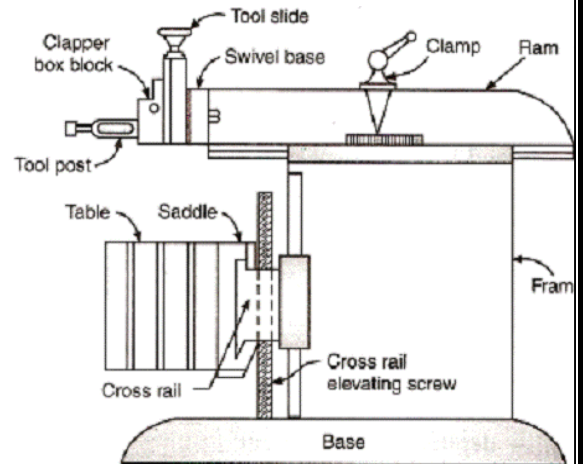


UNIT-3

SHAPER

WORKING PRINCIPLE:

The job is rigidly held in a vice or clamped on a machine table. The tool is held in tool post mounted on the ram of the machine. The ram reciprocates to and fro and in doing so, makes the tool to cut the material in the forward stroke. No cutting of material takes place, during the return stroke of the ram. Hence it is called idle stroke. In case of draw-cut shaper, the cutting takes place in the return stroke and forward stroke is idle stroke. The job is given an indexed feed in a direction normal to the line of action of the cutting tool.



PRINCIPAL PARTS:

- 1. Base:** It is a heavy and robust cast iron body which acts as a support for all other parts of the machine, which are mounted over it.
- 2. Column:** It is a box type cast Iron body, mounted on the base and acts as housing for the operating mechanism of the machine, and the electricals. It also acts as a support for other parts of the machine such as cross rail and ram, etc. On its top it carries a machined ways, in which ram reciprocates and vertical guide ways at its front.
- 3. Cross-rail:** It is a heavy cast Iron construction, attached to the column at its front on the vertical guide ways. It carries two mechanisms, one for elevating the table and the other for across traverse of the table.
- 4. Table:** It is made of cast Iron and has a box type construction. It holds and supports the work during the operation and slides along the cross-rail to provide feed to the work. T-slots are provided on its top and sides for securing the work to it.
- 5. Ram:** It is also an Iron casting, semi circular in shape and provided with a ribbed construction inside for rigidity and strength. It carries the tool head and travels in dove tail guide ways to provide a straight line motion to the tool. It carries the mechanism for adjustment of ram position inside it.
- 6. Toolhead:** It is the device to hold the tool. It can slide up and down and can be swung to a desired angle to set the tool at a desired position for the operation.
- 7. Vice:** It is a job holding device and is mounted on the table. It holds and supports the work during the operation. Alternatively, the job can be directly clamped to the machine table.

SIZE AND SPECIFICATIONS

The size of the shaper is determined by the maximum length of cut or stroke it can make. A standard shaper is usually capable of holding and machining a cube of the same dimensions as the length of stroke. The length of stroke is always the principal dimension, but a number of other details are also required to specify a shaper fully. Complete specifications of a 300 mm stroke shaper are as follows.

1. Length of stroke	300mm
2. Max. Horizontal travel of table	350mm
3. Max. Vertical travel of table	365mm
4. Max. Distance from table to ram	12mm
5. Max. Vertical travel of tool slide	117mm
6. Length and width of table top	300×250mm
7. Length and depth of table side	241×317mm
8. Power of Motor	2/2HP OR 1.5/1.5kw
9. No. of ram cycles per minimum	6
10. Range of ram cycle per minimum	21 to 22 mm
11. Toolbox take size of tool	16×22mm
12. Max. Vice opening	152mm
13. Approximate Weight	700kg
14. Floor space	1350×90mm

CLASSIFICATION OF SHAPERS

Shapers are classified in many ways, i.e. according to length of stroke, type of driving mechanism, direction of travel of ram, the type of work they do, the type of design of table etc. The main classification is as follows:

1. Standard Shaper: It consists of a plain table, major may not have the vertical supports at its front. In some machines there is a provision for the table to swivel around horizontal axis, parallel to ram. This enables machining of inclined flat surfaces. Material is cut in the forward stroke of the tool and the return stroke is idle. It is also known as plain shaper.

2. Draw-cut Shaper: It is similar to standard shaper, but is comparatively much heavier and the metal cutting operation takes place during the return stroke of the ram i.e. in moving towards the column. Its heavy construction enables heavier cuts with less vibration.

3. Horizontal Shaper: It is a very popular shaper in which the ram and tool reciprocates in horizontal plane. Normally used to machine flat surfaces.

4. Universal Shaper: It is a horizontal type shaper but its table can be swung about a horizontal axis parallel to ram ways. The top of this table can be tilted about another horizontal axis which is normal to the former axis. If a swivel vice is fitted to this table the work can be rotated about three possible axes. Machining of surfaces can be taken up in different planes and the machine is very useful for tool-room work.

5. Vertical Shaper: This shaper has its ram reciprocating in a vertical direction. The table is of circular, rotary type. The ram of vertical shaper can be adjusted 10° on either side of vertical, enabling machining of inclined surfaces also.

6. Geared Shaper: This classification is according to the type of driving mechanism. This type of shaper carries a rake under its arm which is driven by spur gear (pinion). This has become obsolete.

Shaping Width B = Width of work piece + 2 × allowance

$$\text{No. of Cycles required}(\eta) = \frac{\text{Shaping Width}(B)}{\text{Feed per cycle}(f)} = \frac{B}{f} \quad (f = \text{feed per cycle in mm})$$

Machining time = no. of cycle

Machining time = no. of cycles × Time required for each cycle

$$= \frac{B}{f} \times \frac{L(1+k)}{V_1} = \frac{L \times B (1+k)}{f \times V_1} \text{ min}$$

PLANING MACHINES

Planing is machining of large flat surfaces. These surfaces may be horizontal, vertical or inclined. The function of a planing machine is similar to that of a shaper except that the planer is basically designed to undertake machining of large and heavy jobs which are impracticable to be machined on shaper or milling machine etc. Planing machine is the most economical for machining large flat surfaces. Planing machine is different from a shaper in that for machining, the work, loaded on the table, reciprocates past the stationary tool in a planer, whereas in shaper the tool reciprocates past the stationary work.

WORKING PRINCIPLE:

It is almost a reverse case to that of a shaper. The work is rigidly held on the work table of the machine. The tool is held vertically in tool head mounted on the cross-rail. The work table, together with the job is made to reciprocate past the vertically head tool. The indexed feed, after each cut, is given to the tool during the idle stroke of the table.

