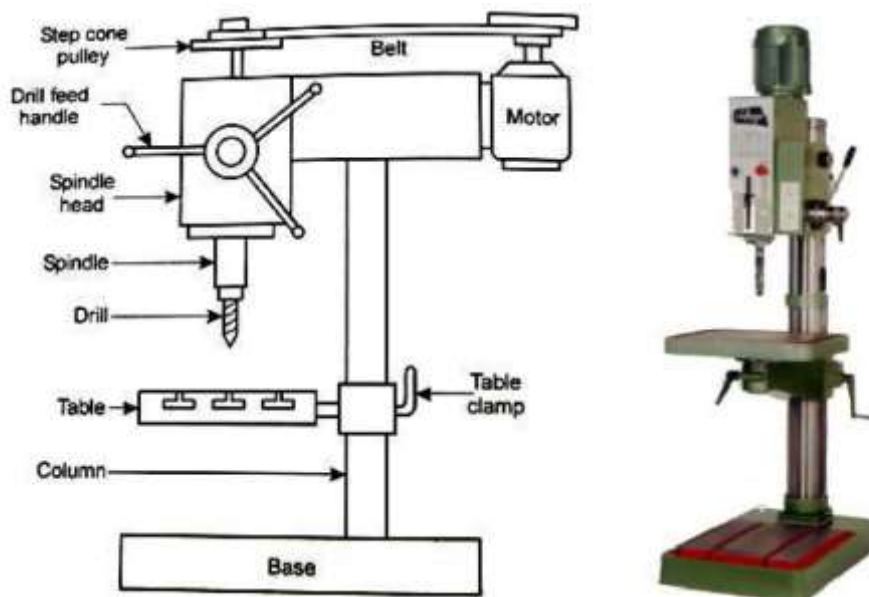


Fig. 3.111 Floor mounting sensitive drilling machine Fig. 3.112 Pillar drilling machine

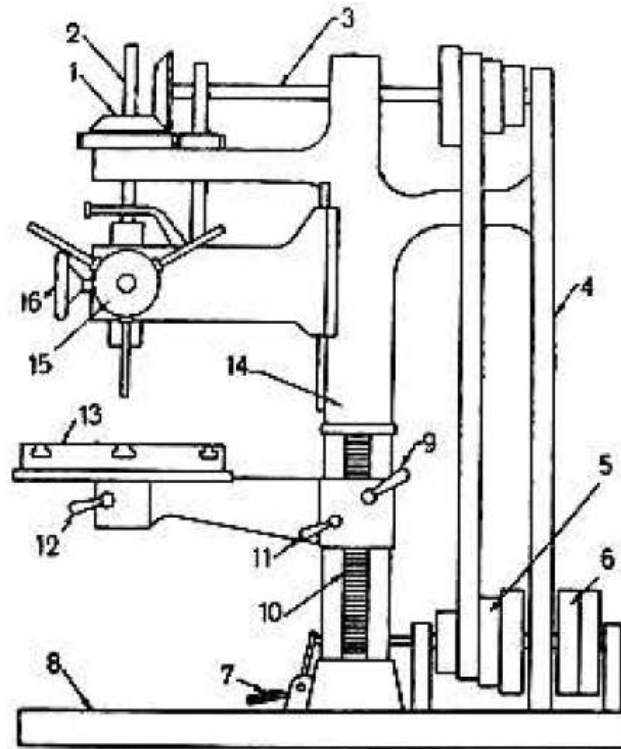
Pillar or Round column section upright drilling machine

Fig. 3.112 illustrates a pillar or round column section upright drilling machine. This machine is usually called pillar drilling machine. It is quite similar to the table top drilling machine but of little larger size and higher capacity (0.55 ~ 1.1 kW) and are mounted on the floor. In this machine the drill feed and the work table movements are done manually. This low cost drilling machine has a base, a tall tubular column, an arm supporting the table and a drill head assembly. The arm may be moved up and down on the column and also be moved in an arc up to 180° around the column. The table may be rotated 360° about its own centre independent of the position of the arm. It is generally

used for small jobs and light drilling. The maximum size of holes that can be drilled is not more than 50 mm.

Box column section upright drilling machine

Fig. 3.113 illustrates a box column section upright drilling machine. The major parts are:



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. Foot pedal
8. Base
9. Table elevating handle
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

Base: It is a part of the machine on which vertical column is mounted. The top of the base 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 It 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 box column type, the front face of the column is accurately machined to form guide ways on which the table can slide up and down for vertical adjustment.

Table It 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. The table 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.

Drill head It 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.

Spindle Holds the drill and transmits rotation and axial translation to the tool for providing cutting motion and feed motion - both to the drill.

Radial drilling machine

Fig. 3.114 illustrates a radial drilling machine. The major parts are:

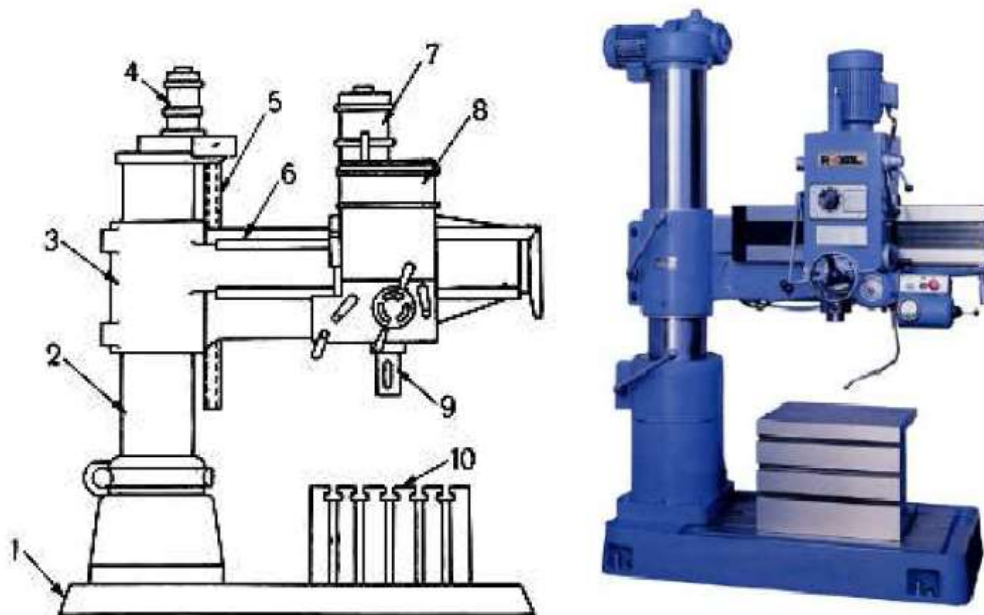


Fig. 3.114 Radial drilling machine

Base: It 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.

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 speeds 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.

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. 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 the gear train within the drill head, the speed of the spindle may be varied. Through another gear train 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.

Working principle: The work is mounted on the table or when the work is very large it may be placed on the floor or in a pit. Then the position of the arm and the drill head is altered so that the drill may be pointed exactly on the location where the hole is to be drilled. When several holes are drilled on a large work piece, the drill head is 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 work pieces. There are some more machines where the drill spindle can be additionally swiveled and / or tilted.

Gang drilling machine

In this almost single purpose and more productive drilling machine a number of spindles (2 to 6) with drills (of same or different size) in a row are made to produce number of holes progressively or simultaneously through the jig. Fig. 3.115 illustrates a typical gang drilling machine.

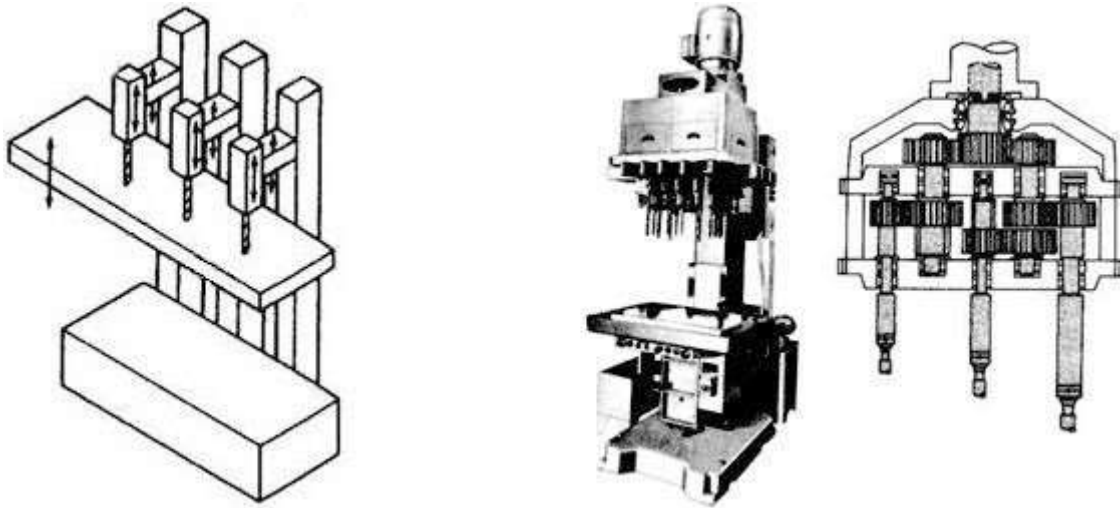


Fig. 3.115 Gang drilling machine Fig. 3.116 Multiple spindle drilling machine

Multiple spindle drilling machine

Fig. 3.116 schematically shows a typical multiple spindle drilling machine. In this high production machine a large number of drills work concurrently on a blank through a jig specially made for the particular work. The entire drilling head works repeatedly using the same jig for batch or lot production. The rotations of the drills are derived from the main spindle and the central gear through a number of planetary gears in mesh with the central gear and the corresponding flexible shafts. The positions of those parallel shafts holding the drills are adjusted depending upon the locations of the holes to be made on the job. Each shaft possesses a telescopic part and two universal joints at its ends to allow its change in length and orientation respectively for adjustment of location of the drills of varying size and length. In some heavy duty multi spindle drilling machines, the work-table is raised to give feed motion instead of moving the heavy drilling head.

Deep hole drilling machine

Very deep holes of L/D ratio 6 to even 30, required for rifle barrels, long spindles, oil holes in shafts, bearings, connecting rods etc, are very difficult to make for slenderness of the drills and difficulties in cutting fluid application and chip removal. Such drilling cannot be done in ordinary drilling machines and by using ordinary drills. It needs machines like deep hole drilling machine such as gun drilling machines with horizontal axis or vertical axis.

These machines are provided with:

- High spindle speed.

- High rigidity.

- Tool guide.

- Pressurized cutting oil for effective cooling, chip removal and lubrication at the drill tip.

Fig. 3.117 schematically shows a deep hole drill tool used in the deep hole drilling operation.