PRINCIPAL PARTS:

1. Bed: It is a very large and heavy cast iron structure with cross ribs for additional strength and stiffness as it supports the whole structure of the machine over it. It is about two times longer than the table it carries over it. At its top it carries either v-ways or flat ways to support and guide the table. All the ways are straight, parallel and constantly lubricated with pressure lubrication at several points along the ways.

2. Table: It is made of Cast Iron with accurately machined top. It is a box type construction with ribs under it to make it strong to support heavy work over it. At its top, it carries longitudinal T-slots and holes to accommodate the clamping bolts and other devices to hold the work. Under the table, chip pockets are cast integral with it for collecting and removing the chips.

3. Housings or Columns: The columns are vertical members, situated on both sides in case of a double housing planer and on one side only in case of an open side planer. Inside them, they carry the different mechanisms for transmission of power to the upper part of machine, from the main drive, viz. cross-rail elevating screws, vertical feed shaft and cross feed bar etc.

4. Cross-rail: It is a horizontal member of a heavy structure connecting the two vertical columns of the machine. It provides additional rigidity to the machine. By means of elevating screws it can be moved up and down along the ways on the columns. Clamps are provided to lock the cross-rail in any desired position along the columns. A suitable device is incorporated to ensure that the cross-rail is perfectly horizontal before clamping. The cross-rail is moved up or down uniformly on both ends, both the elevating screws are rotated simultaneously by horizontal shaft, mounted on the top of the machine through bevel gears. Ways are provided at the front of the cross-rail for the two vertical tool heads. Inside the rail are provided the feed rods for vertical power feed and cross feed to the tools. The rail is made sufficiently long, to project on both sides of columns, so that, one of the two tool

heads can be pushed out to one end. This will enable the other tool head to travel freely cross-wise from one end of the table to the other, covering entire width of the job.

5. Tool Heads: The planer tool heads, both in construction and operation resembles the shaper toolheads. Four toolheads can be fitted in a planer and any or all of them can be used at a time. Two tool heads can be fitted in vertical position on the cross-rail and the other two on the vertical columns. Each column carries one side tool head.

The method of mounting is similar for all the tool heads. First the saddles are mounted on the horizontal ways of the cross-rail (for vertical tool heads) and vertical ways of the columns (for side tool heads) these saddles further carry machined ways at their front, on which tool heads are mounted. All the four tool heads work independently, simultaneously.

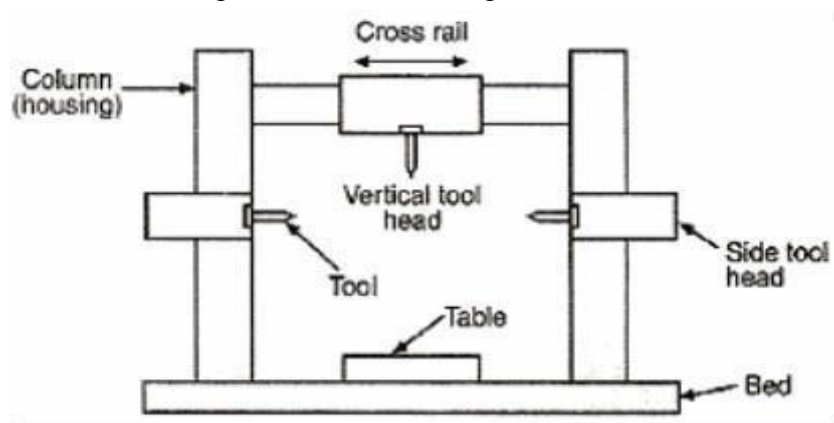
The tool heads on the cross-rail can travel horizontally, along the rail. They can also be raised or lowered by moving cross-rail up or down. The tools can be fed down wards by rotating the down feed screw. Similarly the side tool heads can move up and down along the vertical column ways. Their tools can be fed horizontally in to the job or at desired inclination. A swivel plate incorporated between the slide and saddle. This enables the tool head swivel through an angle of 70° on either side from its normal position. Both hand feeds and power feeds can be used, but power feeds are commonly used.

6. Controls: Various controls for starting, operating and stopping the various mechanisms, automatic cutting off speed and regulation and similar other functions are provided with in quick approach of the operator of the machine.

SPECIFICATIONS:

Planers are made in different sizes, the main specifications are

1. Horizontal distance between the two vertical columns or housings.
2. Vertical distance between the table top and the cross-rail when it is in top most position.
3. Maximum length of table travel or length of stroke.



TYPES OF PLANERS:

A large variety of planers of different designs and sizes are available and they are broadly classified in to the following types:

1. Standard or Double housing planer
2. Open side planer
3. Planer Miller
4. Plate planer
5. Pit planer

6. Divided table planer, and
7. Plano-Guillotine shearing machine.

1. STANDARD OR DOUBLE HOUSING PLANER:

This is most commonly used type of planer. It consists of two vertical housings or columns, one on each side of bed. The housings carry vertical machined and scraped ways. The cross rail is fitted between the two housings and carries one or two vertical tool heads. The worktable is mounted over the bed. Side tool heads are fitted on the vertical housings.

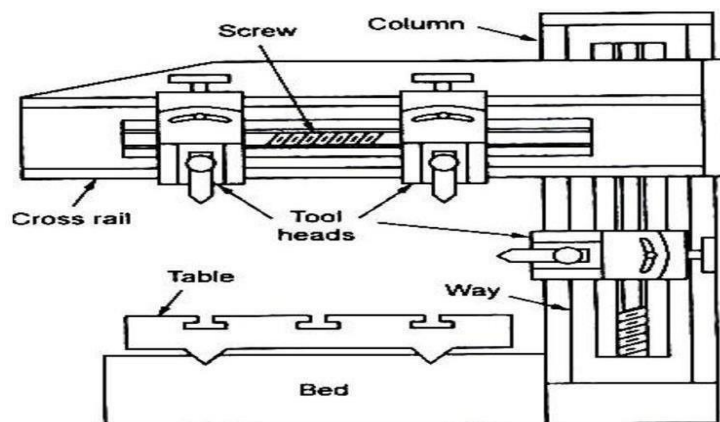
These machines are heavy duty type and have very rigid construction. They use high cutting speeds but the size of the work is limited to width table i.e. the horizontal distance between the two columns. Extremely large and heavy casting, like machine beds, tables, plates, slides of columns, it is possible to hold a number of work pieces in a series over the bed length and machine them together. This will effect in saving machining time. Because of four tool heads a number of surfaces can be machined simultaneously. Because of high rigidity of machine, robust design of cutting tools, heavier cuts can be taken, which leads to quicker metal removal and reduced machining time and hence to economical machining.

2. OPEN SIDE PLANER:

This type of planer consists of only one housing, situated vertically on one side of the bed and the other side is left open without any obstruction. The cross-rail is of cantilever type and is wholly supported on the single column. Only three tool heads can be used maximum. The other features are same as double housing planer.

The main advantage of an open side planer is its adaptability for machining components which are much wider than could pass between the housings.

OPEN SIDE PLANER



3. PLANER MILLER:

It is actually a combination of the two machines, and hence the name planer miller. It resembles a double housing planer but the conventional revolving cutters.

4. PLATE PLANER:

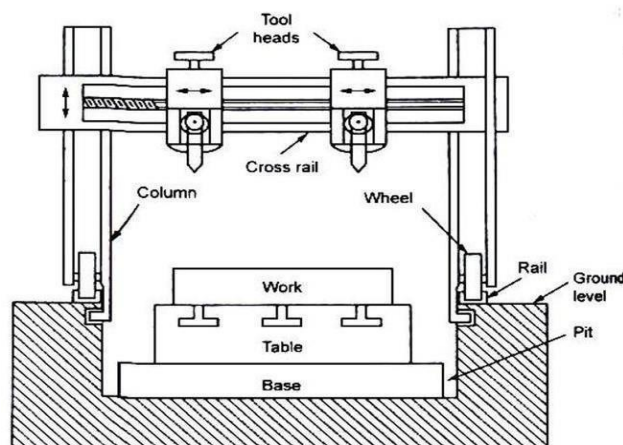
This is completely different from the conventional type both in construction and operation. The bed and the table of the plate planer are a fixed unit and the work is mounted on the table. The toolhead is mounted on a movable carriage, which can travel longitudinally along the bed. The operator also stands on a flat form attached to the carriage and travels along it during machining. The work remains stationary while the tool moves to and fro. The

tool holder can hold one or more tools at a time and can also be tilted for machining slant surfaces. It is a single purpose machine for a special work. Ex: machining edges of boiler plates, ships plates, for pipe lines and for welding.

5. PITPLANER:

This machine is especially designed for machining long, heavy and tall work, that can't be machined on the conventional type of planers. The job is mounted either on stationary table or on the floor inside a pit. The machine is provided with two short vertical housing which carry cross-rail. One or two tool heads are mounted on the cross rail and two side tool posts on the housings. This whole unit travels along the horizontal ways to and fro and thus the tool moves past the work for machining the surface. The horizontal and inclined surfaces of the work piece are machined on these planers.

PIT PLANER



6. DIVIDED TABLE PLANER:

In this machine, the table is constructed in two or more parts which can be joined together to hold a very large work. Large part of total time, spent on machining a job, is spent in its proper setting because of the difficulty in handling the work due to its heavy weight. This machine with divided table is employed such that when the work on one table is being machined, the same is being simultaneously set up on the other table in readiness for replacing after the operation is over. Thus considerable setting time is saved.

7. PLANO-GUILLOTINE SHEARING MACHINE:

It is also a special purpose machine used for cutting and preparing ends of large plates. It is provided with a traversing cutter head which carries a rotary disc cutter instead of a single point tool. The standard cutter will always cut square with the surface. Other cutters can be fitted to cut to an angle. A swiveling type of head is also provided in order to produce angular cuts. The plate is sheared off in a single traverse of the cutter head. The machine, thus gives much higher output than the conventional planer.

DRIVING MECHANISMS:

Four different methods are employed for driving the table of a planer. They are as follows:

1. Crank drive: Similar to the one used for driving the ram of a shaper. It is however obsolete now.

2. Belt drive: In this the motor drives a counter shaft, which is turn, drives the main driving shaft through belts and a set of fast and loose pulleys. This shaft drives a pinion which meshes with a rack under the machine table.

3. Direct reversible drive: In this the reversible motor, through a set of reduction gears, drives the pinion which meshes with the rack provided under the machine table.

4. Hydraulic drive: it is quite similar to the one used for driving the ram of a shaper. More than one cylinder can be used for achieving different speeds.

What ever may be the methods of drive used for a planer table, it should essentially meet the following operating requirements:

- i. It should be long lasting and its control should be easy.
- ii. It should be capable of providing several quick and safe reversals of the table continuously without any chance of break down.
- iii. It should incorporate a mechanism for faster return of the table, accurately at the same point in each stroke, without any stroke or vibrations. The return speed of the table is supposed to be 3 to 4
- iv. It should provide a fairly wide range of variable speeds.
- v. It should not unduly vary, after being set, during cutting.
- vi. It should be possible to stop the running table suddenly. Whenever desired for any purpose, and restart it instantly.
- vii. It should incorporate a mechanism for speed reduction.

CUTTING SPEED, FEED AND DEPTH OF CUT:

Frequent variations in cutting speeds are not needed and it will be considered on account of the kind of cutting tool and material to be machined. Planer is used for machining heavy jobs and obviously heavier cuts are used, with the result uses much slower speeds than most of other machines. Suitable cutting speed is selected depending upon tool material and the work. Planer usually employs a cutting speed of 6 to 15 m/min and return speed 30 m/min. a cutting speed of 25 m/min and a return speed of 45 m/min is obtained on hydraulic planers. The feed and depth of cut depends upon the material of the work, required surface finish and rigidity of the machine.

OPERATIONS DONE ON PLANER:

A planer performs the same operations as performed by a shaper, with the main difference that the work pieces handled on a planer are longer and heavier than those machined on a shaper and also the surfaces machined on a planer are much larger and wider than those produced on a shaper. The common operations performed on a planer are:

1. Machining horizontal flat surfaces.
2. Machining vertical flat surfaces.
3. Machining angular surfaces, including dove-tails.
4. Machining different types of slots and grooves.
5. Machining curved surfaces.
6. Machining along premarked contours.