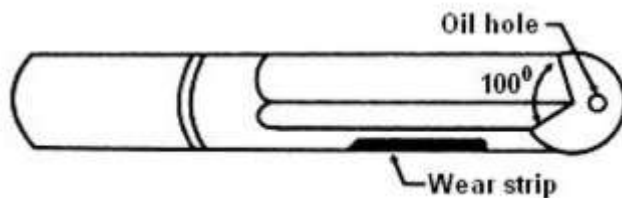


Fig. 3.117 Deep hole drill

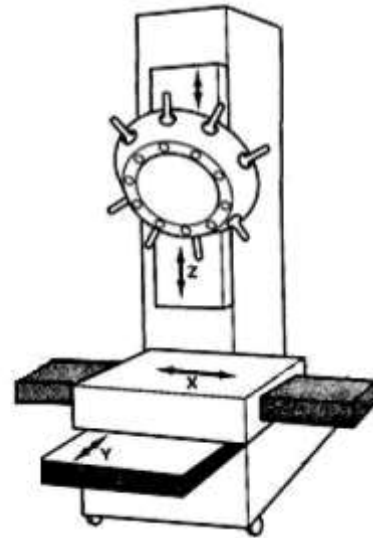


Fig. 3.118 Turret type drilling machine

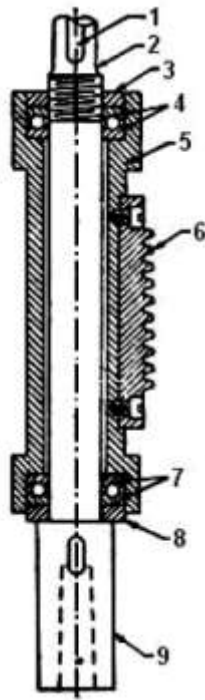
Turret type drilling machine

Fig. 3.118 schematically shows a typical turret type drilling machine. Turret drilling machine is structurally rigid column type drilling machine but is more productive like gang drill machine by having a pentagon or hexagon turret. The turret holds a number of drills and similar tools, is indexed and moved up and down to perform quickly the desired series of operations progressively. These drilling machines are available with varying degree of automation both fixed and flexible type.

Spindle and drill head assembly

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 piece. 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. 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. The drill spindle assembly is illustrated in Fig. 3.119.



1. Key way on the spindle
2. Spindle
3. Nut
4. Thrust bearings
5. Quill or Sleeve
6. Rack
7. Washer
8. Lower end of the spindle

Fig. 3.119 Drill spindle assembly

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:

By step cone pulley drive.

By step cone pulley drive with one or more back gears.

By gearing.

Step cone pulley drive

Fig. 3.113 shows the schematic view of 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 back gears are incorporated in the machine in addition to the step cone pulley.

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.

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:

Quick traverse hand feed.

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. Quick hand feed is obtained by rotating the hand wheel pivoted to the pinion. One turn of the hand wheel will cause the pinion to rotate through one complete revolution giving quick hand feed movement of the spindle.

The sensitive hand feed is applied for trial cut and for drilling small holes. The sensitive feed hand wheel is attached to the rear end of the worm shaft. Rotation of the hand wheel will cause the worm and worm gear to rotate and a slow but sensitive feed is obtained.

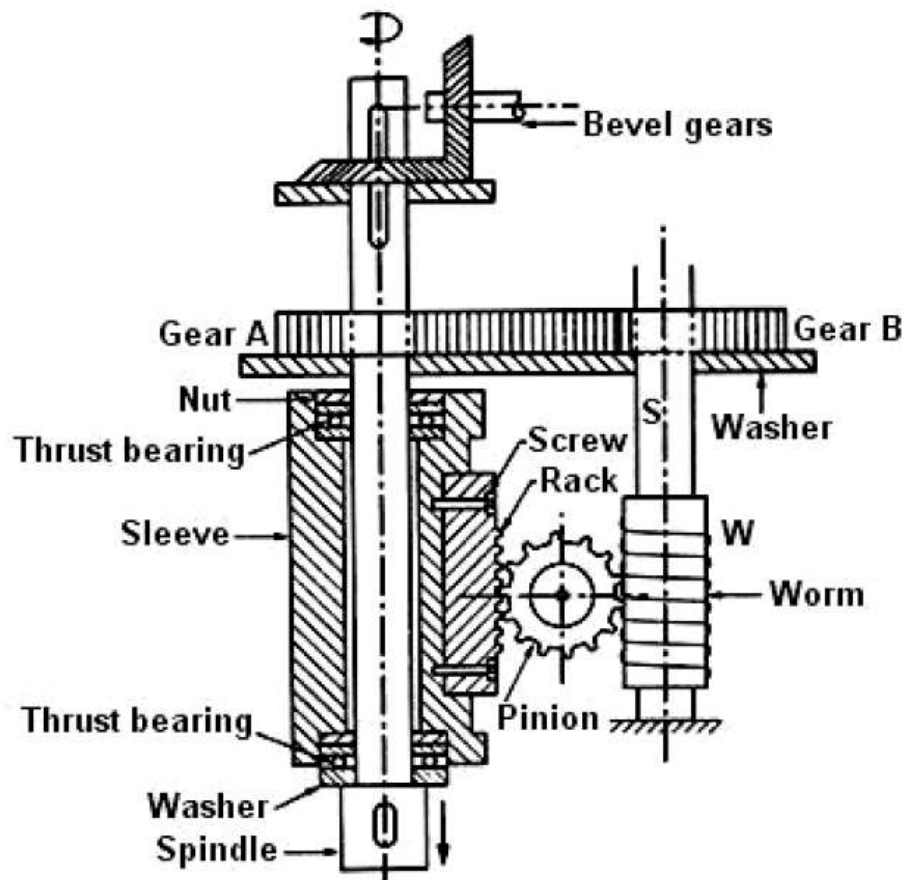


Fig. 3.120 Automatic feed mechanism

The automatic feed is applied while drilling larger diameter holes as the cutting pressure required is sufficiently great. Fig.3.120 illustrates the automatic feed mechanism. The gear A rotates with the spindle as the spindle passes through it. Gear B is connected with gear A, so it also rotates. The shaft S rotates with the gear B as it connected to it. At a suitable distance under the shaft, there is a worm which drives a pinion. The pinion is connected with the rack on the non rotating sleeve (quill) fitted over the spindle. The rotation of the worm rotates the pinion. The rotation of the pinion moves the quill up and down through the rack cut on it. The quill moves the drill spindle up and down. Thus the automatic feed of the drill spindle is achieved. Different ranges of feed can be obtained by means of feed gearbox.

3.10.3 Work holding devices used in drilling machines

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 work piece that it starts revolving along with the tool and may cause injuries to the operator. The work holding devices commonly used for holding the work piece in a drilling machine table are: T-bolts and clamps, machine vises, step blocks, V-blocks, angle plate and drill jigs. All of them except drill jig have been described in Article 3.2.6 and

Page 110. When the work is heavy and / or of odd shape and size, it is directly clamped on the drilling machine table.

Drill jigs

These are used for holding the work in a mass production process. A drill 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. The work is clamped below the jig and the holes are located. The drill is guided by the drill bush. Fig. 3.121 schematically shows some types of drill jigs used in mass production.

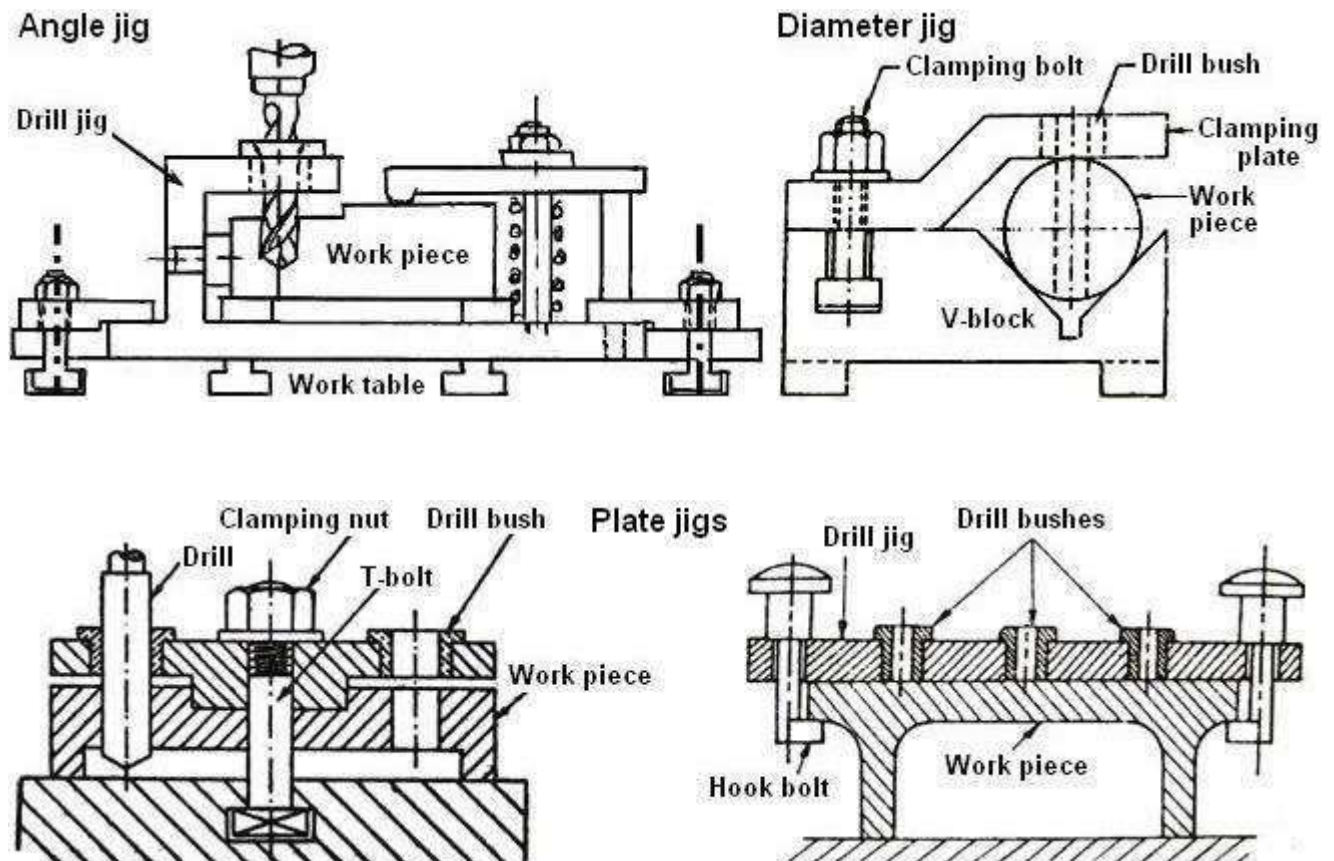


Fig. 3.121 some types of drill jigs

Shaping Machine	Planer Machine	Slotter Machine
1. It is a multipurpose machine, used for producing flat surfaces.	1. It is similar to shaper and is used 'Or producing large surfaces	1. It is similar to vertical shaping machine and used for producing regular or irregular surfaces.
2. The cutting tool reciprocates against the stationary workpiece, during machining.	2. The workpiece is clamped on table, which reciprocates against the stationary cutting tool.	2. The cutting tool reciprocates against the stationary workpiece, during machining. Working Principle
3. The cutting tool is held in tool post, mounted on ram.	3. The cutting tools is held stationary on tool post, mounted on the cross-rail.	3. The cutting tool is held in tool post, mounted on ram.
4. The tool moves in horizontal direction, to	4. The table reciprocates in horizontal direction, to	4. The tool reciprocates in transverse or vertical axis,

remove the material from the workpiece	remove material from the - workpiece.	to remove the material from the workpiece.
5. The cutting action takes place in forward stroke of tool and returns stroke remains idle.	5. The cutting action takes place in forward stroke of table and return stroke remains idle.	5. The cutting action takes place in downward stroke of tool and upward stroke remains idle.
6. The feed is given by movement of table.	6. The feed is given by the linear movement of tool.	6. The cutting feed is given by the movement-of table.
7. It is used for machining flat surfaces like horizontal, vertical or inclined.	7. It is used for machining large flat surfaces.	7. It is used for machining slots, grooves, keyways etc.

3.16 Tool holding devices used in drilling machines

In drilling machines mostly drills of various type and size are used for drilling holes. Often some other tools are also used for enlarging and finishing drilled holes, counter boring, countersinking, tapping etc. The different methods used for holding tools in a drill spindle are:

By directly fitting in the spindle.

By a sleeve.

By a socket.

By chucks.

Drill directly fitted in the spindle

All drilling machines have the spindle bored out to a standard Morse taper (1:20) to receive the taper shank of the tool. While fitting the tool the shank is forced in 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 is removed by pressing a tapered wedge known as the drift or key into the slotted hole of the spindle. Fig. 3.122 (a) shows a drill directly fitted in the spindle. Fig. 3.122 (b) shows a drift.

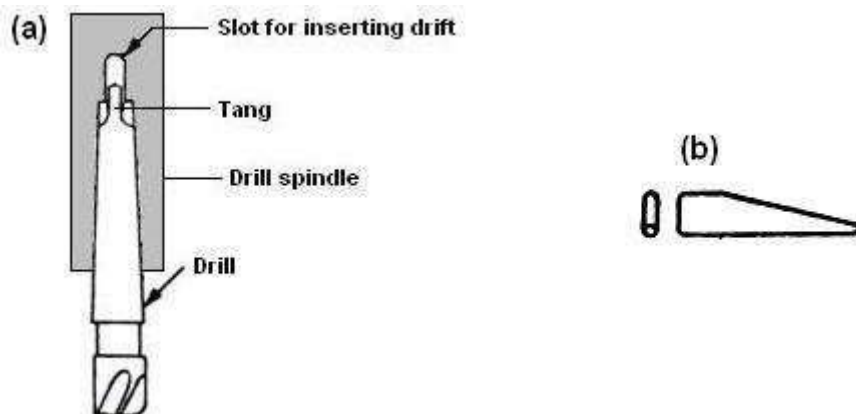


Fig. 3.122 (a) Drill directly fitted in the spindle and (b) Drift or key

Drill 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 the taper holds the shanks of smaller size tools or smaller sleeves. The sleeve fits into the taper hole of the spindle. The sleeve has a 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 size of the tool shanks may be held in the spindle by using different sizes of sleeves. Fig. 3.123 (a) shows a drill sleeve. Fig. 3.123 (b) shows a drill sleeve holding a drill fitted in the drill spindle. Fig. 3.123 (c) shows different sizes of drill sleeves.

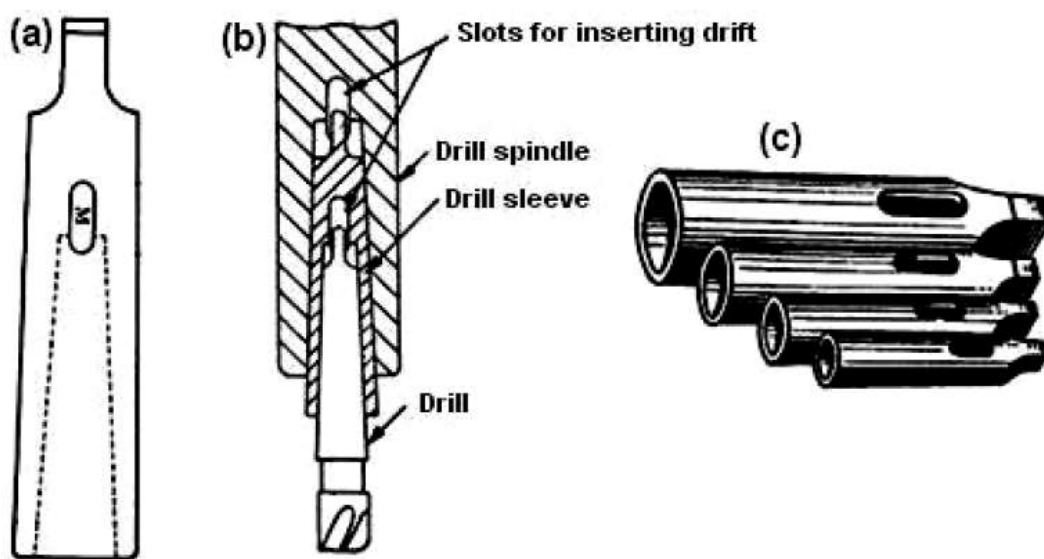


Fig. 3.123 (a) Drill sleeve (b) Drill sleeve holding a drill fitted in the drill spindle and
(c) Different sizes of drill sleeves.

Drill 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. 3.124 shows a drill socket.

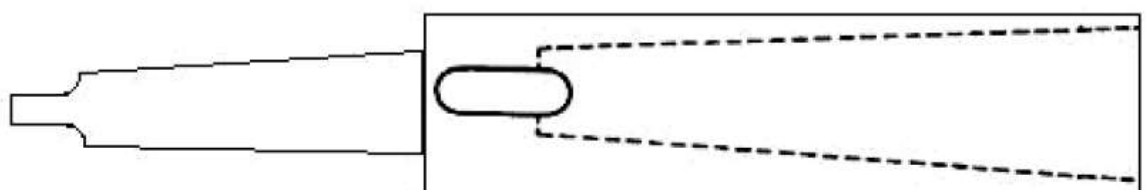


Fig. 3.124 Drill socket

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 drill 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 type of drill chuck used is three jaw self centering drill chuck.

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. Fig. 3.125 shows a three jaw self centering drill chuck

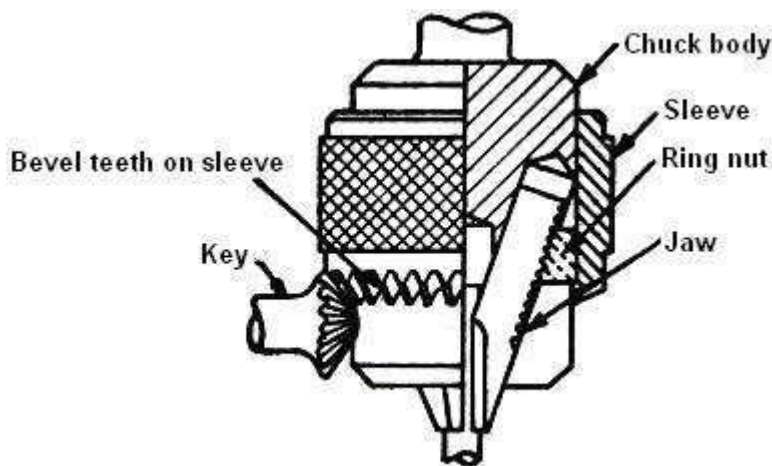


Fig. 3.125 Three jaw self centering drill chuck

Work Holding Devices

1. Machine Table Vice

The machine vice is equipped with jaws which clamp the work piece. The vice can be bolted to the drilling table or the tail can be swung around. Fig. 13 shows the standard and swivel vice.

The swivel vice is a machine vice that can be swivel through 360° on a horizontal plane.

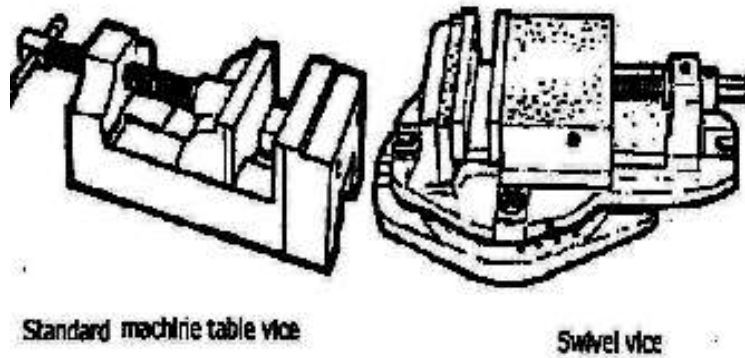


Fig. 13 Machine Table vice.

2. Step Blocks

These are built to allow height adjustment for mounting the drilling jobs and are used with strap clamps and long T-slot bolts.

3. Clamps

These are small, portable vises, which bears against the work piece and holding devices. Common types of clamps are C-clamp, Parallel clamp, machine strap clamp, U-clamp etc.. Fig. 14 shows the correct and incorrect methods of mounting the work piece.

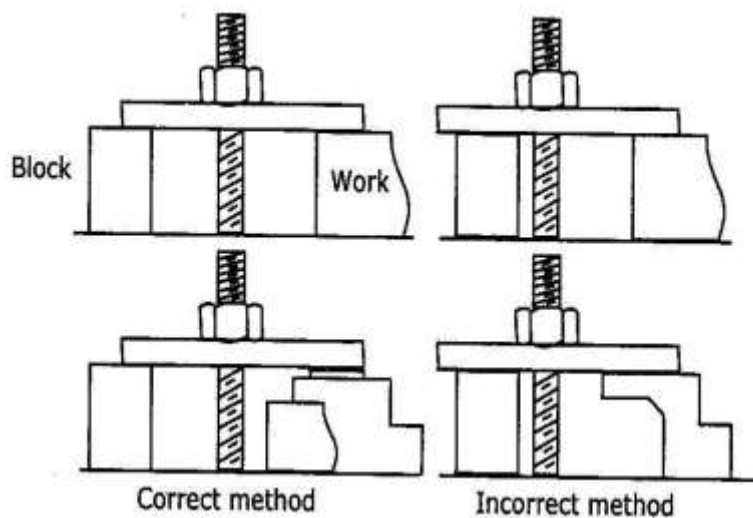


Fig. 14 Correct and incorrect methods of clamping the work piece.

4. V-Blocks

These are designed to hold round work pieces.

5. Angles

Angle plates are made in a 90° angle with slots and bolt holes for securing work to the table.

6. Jigs

The jig guides the drill through a bushing to locate and drill holes accurately.

7. T- Slots Bolt

These are special bolts which has a T shaped head, which slides into the T slots of drilling machine work table.

Drilling tools

Different types of drills are properly used for various applications depending upon work material, tool material, depth and diameter of the holes. General purpose drills may be classified as:

According to material:

High speed steel - most common. Cemented carbides.

Without or with coating.

In the form of brazed, clamped or solid.

According to size:

Large twist drills of diameter around 40 mm.

Micro drills of diameter 25 μm to 500 μm .

Medium range diameter ranges between 3 mm to 25 mm (most widely used).

According to number of flutes:

Two fluted - most common.

Single flute - e.g., gun drill (robust).