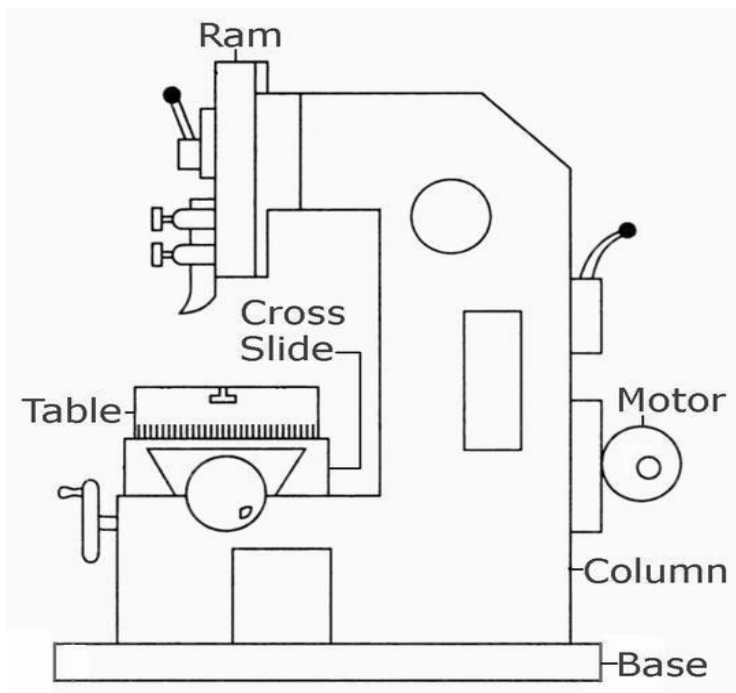
COMPARISON BETWEEN PLANER AND SHAPER

S.No	PLANER	SHAPER
1.	It is heavier, more rigid and costlier m/c.	Comparatively lighter and cheaper m/c.
2.	It requires more floor area.	Less floor area.
3.	It is used for machining large flat surfaces horizontal. Vertical and inclined.	It is also used for the same purposes but for relatively smaller surfaces.

4.	Cutting takes place by reciprocating the work under the tool.	Cutting takes place by moving the cutting tool over the job.
5.	Indexed feed is given to tool during the idle stroke of the work table.	Indexed feed is given to the work during the idle stroke of the ram.
6.	Heavier cuts and coarse feed can be used.	Very heavy cuts and coarse feeds can't be used.
7.	Four tools can be used simultaneously facilitating a faster rate of production.	Only one tool can be used on a shaper.
8.	Because of its larger stroke length and table size, number of jobs can be held in series and machined in single setting.	This is not possible on a shaper.
9.	The tools used are longer, heavier and stronger.	Tools are smaller and lighter.
10.	The work is held on the machine table by means of fixtures and clamping devices.	The work is clamped directly on the table or held in a vice or chuck.

SLOTTING MACHINE

Its construction is similar to that of a vertical shaper. Its ram moves vertically and tool cuts during downward stroke only. Its main use is in cutting different types of slots in most economical way. Its other uses are machining irregular shapes, circular surfaces and other pre-marked profiles both internal as well as external.



MAIN PARTS:

- 1. Base:** It is a heavy cast Iron construction and acts as a support for the column, the driving mechanism ram, table and all other fittings. At its top it carries horizontal ways along which the table can be traversed.
- 2. Column:** It is another heavy cast Iron body, which acts as a housing for the complete driving mechanism. At its front it carries vertical ways, along which the ram moves up and down.

3. Table: Usually circular table is provided on the top of the table are provided T-slots to clamp the work or facilitate the use of fixtures.

4. Ram: It moves in vertical direction, between the vertical guide ways provided in front of the column. At its bottom, it carries the toolpost in which the tool is held. The cutting action takes place during the down ward movement of the ram.

SIZE AND SPECIFICATIONS:

The size of the slotting machine is generally given in terms of maximum length of stroke. The size of the job that can be machined will be less than this size by an amount equal to the sum of the top and bottom clearances of tool.

TYPES OF DRIVES:

Mainly three types of driving mechanisms are used in slotting machines for driving the ram.

1. Slotted disc mechanism.
2. Slotted link and gear mechanism, and
3. Hydraulic mechanism

1. The slotted disc mechanism: It is the simplest of all the methods commonly used for driving the ram of a slotting machine. The driving mechanism consists of, a pinion, a gear a slotted disc and crank. The disc carries a T-slot through which passes a crank pin. Its distance from the centre of the disc can be adjusted as desired.

The main driving pulley, situated at the rear side of the machine is driven by a motor through belts it in turn drives the pinion which drives the gear. The gear being on the same shaft as the disc and drives the disc. The crank and connecting rod mechanism converts the circular motion of the disc into reciprocating motion of the ram. The length of stroke of the ram can be varied by shifting the crank pin towards or away from the centre of the disc. The starting and finishing positions of the ram stroke can be adjusted by means of hand lever for stroke adjustment. The fly wheel provided at the rear side, acts as a shock absorber at the end of the stroke.

2. Slotted link and Gear Mechanism: This mechanism is used in heavier type slotting machines. The mechanism consists of two driving wheels provided with a trunnion. These trunnions work inside the bushed bearings provided on the sides of the machine. Both the wheels carry an eccentric each. Three bolts are provided by means of which the eccentrics can be made loose or fast with the driving wheels. A slotted link of bellcrank type is provided between the driving wheels. The crank pin forms the fulcrum. A die of usually of bronze works in the slot of the link. It is provided with a hardened steel bush, through which passes one of the three bolts. This bolt connects the two eccentrics and carries the above die, so that when eccentric revolve, along the driving wheels the die slides in the slot. Other end of the link is attached to the ram by means of connecting rod. The ram carries a shackle at its top to carry the end of the counter weight arm. The other end of the arm carries the counter weight and the same is provided about a point in its length somewhere on the top of the frame of the machine.

The mechanism works such that as the eccentric revolve the die slides inside the slot of the link and in doing so, it makes the link swing about the fulcrum, provided by the crank pin. With the result, the connecting rod, and hence the ram is alternatively pushed up and pushed down. This enables the reciprocating motion of the ram and the tool. The length of stroke is adjusted by varying the swing of the link. For this the both are made loose and the eccentrics rotated to adjust the throw, i.e. the position of die with respect to centre of rotation of the wheels. After the required adjustment is obtained the both are again tightened to make the mechanism ready again.

4. **Hydraulic Mechanism:** The hydraulic drive used in slotters is the same as shapers. The axis of the cylinder in this case will be in a vertical direction. Both constant pressure and constant volume type drives are prevalent.

TYPES OF SLOTTING MACHINES

Slotting machines are mainly three types.

1. Puncher Slotters
2. Production Slotters.
3. Toolroom Slotters.

1. PUNCHER SLOTTERS: These are heavy duty machines. Usually such jobs are machined which are heavier and have been roughly machined to required shape through other operations like sawing, forging or stamping etc. The slotting machine to the required shape and size.