Three or four flutes - called slot drill.

According to helix angle of the flutes:

Usual: 200 to 350 - most common.

Large helix: 450 to 600 - suitable for deep holes and softer work materials. Small helix: for harder / stronger materials.

Zero helix: spade drills for high production drilling micro-drilling and hard work materials.

According to length to diameter ratio:

Deep hole drill; e.g. crank shaft drill, gun drill etc. General type: $L/\phi \cong 6$ to 10.

Small length: e.g. centre drill.

According to shank:

Straight shank - small size drill being held in drill chuck.

Taper shank - medium to large size drills being fitted into the spindle nose directly or through taper sockets and sleeves.

According to specific applications:

Centre drill [Fig. 3.126 (a)] for small axial holes with 600 taper ends to hold the lathe centre. Step drill and sub land drill [Fig. 3.126 (b and c)] for small holes with 2 or 3 steps.

Half round drill, gun drill and crank shaft drill [Fig. 3.126 (d, e and f)] for making oil holes. Ejector drill for high speed drilling of large diameter holes.

Taper drill for batch production.

Trepanning tool [Fig. 3.126 (g)] for large holes in soft materials.

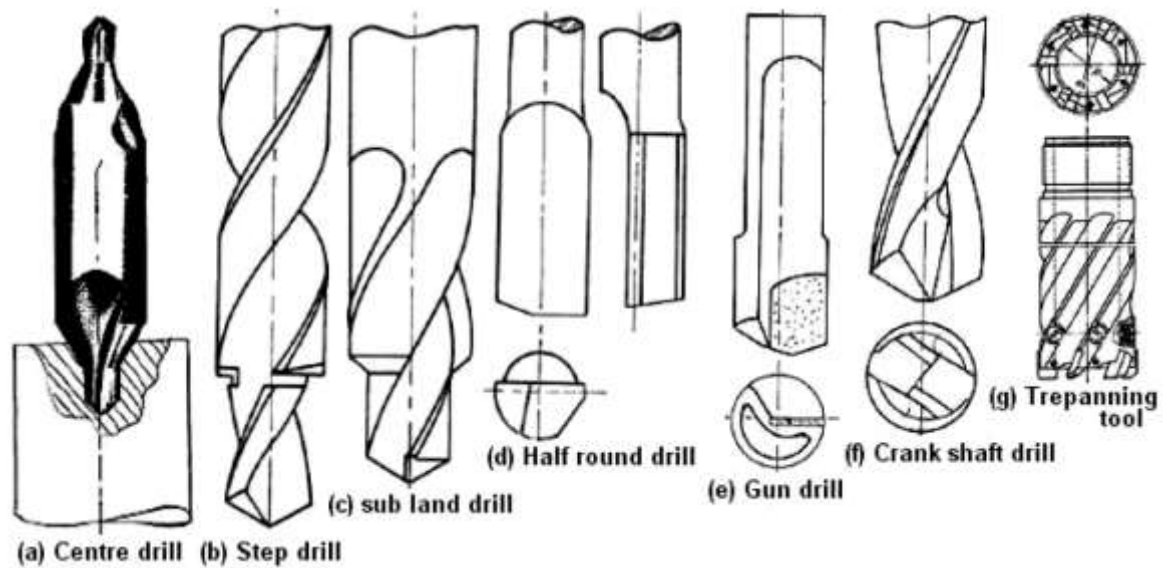
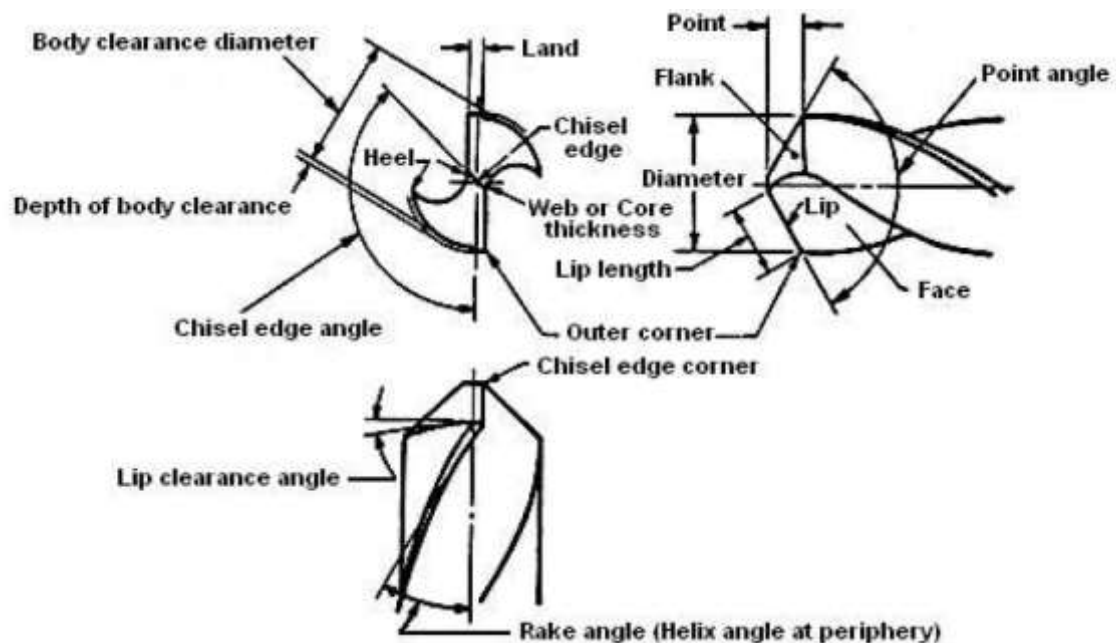


Fig. 3.126 Different types of drills used in various applications

Twist drill nomenclature

The following are the nomenclature, definitions and functions of the different parts of a drill illustrated in Fig. 3.127.



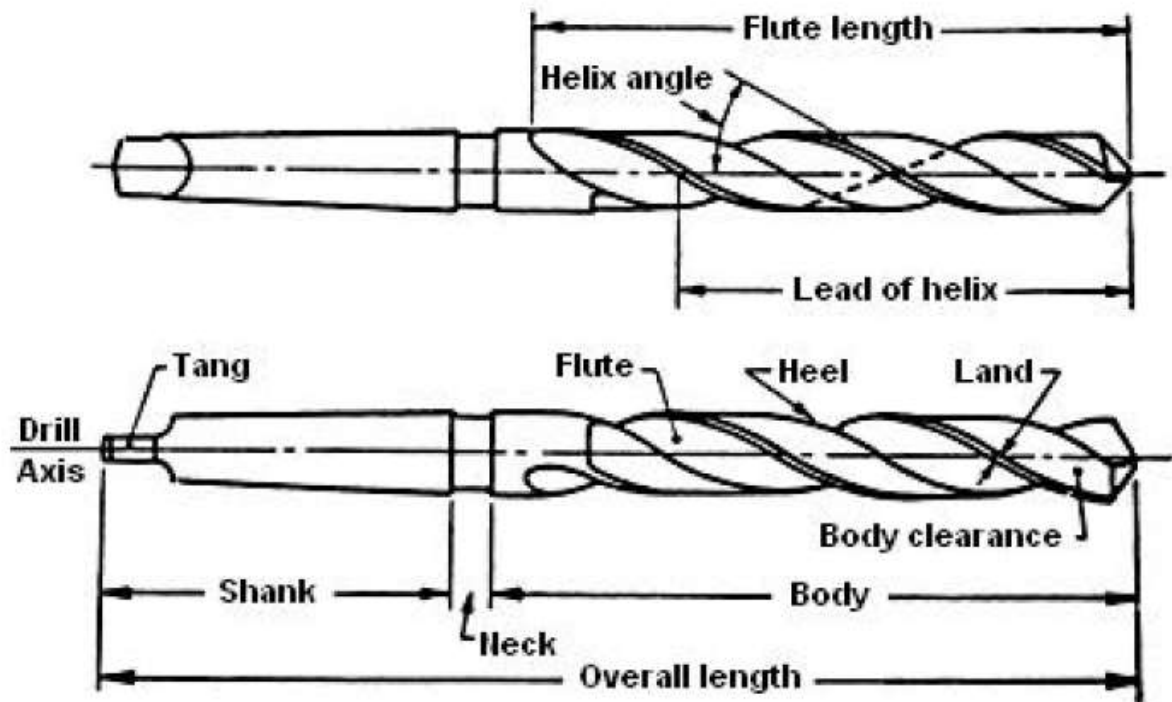


Fig. 3.127 Twist drill nomenclature

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.

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:

To form the cutting edges.

To allow the chips to escape.

To cause the chips to curl.

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.

Lip (cutting edge) The edge formed by the intersections of the flank and face.

The requirements of the drill lip are:

Both lips should be at the same angle of inclination (59°) with the drill axis.

Both lips should be of equal length.

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, which is shaped to produce lips, faces, flanks and chisel edge.

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.

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 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

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 the 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 points 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 to 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.

Drill angles

Chisel edge angle The obtuse angle included between the chisel edge and the lip as viewed from the end of the drill.

Helix angle or rake angle This is the angle formed by the leading edge of the land with a plane having the axis of the drill.

Point angle This is the angle included between the two lips.

Lip clearance angle The angle formed by the flank and a plane at right angles to the drill axis.

3.17 Operations performed

The wide range of applications of drilling machines includes:

Drilling machines are generally or mainly used to originate through or blind straight cylindrical holes in solid rigid bodies and/or enlarge (coaxially) existing holes:

Of different diameters up to 40 mm.

Of varying length depending upon the requirement and the diameter of the drill.

In different materials excepting very hard or very soft materials like rubber, polythene etc. Originating stepped cylindrical holes of different diameter and depth. Making rectangular section slots by using slot drills having 3 or 4 flutes and 180° cone angle. Boring, after drilling, for accuracy and finish or prior to reaming. Counter boring, countersinking, chamfering or combination using suitable tools. Spot facing by flat end tools. Trepanning for making large through holes and or getting cylindrical solid core.

If necessary Reaming is done on drilled or bored holes for accuracy and good surface finish. Different types of reamers of standard sizes are available for different applications.

Also used for cutting internal threads in parts like nuts using suitable attachment.

The different operations that can be performed in a drilling machine are shown in Fig. 3.128.

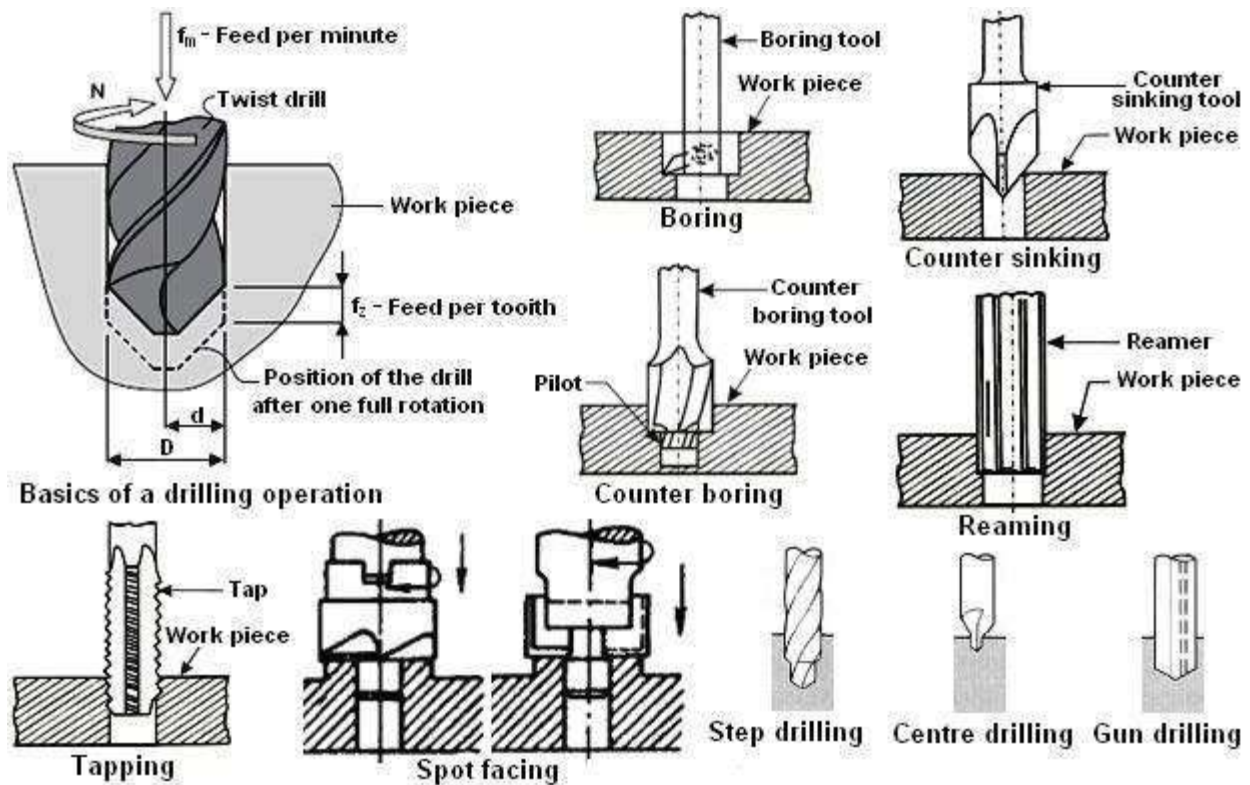


Fig. 3.128 Different operations performed in a drilling machine

REAMING

Reaming is an operation of finishing a hole previously drilled to give a good surface finish and an accurate dimension. A reamer is a multi tooth cutter which rotates and moves axially into the hole. The reamer removes relatively small amount of material. Generally the reamer follows the already existing hole and therefore will not be able to correct the hole misalignment. Fig. 3.129 illustrates the elements of a reamer. Fig. 3.130 shows the different types of reamers of standard sizes.

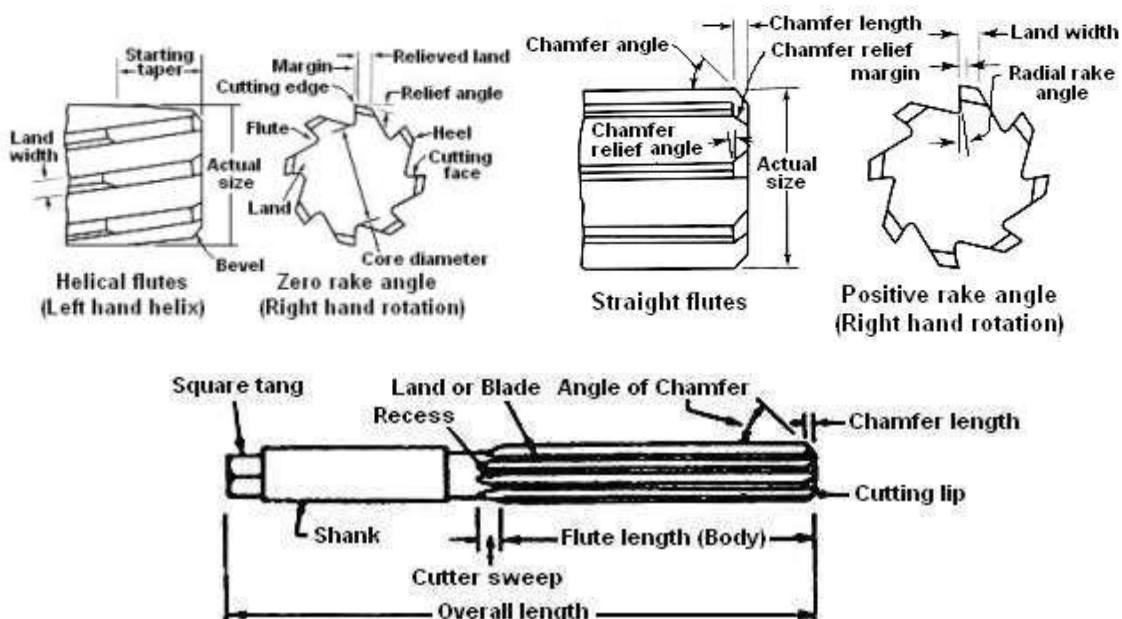


Fig. 3.129 Elements of a reamer

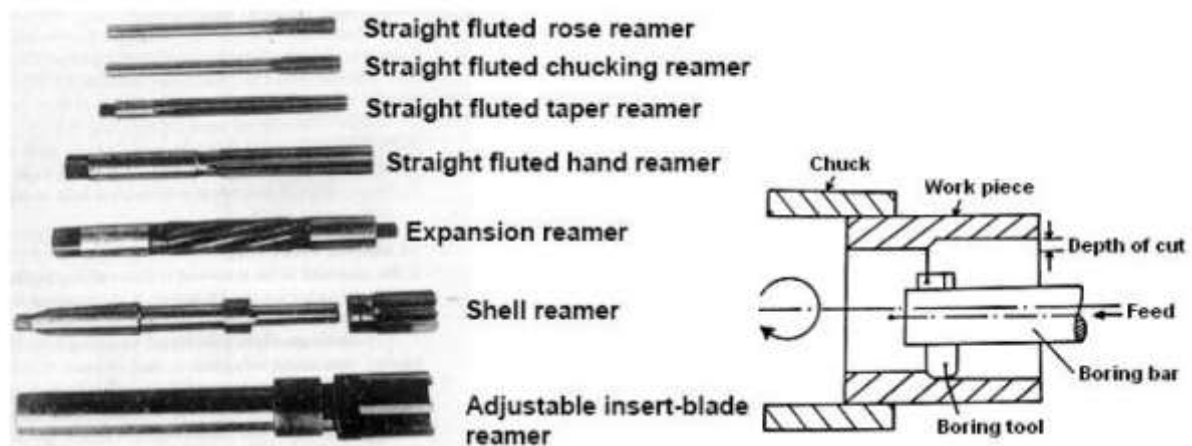


Fig. 3.130 Different types of reamers Fig. 3.131 Principle of boring operation

Reaming

Reaming has been defined as a machining process that uses a multi-edged fluted cutting tool to smooth, enlarge or accurately size an existing hole. Reaming is performed using the same types of machines as drilling.

A reamer is a rotary cutting tool with one or more cutting elements used for enlarging to size and contour a previously formed hole. Its principal support during the cutting action is obtained from the workpiece.

Reamer nomenclature

Here's the basic construction and nomenclature of reamers. The illustration shows the most frequently used style for holes up to 1", called a chucking reamer.

Solid reamers do almost all their cutting with the 45-degree chamfered front end. The flutes guide the reamer and slightly improve the finish. Therefore, reamers should not be used for heavy stock removal.

Axis: The axis is the imaginary straight line that by rotating the reamer between centers.

Back taper: The back taper is a slight decrease in diameter, from front to back in the flute length of reamers.

Body: The body is: 1) The fluted full diameter portion of a reamer, inclusive of the chamfer, starting taper and bevel; 2) the principal supporting member for a set of reamer blades, usually including the shank.

Chamfer: The chamfer is the angular cutting portion at the entering end of a reamer.

Chamfer length: The chamfer length is the length of the chamfer measured parallel to the axis at the cutting edge.

Chamfer relief angle: The chamfer relief angle is the axial relief angle at the outer corner of the chamfer. It is measured by projection into a plane tangent to the periphery at the outer corner of the chamfer.

Clearance: Clearance is the space created by the relief behind the cutting edge or margin of a reamer.

Cutting edge: The cutting edge is the leading edge of the land in the direction of rotation for cutting.

Flutes: The flutes are longitudinal channels formed in the body of the reamer to provide cutting edges, permit passage of chips, and allow cutting fluid to reach the cutting edges.

Flute length: Flute length is the length of the flutes not including the cutter sweep.

Land: The land is the section of the reamer between adjacent flutes.

Margin: The margin is the unrelieved part of the periphery of the land adjacent to the cutting edge.

Neck: The neck is a section of reduced diameter connecting shank to body, or connecting other portions of the reamer.

Overall length: The overall length is the extreme length of the complete reamer from end to end, but not including external centers or expansion screws.

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

Straight shank: A straight shank is a cylindrical shank.

Taper shank: A taper shank is a shank made to fit a specified (conical) taper socket.

Types of reamers

Reamers are made with three shapes of flutes and all are standard.

Straight flute: Straight flute reamers are satisfactory for most work and the least expensive, but should not be used if a keyway or other interruption is in the hole.

Right-hand spiral: Right-hand spiral fluted reamers give freer cutting action and tend to lift the chips out of the hole. They should not be used on copper or soft aluminum because these reamers tend to pull down into the hole.

Left-hand spiral: Left-hand spiral fluted reamers require slightly more pressure to feed but give a smooth cut and can be used on soft, gummy materials, since they tend to be pushed out of the hole as they advance. It is not wise to use these in blind holes, because they push the chips down into the hole.

All reamers are used to produce smooth and accurate holes. Some are turned by hand, and others use machine power.

1: Hand Reamer:

These reamers are operated by hand with a tap wrench fitted on the sequence of the reamer. The work is held in a vice. The flutes may be straight or helical. Shank is straight with a square tang for the wrench.

2: Machine Reamer;

These are similar to hand reamer, except that the shank is tapered.

3: Chucking Reamers:

These are machine reamers with shorter flutes. These may be either of the type known as rose reamers or fluted reamers. These are used for heavy roughing cuts.

4: Fluting Reamers:

These holders are not rigid but are fluting this permits the reamer. To follow the previously made hole naturally and without restraint resulting in a better hole.

5: Expanding Reamers:

These reamers allow slight increase in their size to allow for wear to remove an extra amount of material. For this the body of the reamers is bored tapered and is slitted. A taper plug runs through the hole end is operated by a screw so that it acts as the expander.

6: Adjustable Reamers:

In these reamers separate blades are inserted in the grooves provided in the body of the reamer. The blades can be moved up or down of the reamer.

7: Tapered Reamers:

These reamers are used to finish the taper holes for cutting the taper things used to secure the collars, pulleys etc to the shaft.