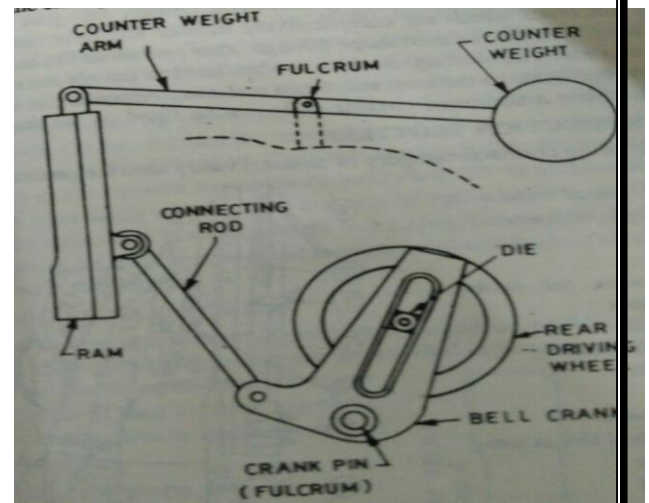
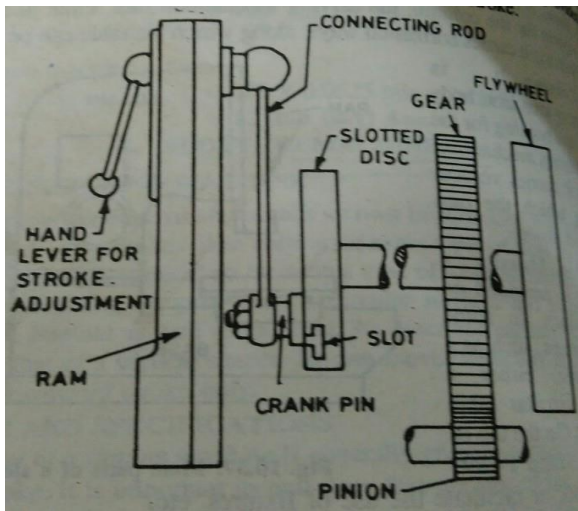
2. PRODUCTION SLOTTERS: This is a common category of slotters generally used for production work. It consists of a heavy cast base and heavy frame, made usually in two parts. The upper part may be stationary type or tilting type. In tilting type of frames a worm and worm wheel are provided at the rear side to enable the tilting of the frame. The tilting type frame enables machining of tapered surfaces, in addition to the normal machining operations performed with a stationary type of frame.

The drive of the ram is obtained by means of a slotted disc and connecting rod. The fly wheel is fitted to prevent shock at the end of the stroke. The ram carries V-slides with hardness ground faces. Two loose strips, fitted vertically in front of the frame, form guide ways for the ram. One of these is secured rigidly to the frame and the other carries adjusting screws to take up wear. The lower part of the frame is provided with horizontal ways. On this is fitted the cross slide, which can be given transverse motion by means of hand wheel. The table is mounted on the cross slide and can be given cross motion by means of a hand wheel. The table carries teeth along its periphery and can be rotated by means of worm meshing with these teeth.

3. TOOL ROOM SLOTTERS: These slotting machines are of precision type and are used for very accurate machining. Usually tilting type frame is provided in these machines to enable machining at different angles. Slotted link type drive is commonly used. Rest of the construction is similar to that of production Slotter.

OPERATIONS:

Its main use is in cutting different types of slots and is most economical for this kind of work. Its other uses are machining irregular shapes, circular surfaces and other pre marked profiles both internal as well as external. Its construction is similar to that of a vertical shaper. Its ram moves vertically and tool cuts during down ward stroke only.

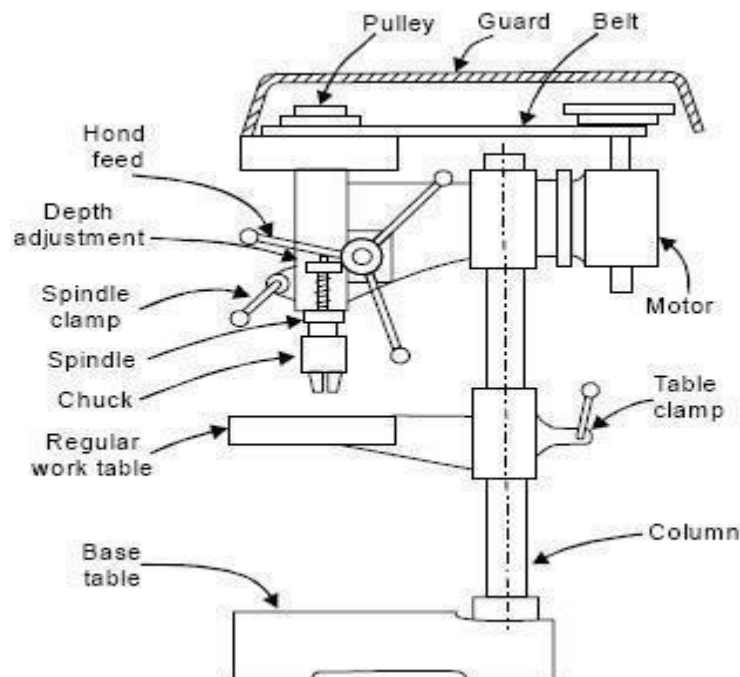


DRILLING

Drilling is an operation to produce holes in a solid metal by means of a revolving tool called drill. The drilling is followed by reaming for dimensional accuracy and fine surface finish by means of a multi-tooth revolving tool called reamer.

Boring is the operation for enlarging an existing hole previously produced through drill, cast, punched or by any other suitable operation.

The operations of drilling, boring and reaming can be performed both by hand feed as well as power feed on a large number of machines such as centre lathe, drilling machine, boring machine, turning mill (vertical lathe), Capstan and Turret Lathes, Automatic Lathes etc.



DRILL SIZE AND SPECIFICATIONS:

According to the Indian standards the drills are specified by their diameters, series they belong to, the material they are made of and the IS number. These data are mainly based on the material for which the drill is to be normally used. They are made in 3 types:

1. Type-N → For normal low Carbon Steel.

2. Type-H→For hard materials.
3. Type-S→For soft and tough materials.

Example: A twist drill specified as “9.50 IS: 5101 HS” means a twist drill of 9.50mm dia. Confirming to IS: 5101 made of high speed steel unless otherwise mentioned in the tool designation the type should be taken as „N“ and the point angle as 118°.

In metric sizes the drills are normally manufactured in diameters ranging from 0.2mm to 10mm.

TYPES OF DRILLING MACHINES:

Drilling machines are manufactured in various sizes and varieties to suit the different types of work.