8: Shell Reamers:

Solid reamers (upto about 20mm diameter or usually made of Hss) to reduce the cost of larger reamers the cutting portion is made as separate shell which are mounted on standard shanks made of lower cost steel. These reamers are however do not very rigid and accurate inserted tooth or plates in shells in further reduced the cost of reamers can tip with cemented carbides.

Operating conditions

In reaming, speed and feed are important; stock removal and alignment must be considered in order to produce chatter-free holes. Reaming speeds Speeds for machine reaming may vary considerably depending in part on the material to be reamed, type of machine, and required finish and accuracy. In general most machine reaming is done at about 2/3 the speed used for drilling the same material.

Reaming feeds: Feeds for reaming are usually much higher than those used for drilling, often running 200 to 300 percent of drill feeds. Too low a feed may result in excessive reamer wear. At all times it is necessary that the feed be high enough to permit the reamer to cut rather than to rub or burnish.

Too high a feed may tend to reduce the accuracy of the hole and may also lower the quality of the finish. The basic idea is to use as high a feed as possible and still produce the required finish and accuracy.

Stock to be removed: For the same reason, insufficient stock for reaming may result in a burnishing rather than a cutting action. It is difficult to generalize on this phase as it is tied in closely with type of material, feed, finish required, depth of hole and chip capacity of the reamer.

Alignment: In the ideal reaming job, the spindle, reamer, bushing, and hole to be machined are all in perfect alignment. Any variation from this tends to increase reamer wear and detracts from the accuracy of the hole. Tapered, oversize, or bell-mouthed holes should call for a check of alignment. Sometimes the bad effects of misalignment can be reduced through the use of floating or adjustable holders. Quite often if the user will grind a slight back taper on the reamer it will also be of help in overcoming the effects of misalignment.

Chatter: The presence of chatter while reaming has a very bad effect on reamer life and on the finish in the hole. Chatter may be the result of one of several causes, some of which are listed:

- Excessive speed;
- Too much clearance on reamer;
- Lack of rigidity in jig;
- Insecure holding of work;
- Excessive overhang of reamer or spindle;
- Too light a feed.

Reaming operations can be performed on lathes, drills and machining centers.

3.12 BORING

Boring is an operation of enlarging and locating previously drilled holes with a single point cutting tool. The machine used for this purpose is called boring machine. The boring machine is one of the most versatile machine tools used to bore holes in large and heavy parts such as engine frames, steam engine cylinders, machine housings etc. Drilling, milling and facing operations also can be performed in this machine. Screw cutting. Turning, planetary grinding and gear cutting operations also can be done by fitting simple attachments. The principle of boring operation is illustrated in Fig. 3.131.

3.12.1 Horizontal boring machines

In horizontal boring machine, the tool revolves and the work is stationary. A horizontal boring machine can perform boring, reaming, turning, threading, facing, milling, grooving, recessing and many other operations with suitable tools. Work pieces which are heavy, irregular, unsymmetrical or bulky can be conveniently held and machined. This machine has two vertical columns. A headstock slides up and down in one column. It may be adjusted to any desired height and clamped. The headstock holds the cutting tool. The cutting tool revolves in the headstock in

horizontal axis. A sliding type bearing block is provided in the other vertical column. It is used to support the boring bar. The work piece is mounted on the table and is clamped with ordinary strap clamps, T-slot bolts and nuts, or it is held in a special fixture if so required. Various types of rotary and universal swiveling attachments can be installed on the horizontal boring machines table to bore holes at various angles in horizontal and vertical planes. Fig. 3.132 schematically shows the basic configuration of a horizontal boring machine.

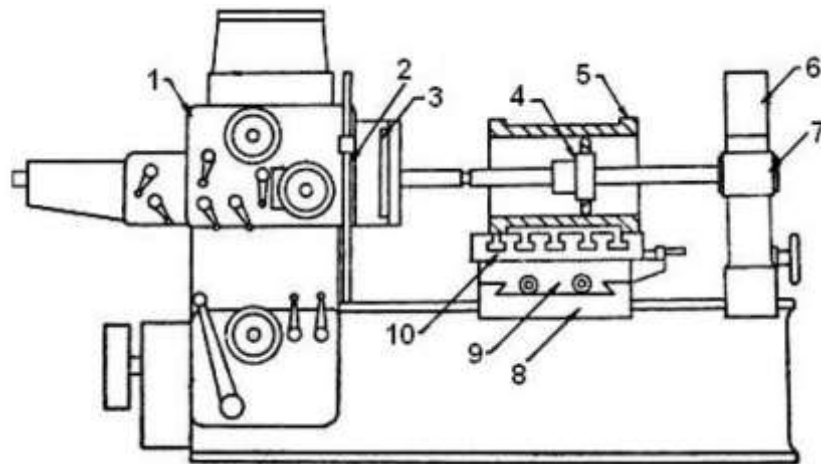


Fig. 3.132 Basic configuration of a horizontal boring machine

1. Head stock
2. Head stock elevating screw
3. Boring head
4. Boring tool on boring bar
5. Work piece
6. End supporting column
7. Bearing block
8. Saddle
9. Coss slide
10. Work table

3.12.2 Types of horizontal boring machine

Different types of horizontal boring machines have been designed to suit different purposes.

They are:

3.12.2.1 Table type horizontal boring machine

The work is held stationary on a coordinate work table having in and out as well as back and forth movements that is perpendicular and parallel to the spindle axis. The spindle carrying the tool can be fed axially. Alternatively, the table travels parallel to the spindle axis (longitudinal feed). This method of boring with longitudinal feed of the table is employed when holes are of considerable length and being bending of the boring bar is possible. Fig. 3.133 shows the table type horizontal boring machine.

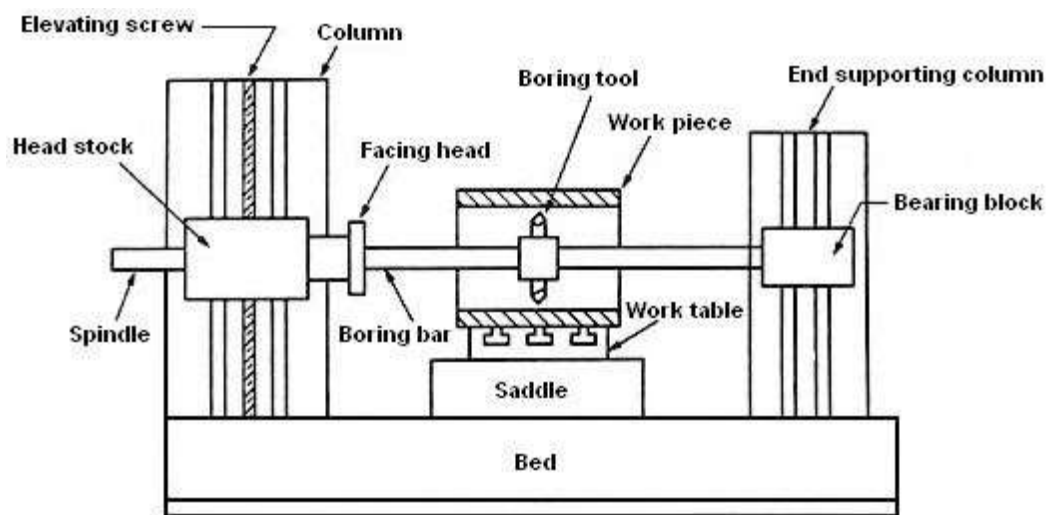


Fig. 3.133 Table type horizontal boring machine

3.12.2.2 Planer type horizontal boring machine

This machine is similar to the table type horizontal boring machine except that the work table has only in and out movements that is perpendicular to the spindle axis. Other features and applications of this machine are similar to the table type horizontal boring machine. This type of machine is suitable for supporting a long work. Fig. 3.134 shows the planer type horizontal boring machine.

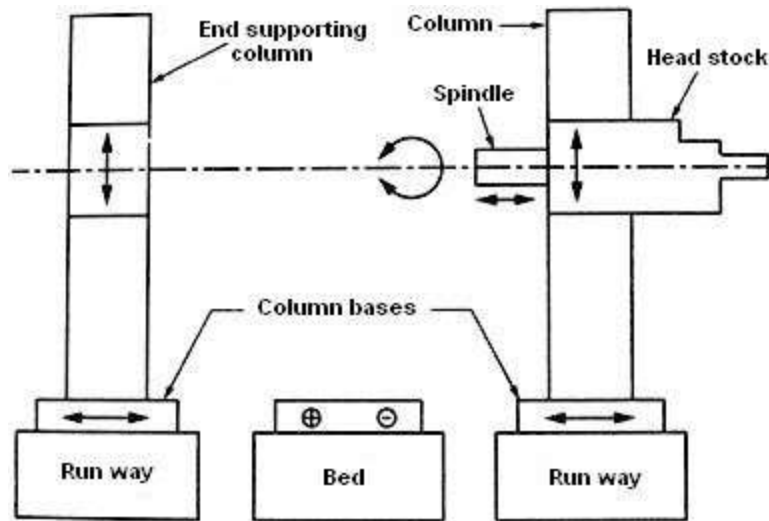


Fig. 3.134 Planer type horizontal boring machine

3.12.2.3 Floor type horizontal boring machine

Here, there is no work table and the job is mounted on a stationary T-slotted floor plate. This design is used when large and heavy jobs can not be mounted and adjusted on the work table. Horizontal movement perpendicular to the spindle axis is obtained by traversing the column carrying the head stock, on guide ways. Fig. 3.135 shows the floor type horizontal boring machine.

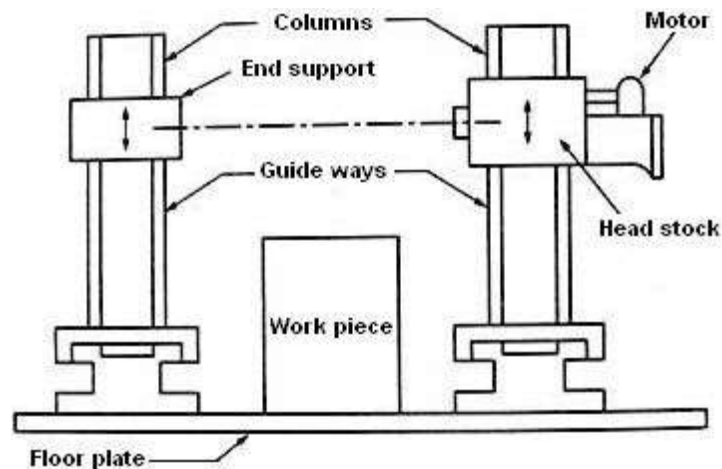


Fig. 3.135 Floor type horizontal boring machine

3.12.2.4 Multiple head type horizontal boring machine

The machine resembles a double housing planer or a Plano-miller and is used for boring holes of large diameter in mass production. The machine may have two, three or four headstocks. This type of machine may be used both as a horizontal and vertical machine. Fig. 3.136 shows the multiple head type horizontal boring machine.

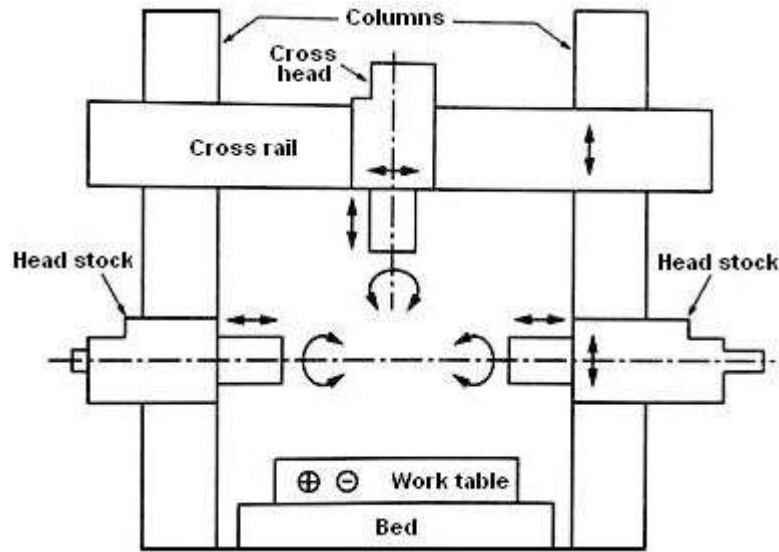


Fig. 3.136 Multiple head type horizontal boring machine

3.12.3 Vertical boring machines

For convenience, parts whose length or height is less than the diameter are machined on vertical boring machines. The typical works are: Large gear blanks, locomotive and rolling stock tires, fly wheels, large flanges, steam and water turbine castings etc. On a vertical boring machine, the work is fastened on a horizontal revolving table, and the cutting tool(s) which are stationary, advance vertically into it as the table revolves.

There are two types of vertical boring machine: Single column vertical boring machine and double column vertical boring machine. The single column vertical boring machine looks like a drilling machine or a knee type vertical milling machine. Guide ways are employed on the column to support the spindle head in the vertical direction. A double column vertical boring machine is shown in Fig. 3.137. The work is accommodated on the horizontal revolving table at the front of the machine. The circular work can be clamped on to the table with the help of jaw chucks whereas the T-slots can be used with bolts and clamps for setting up and holding irregular work. A horizontal cross rail is carried on vertical slideways and carries the tool holder slide(s). On machines designed for working on large batches of identical parts, a single slide with turret may be employed. Fig. 3.138 shows the turret boring machine.

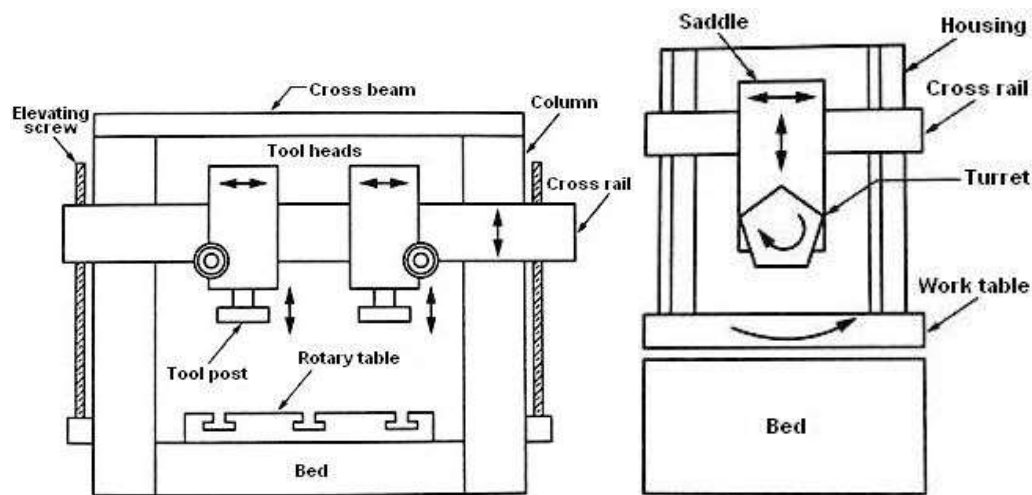


Fig. 3.137 Double column vertical boring machine Fig. 3.138 Turret boring machine

3.12.5 Boring tools

A boring tool consists of a single point cutting tool (boring bit) held in a tool holder known as boring bar. The boring bit is held in a cross hole at the end of the boring bar. The boring bit is adjusted and held in position with the help of set screws. The material of the boring bit can be: Solid HSS, solid carbide, brazed carbide, disposable carbide tips or diamond tips. Boring tools are of two types: fixed type and rotating type. Fixed type boring tools are used on working rotating machines such as lathes, whereas rotating type boring tools are used on tool rotating machines such as drilling machines, milling machines and boring machines. Fig. 3.140 shows the different types of boring tools (bars).

3.13 TAPPING

Tapping has been defined as: A process for producing internal threads using a tool (tap) that has teeth on its periphery to cut threads in a predrilled hole. A combined rotary and axial relative motion between tap and workpiece forms threads.

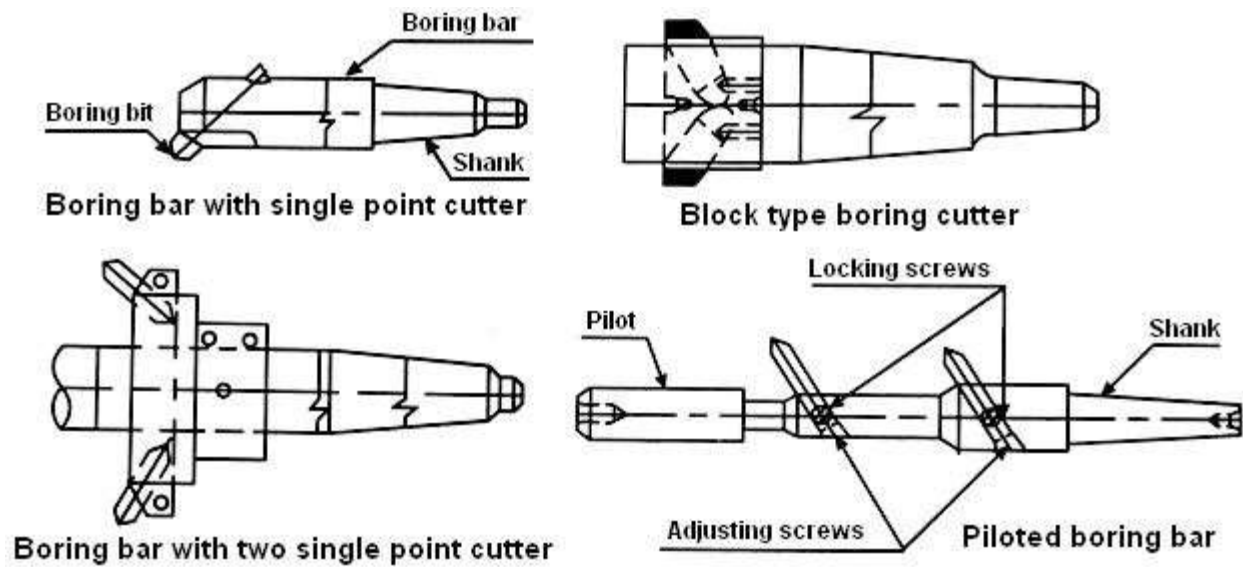


Fig. 3.140 Different types of boring tools (bars)

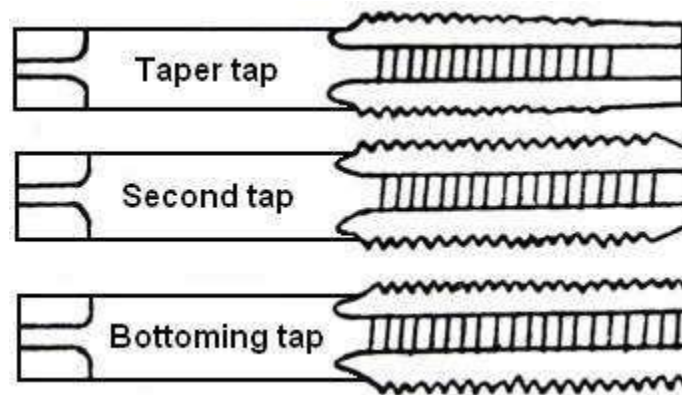


Fig. 3.141 Hand (solid) taps

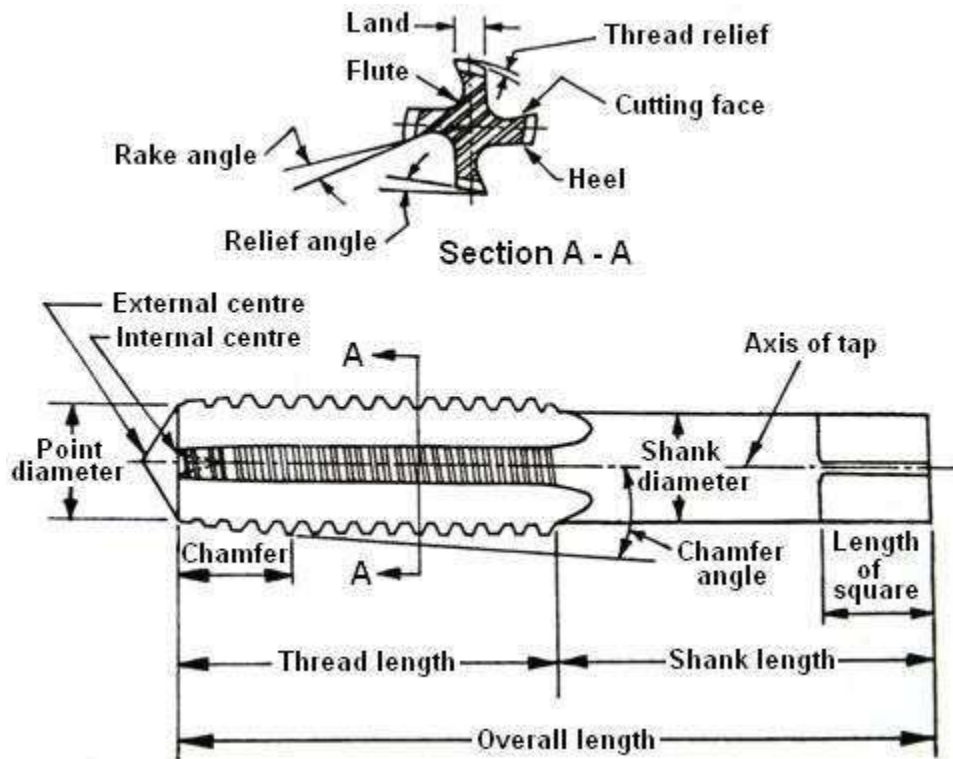


Fig. 3.142 Elements of a solid tap

Screw threads have many dimensions. It is important in modern manufacturing to have a working knowledge of screw thread terminology. A "right-hand thread" is a screw thread that requires right-hand or clockwise rotation to tighten it. "Thread fit" is the range of tightness or looseness between external and internal mating threads. "Thread series" are groups of diameter and pitch combinations that are distinguished from each other by the number of threads per inch applied to a specific diameter. The two common thread series used in industry are the coarse and fine series, specified as UNC and UNF.

Tap nomenclature

Chamfer: Chamfer is the tapering of the threads at the front end of each land of a chaser, tap, or die by cutting away and relieving the crest of the first few teeth to distribute the cutting action over several teeth.