They are broadly classified as:

- | | |
|---|---|
| 1. Portable drilling Machine. | 2. Sensitive or Bench drill. |
| 3. Upright drilling Machine (Single Spindle Type) | 4. Upright drilling Machine (Turret Type) |
| 5. Radial drilling Machine | 6. Multiple spindle drilling Machine. |
| 7. Deep hole drilling Machine | 8. Gang drilling Machine. |
| 9. Horizontal drilling Machine | 10. Automatic drilling Machine. |

1. PORTABLE DRILLING MACHINE:

It is a very small, compact and self-contained unit carrying a small electric motor inside it. It is very commonly used for drilling holes in such components that can't be transported to the shop due to their size or weight. On account of the high speeds available considerable time is saved. Another advantage is that the holes can be drilled at any desired inclination. Portable drills have a capacity to drill holes up to max. of 18mm dia.

2. SENSITIVE OR BENCH DRILL:

This type of drill machine is used for very light work. Its construction is very simple and so is the operation. No gears are used in the drive. It can be swung to any desired position. Vertical movement to the spindle is given by the feed handle through a rack and pinion arrangement. The max. dia. it can drill is 20mm dia steel.

3. UPRIGHT DRILLING MACHINE (SINGLE SPINDLE):

It is used for heavier work and has a back gearing arrangement. It differs from sensitive drill in its weight, rigidity, application of power feed and wide range of spindle speeds. The drilling capacity is up to 75mm in steel. The table can be swung to any position with rotary movement. It enables any part of the surface to come under the tool without disturbing work.

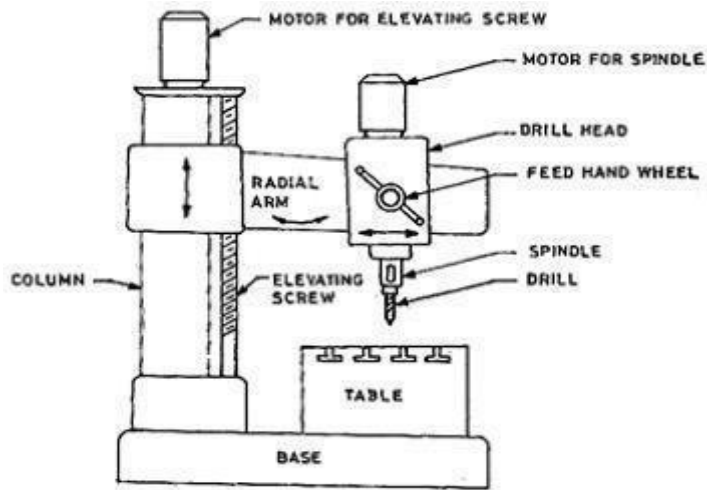
4. UPRIGHT DRILLING MACHINE (TURRET TYPE):

It is a production drilling machine and is very useful when a series of different size holes are to be drilled repeatedly or number of different operations like drilling, reaming, counter boring, counter sinking, spot facing etc are to be performed in sequence repeatedly. The turret head which carries six, eight or ten different tool mounting positions is mounted on a ram. It can be easily indexed to bring the proper tool in operating position over the work and can be raised or lowered by moving the ram upwards or downwards. The required tools are mounted in sequence in the turret head so that they automatically come in operating position when the head is indexed. This type of machine eliminates tool changing time and a single machine can be used to perform no. of different operations one after the other.

5. RADIAL DRILLING MACHINE:

This machine is very useful because of its wider range of operation. Its principal use is in drilling holes on such work which is difficult to be handled frequently. In this the tool is moved to the desired position instead of moving the work for drilling.

Based on the type and number of movements possible, the radial drill can be broadly grouped as:



i. Plain Radial drill: Three principal movements are possible in this type of machine. Viz. vertical movement of the arm along the column, horizontal sliding movement of the drilling head or spindle head along the arm and radial swinging of the arm in horizontal plane.

ii. Semi-Universal Radial drills: These machines in addition to the above three basic movements, carry provision for swinging of spindle head about horizontal axis which is normal to the arm. Thus the head, hence the spindle can be inclined to a suitable angle with its normal vertical position on either side, enabling drilling of holes at desired inclination with the normal vertical position.

iii. Universal Radial drills: in this machine, the arm itself can be rotated through a desired angle along horizontal axis. This is in addition to the four possible movements available on a semi-universal machine. Thus this machine is highly versatile and facilitates drilling at any desired inclination and location. It is normally provided with a geared drive.

6. MULTIPLE SPINDLE DRILLING MACHINE:

These machines are mostly used in production work and are so designed that several holes of different sizes can be drilled simultaneously increasing the production with sufficient accuracy. In these two or more spindles are driven from a common driving shaft through worm and worm gears or belts. Drill heads with a capacity to drive up to 50 spindles simultaneously are available. In these heads it is possible to adjust the spindles to several different positions to enable drilling of holes at any location within the area covered by the head.

7. DEEP HOLE DRILLING MACHINE:

Where very long holes of relatively smaller diameter are required to be drilled these machines are used, such as in rifle barrels and long spindles. These machines can be horizontal as well as vertical types, according to the requirements. These machines are provided with head stock and a carriage. The work is mounted between these two and the carriage carries the drill. On the head stock side, the work is supported on a spindle which also rotates the same as the drill is fed slowly.

In deep hole drilling operation, the work rotates at high speed, while the drill is fed in to the work at low speed and feed. Since the drill is quite long it is required to be supported, so is the case with the work piece, for which steadyrests are used. Coolant is simultaneously fed to the cutting edges through the passages and it will cool the cutting edges and take away the chips along with it. The drill is withdrawn each time it has cut through a length equal to its diameter. This helps in easy removal of the chips from the hole. Horizontal designs are used for longer jobs and vertical designs are used for relatively shorter jobs.

8. GANG DRILLING MACHINE:

It is a multiple spindle drilling machine and all the spindles are arranged in a row. These spindles are driven either separately or collectively. This machine is very useful when the nature of work is such that a number of operations like drilling, reaming, counter boring and tapping etc are to be performed in succession on it. The work moves from one spindle to the other, after each operation. The number of spindles depends upon the type of production. Four spindles are very common. One operator can perform all the operations.

9. HORIZONTAL DRILLING MACHINE:

All drilling machines, except one variety of deep hole drilling machines, are of vertical type. In these machines the spindle and the tool are in horizontal position and are mainly used for long jobs, such as columns pipes and barrels etc which are difficult to be drilled in vertical position. The horizontal drilling is also used for jobs of excessive weight and extraordinary large size jobs which can't be handled easily. The operation of drilling performed by keeping the job stationary and moving the machine.