Crest: Crest is the surface of the thread which joins the flanks of the thread and is farthest from the cylinder or cone from which the thread projects.

Flank: Flank is the part of a helical thread surface which connects the crest and the root, and which is theoretically a straight line in an axial plane section.

Flute: Flute is the longitudinal channel formed in a tap to create cutting edges on the thread profile and to provide chip spaces and cutting fluid passage.

Hook angle: The hook angle is the angle of inclination of a concave face, usually specified either as "chordal hook" or "tangential hook."

Land: The land is one of the threaded sections between the flutes of a tap.

Lead of thread: The lead of thread is the distance a screw thread advances axially in one complete turn. On a single start tap, the lead and pitch are identical. On a multiple start tap the lead is the multiple of the pitch.

Major diameter: This is the diameter of the major cylinder or cone, at a given position on the axis that bounds the crests of an external thread or the roots of an internal thread.

Minor diameter: Minor diameter is the diameter of the minor cylinder or cone, at a given position on the axis that bounds the roots of an external thread or the crests of an internal thread.

Pitch diameter: Pitch diameter is the diameter of an imaginary cylinder or cone, at a given point on the axis of such a diameter and location of its axis, that its surface would pass through the thread in a manner such as to make the thread ridge and the thread groove equal and, as such, is located equidistant between the sharp major and minor cylinders or cones of a given thread form. On a theoretically perfect thread, these widths are equal to one half of the basic pitch (measured parallel to the axis).

Spiral point: A spiral point is the angular fluting in the cutting face of the land at the chamfered end. It is formed at an angle with respect to the tap axis of opposite hand to that of rotation. Its length is usually greater than the chamfer length and its angle with respect to the tap axis is usually made great enough to direct the chips ahead of the tap. The tap may or may not have longitudinal flutes.

Square: Square is the four driving flats parallel to the axis on a tap shank forming a square or square with round corners.

Types of taps

Hand Taps: Today the hand tap is used both by hand and in machines of all types. This is the basic tap design: four straight flutes, in taper plug, or bottoming types. The small, numbered machine screw sizes are standard in two and three flutes depending on the size.

If soft and stringy metals are being tapped, or if horizontal holes are being made, either two- or three-flute taps can be used in the larger sizes. The flute spaces are larger, but the taps are weaker. The two-flute especially has a very small cross section.

The chips formed by these taps cannot get out; thus, they accumulate in the flute spaces. This causes added friction and is a major cause of broken taps.

Spiral point tap: The spiral point or "gun" tap is made the same as the standard hand tap except at the point. A slash is ground in each flute at the point of the tap. This accomplishes several things:

- The gun tap has fewer flutes (usually three), and they are shallower. This means a stronger tap.
- The chips are forced out ahead of the tap instead of accumulating in the flutes, as they will with a plug tap.
- Because of these two factors, the spiral point tap can often be run faster than the hand tap, and tap breakage is greatly reduced.

This tap has, in many cases, replaced the "standard" style in industry, especially for open-ended trough holes in mild steel and aluminum. Both regular and spiral-point taps are made in all sizes including metric.

Spiral flute tap: The spiral flute-bottoming tap is made in regular and fast spirals, that is, with small or large helix angle. They are sometimes called "helical-fluted" taps. The use of these taps has been increasing since they pull the chip up out of the hole and produce good threads in soft metals (such as aluminum, zinc, and copper), yet also work well in Monel metal, stainless steel and cast steel. They are made in all sizes up to 1 1/2" and in metric sizes up to 12 mm.

While the "standard" taps will efficiently do most work, if a great deal of aluminum, brass, cast iron or stainless steel is being tapped, the manufacturer can supply "standard" specials that will do a better job.

Pipe taps: General Purpose Pipe Taps are used for threading a wide range of materials both ferrous and non-ferrous. All pipe taps are supplied with 2 1/2 to 3 1/2 thread chamfer. The nominal size of a pipe tap is that of the pipe fitting to be tapped, not the actual size of the tap. Ground Thread Pipe Taps are standard in American Standard Pipe Form (NPT) and American Standard Dryseal Pipe Form (NPTF). NPT threads require the use of a "sealer" like Teflon tape or pipe compound. Dryseal taps are used to tap fittings that will give a pressure tight joint without the use of a "sealer."

Fluteless taps: Fluteless taps do not look like taps, except for the spiral "threads." These taps are not round. They are shaped so that they "cold form" the metal out of the wall of the hole into the thread form with no chips. The fluteless tap was originally designed for use in aluminum, brass, and zinc alloys. However, it is being successfully used in mild steel and some stainless steels. Thus, it is worth checking for use where BHN is under 180. They are available in most sizes, including metric threads.

Collapsing Taps: These taps collapse to a smaller diameter at the end of the cut. Thus, when used on lathes of any kind, they can be pulled back rapidly. They are made in sizes from about 1 inch up, in both machine and pipe threads. They use three to six separate "chasers" which must be ground as a set. The tap holder and special dies make this assembly moderately expensive, but it is economical for medium and high production work.

Operating options

Some threads, both external and internal, can be cut with a single-point tool as previously shown. However, most frequently a die or tap of some type is used because it is faster and generally more accurate.

Taps are made in many styles, but a few styles do 90 percent of the work. The cutting end of the tap is made in three different tapers.

The "taper tap" is not often used today. Occasionally, it is used first as a starter if the metal is difficult to tap. The end is tapered about 5 degrees per side, which makes eight partial threads.

The "plug tap" is the style used probably 90 percent of the time. With the proper geometry of the cutting edge and a good lubricant, a plug tap will do most of the work needed. The end is tapered 8 degrees per side, which makes four or five incomplete threads.

The "bottoming tap" is used only for blind holes where the thread must go close to the bottom of the hole. It has only 1 1/2 to 3 incomplete threads. If the hole can be drilled deeper, a bottoming tap may not be needed. The plug tap must be used first, followed by the bottoming tap.

All three types of end tapers are made from identical taps. Size, length, and all measurements except the end taper are the same.

Material used for taps is usually high-speed steel in the M1, M2, M7 and sometimes the M40 series cobalt high-speed steels. A few taps are made of solid tungsten carbide.

Most taps today have ground threads. The grinding is done after hardening and makes much more accurate cutting tools. "Cut thread" taps are available at a somewhat lower cost in some styles and sizes.

Just like reaming operations, tapping can be performed on lathes, drills and machining centers.

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3.18 Fine Boring Machines

3.19 Jig boring machine

It is very precise vertical type boring machine. The spindle and spindle bearings are constructed with very high precision. The table can be moved precisely in two mutually perpendicular directions in a plane normal to the spindle axis. The coordinate method for locating holes is employed. Holes can be located to within tolerances of 0.0025 mm. Jig boring machines are relatively costlier. Hence, they are found only in the large machine shops, where a sufficient amount of accurate hole locating is done. Jig

boring machines are basically designed for use in the making jigs, fixtures and other special tooling. Fig. 3.139 shows the block diagram of a jig boring machine.

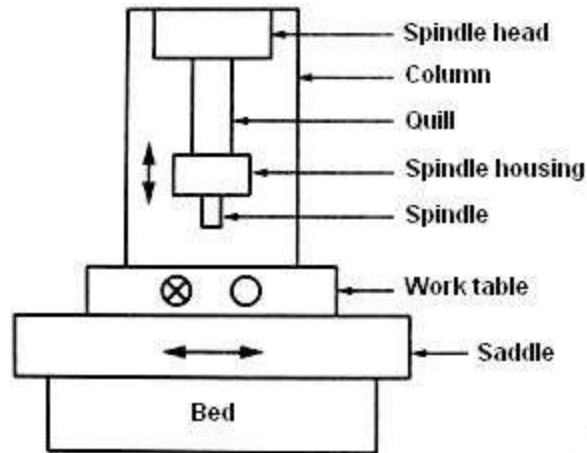


Fig. 3.139 Block diagram of a jig boring machine

Definitions

1. Cutting Speed (v):-

It's the peripheral speed of the drill. The cutting speed depends upon the properties of the material being drilled, drill material, drill diameter, rate of speed, coolant used etc...

$$v = \pi \cdot D \cdot N \text{ where}$$

D = dia of the drill in m

N = Speed of rotation in rpm

2. Feed Rate (f):-

It's the movement of drill along the axis (rpm)

3. Depth of Cut (d):-

The distance from the machined surface to the drill axis.

$$d = D / 2$$

As the depth of hole increases, the chip ejection becomes more difficult and the fresh cutting fluid is not able to cutting zone. Hence for machining the lengthy hole special type of drill called 'gun drill' is used.

4. Material Removal Rate:-

It's the volume of material removed by the drill per unit time

$$MRR = (\pi D^2 / 4) * f * N \text{ mm}^3 / \text{min}$$

5. Machining Time (T) :-

It depends upon the length (L) of the hole to be drilled , to the Speed (N) and feed (f) of the drill

$$t = L / f N \text{ min}$$

Precautions for Drilling machine

- Lubrication is important to remove heat and friction.
- Machines should be cleaned after use
- Chips should be removed using brush.
- T-slots, grooves, spindles sleeves, belts, and pulley should be cleaned.
- Machines should be lightly oiled to prevent from rusting

Safety Precautions

- Do not support the work piece by hand – use work holding device.
- Use brush to clean the chip
- No adjustments while the machine is operating
- Ensure for the cutting tools running straight before starting the operation.
- Never place tools on the drilling table
- Avoid loose clothing and protect the eyes.
- Ease the feed if drill breaks inside the work piece.

Problems

1. Calculate the speed of the drill bit to drill a hole of dia 20mm where the cutting speed is 25mts/min.

$$N \text{ [rpm]} = (\pi * D * N) / 1000$$

$$= (25 * 1000) / (\pi * 20)$$

$$= 397.8 \text{ rpm}$$

2. The dia of one end of a taper plug is 150mm and dia of the other end is 80mm and the length is 300mm. Calculate its taper.

$$\text{Taper per mm} = (D-d)/L$$

$$= (150-80) / 300$$

$$= 0.233 \text{ mm}$$

3. . The dia of one end of a taper plug is 150mm and dia of the other end is 80mm and the length is 300mm. Calculate its taper angle.

$$\tan \alpha/2 = (D-d)/2 L$$

$$= (150-80)/ 2*300$$

$$= 6.65^\circ$$

Review Questions:

Part – A

1. What is meant by drilling?
2. Which tool is commonly used for drilling?
3. Name the different types of drilling machine?
4. What is meant by hand feed?
5. What is meant by power feed?
6. What are the salient features of radial drilling machine?
7. What are the different ways to mount the drilling tool?
8. Name the different types of drilling operations?
9. What is meant by reaming?
10. What is boring?
11. What is the difference between reaming and boring?
12. What is counter boring?
13. What is countersinking?
14. What is the purpose of tapping operation?
15. Name some work holding devices?

Part – B

1. Explain with neat sketch the salient features of radial drilling machine?
2. Draw and explain the working principle of upright drilling machine?
3. With neat sketch describe the nomenclature of twist drill?
4. Discuss in detail with diagram the various operations that can be performed in drilling machine