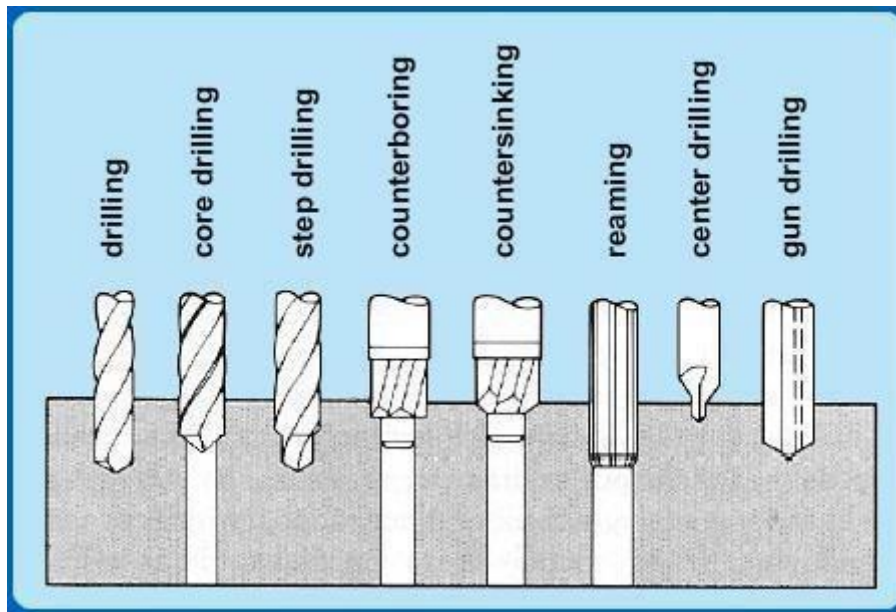
10. AUTOMATIC DRILLING MACHINE:

These are production machines arranged in series to perform a number of different operations in sequence at successive work stations. The work pieces, after completion of an operation at one station, are automatically transferred to the next station for another operation. The operation sequence, related cutting speeds, feeds, start and finish of the operation at each station etc are so arranged and synchronized that once the work piece is loaded at the first station, it automatically switches onto the next operation and unloaded.

Several different operations like drilling, boring, tapping, milling, honing etc can be performed on a job in succession on these machines.

OPERATIONS DONE ON DRILLING MACHINES:

1. Drilling
2. Reaming
3. Boring
4. Counterboring
5. Countersinking
6. Spotfacing
7. Tapping



1. Drilling: It is the main operation done on a drilling machine. It is the operation of producing a circular hole in a solid metal by means of a revolving tool called drill bit.

2. Reaming: It is the operation of finishing a hole to bring it to accurate size and have a fine surface finish. The operation is performed by means of a multi-tooth tool called reamer. The operation is used to produce a straight, smooth and accurate hole. The accuracy to be expected is within ± 0.005 mm.

3. Boring: It is an operation used for enlarging a hole to bring it to the required size and have a better finish. It involves the use of an adjustable cutting tool having a single cutting edge. It can be used for correcting the hole location and out of roundness, if any, as the tool can be adjusted to remove more metal from one side of the hole than the other. It is a slower process than reaming. The accuracy to be expected is within ± 0.0125 mm.

4. Counter Boring: The operation is used for enlarging only a limited portion of the hole, is called counter-boring. It can be performed by means of a double tool boring bar or a counter boring tool. In order to maintain alignment and true concentricity of the counter bored hole with the previously drilled hole, the counter boring tool is provided with a pilot at its bottom.

5. Counter Sinking: It is the operation used for enlarging the end of a hole to give it a conical shape for a short distance. This is done for providing a seat for the countersunk heads of screws, so that the top face of screw matches with the main surface of work. The standard counter sunk carry included angle of 60° , 82° or 90° .

6. Spot facing: This operation is used for squaring and finishing the surface around and at the end of a hole, so that the same can provide a smooth and true seat to the underside of bolt heads or collars etc. This is usually done on castings or forgings. The hole may be spot faced below the rough or above it, i.e. on the upper surface of the boss if the same is provided.

7. Tapping: It is the operation done for forming internal threads by means of a tapping tool. To perform this operation the machine should be equipped with a reversible motor or some other reversing mechanism. Drill size for tapping = $0.08 \times$ tapping size. Drill size = tapping size - 2 \times depth of thread.

TOOL HOLDING DEVICES:

Taper shank drills, of which the shank is sufficiently large, are directly fitted in the tapered hole of the spindle nose. The taper shank tools of which the shank is too small to fit the tapered hole of the spindle are held in a socket. The shank of this socket has a standard taper

to fit in to the taper hole of the spindle. Still the smaller taper shank drills or other tools are first fitted with a sleeve, which fits in to the socket and the complete assembly in the spindle. The socket as well as sleeve both carries a key slot each and a tang is provided at the end of the tapered hole and helps in providing a positive drive for the tool as the grip of taper alone is not sufficient. The drift helps in taking out the socket, sleeve or the tool by driving it in to the key slot. By doing so the drift presses against the top of the tang and because of the taper on the shank as well as the corresponding hole, the part or the tool is driven out. Straight shank drills are always held in a drill chuck.

Holding Parallel Shank Drills:

A drill chuck is the most useful device for holding the parallel shank drills and other small tools. Two types of chucks are commonly used.

1. Self-centering three-jaw Chuck.
2. Quick change Chuck.

A drill chuck is capable of holding wide range of drill sizes and it is usually provided with radial fingers for this purpose. The chuck key is used for rotating the tool head body of the chuck. Inside the body, there are three radial fingers which carry teeth on their outer faces. These teeth mesh with three toothed blocks, mounted on ball bearings inside. For operating the chuck, the pilot of the keys is inserted in the pilot hole so that the teeth of the gear, provided on the key, engage with the teeth provided on the body. As the key is rotated, the outer body rotates together with the toothed blocks inside. This forces the fingers to move outwards or inwards, depending on the direction of rotation of the key. This enables a firm gripping of the tool or its loosening respectively. While operating this chuck, the drill spindle has to be stopped and then only the key is fitted and rotated.

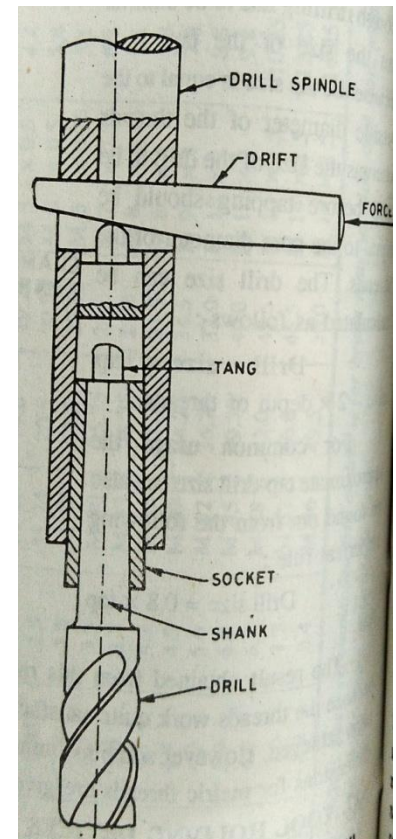
Quick change Chuck: It is mainly used in mass production work. The main advantage of this chuck is that the machine spindle is not required to be stopped, while changing the tool. Thus a number of

tools can be held and replaced quickly, one after the other, without stopping the spindle. This type of requirement is always there, when a number of different operations like reaming, boring, spot facing etc are to be performed repeatedly on the same machine, such that a different tool is to be held for each operation.

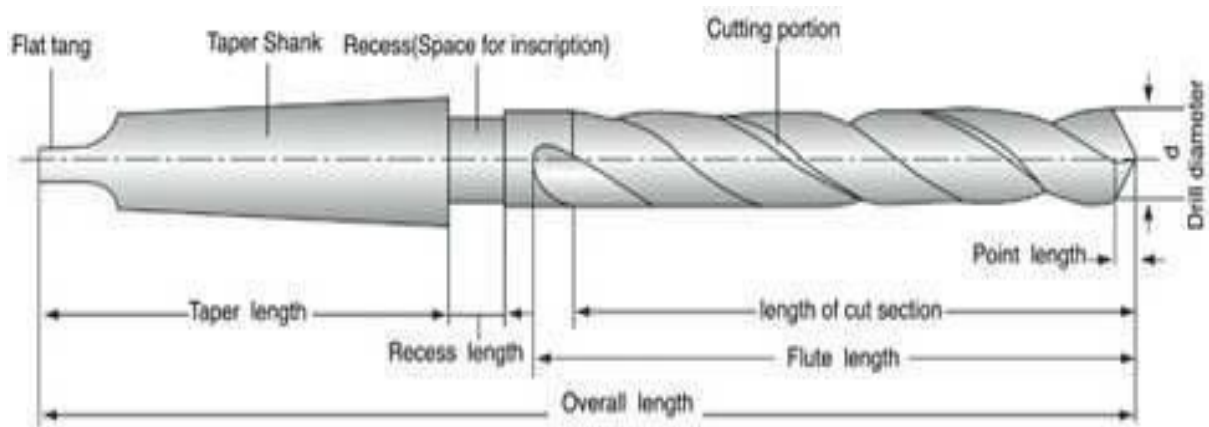
A drill chuck is normally permanently fitted to the drill spindle on smaller and lighter type of drill machines. But on larger and heavier type of machines, the chucks carry standard taper shanks, which fit in to the corresponding tapered holes in the spindles.

TWIST DRILLS:

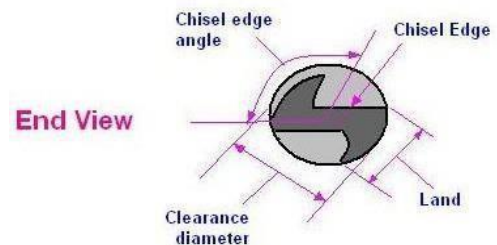
Twist drill is the most widely used tool in modern drilling practice. It consists of a cylindrical body carrying two spiral flutes cut on it. Twist drills are usually made of high speed steel. They are made in various sizes to suit the work and are provided with either tapered shank or parallel shank. Small drills say up to 12.7mm dia. are provided with parallel shank and larger sizes with tapered shank. Morse taper is commonly used for the tapered shank. Other types of shanks used on twist drills are bit shank and ratchet shank, but they are not very common.



Twist drill consists of two main parts. Viz. **ashank**, which is gripped in the drill chuck or sleeve and the other the **body**, which forms the main cutting unit.



Tapered shank drills carry a tang at the end of the shank to ensure positive grip. The body consists of flutes, for removal of chips, the lips or cutting edges, the point or dead centre. The land or portion of full diameter which guides the drill in the hole and the body clearance or relief.



The drill should be so ground that the point is exactly in the centre i.e. the axis of the body and the lips are of equal angle and length. This will enable the production of a perfectly round, smooth, parallel and accurate hole of desired size and the drill will have better life. Unequal lips result in an over sized hole. This can be easily tested by drilling a small hole in mild steel. If the drill is correctly ground the spirals of chips that cut out will be exactly alike. If one is smaller than the other, or is broken it indicates an incorrect grinding. Alternatively, a drill grinding gauge can be used to test the same.

The advantages of using twist drills are:

1. The chips and cuttings of the metal are automatically driven out of the hole through the flutes.
2. Cutting edges are retained in good condition for a long time, thus avoiding the frequent re-grinding of the drill.
3. Heavier feeds and speeds can be used safely, resulting in a considerable saving of time.
4. For the same size and depth of the hole, they need less power in comparison to other forms of drills.

TWIST DRILL PARTS:

The twist drills are made to carry one of the following two types of spiral grooves on the body.

1. HIGH HELIX: They carry a helix angle of 35° to 40° and a heavy web. Their groove width is larger than that of the usual twist drills and therefore they enable easier and quicker disposal of chips. They are largely used for deep hole drilling especially in low tensile strength materials like Copper, Aluminum die casting alloys, Plastics, Wood etc. They are also known as **Fast spiral drills**.

2. LOW HELIX: They carry a small helix angle and are relatively more rigid. On account of their high rigidity, they are capable of taking higher torque and heavier feeds. They are widely used in general drilling work. They are also known as **Slow spiral drills**.

The detailed description of the different parts of a twist drill and their functions are as follows:

- 1. Body:** It is that part of the drill which carries flutes and extends from dead centre up to the start of the neck.
- 2. Axis:** The longitudinal centre line of the drill, along which the whole body, neck and shank of the drill are concentric, is called the axis of the drill.
- 3. Chisel edges or dead centre:** The short edge formed at the extreme tip end of the drill, due to the intersection of the flanks, is called the chisel edge or dead centre. It coincides with axis of the drill. Some of the drills carry a screw type or spiral shaped chisel edge instead of a sharp edge type. This facilitates more accurate location of holes and lower axial thrust.
- 4. Shank:** The portion of the drill beyond neck, which is gripped in the holding device (ex-Drill chuck, sleeve etc), is called Shank.
- 5. Point:** The conical surface at the end of the flutes, formed by grinding, and containing the dead centre, lips and flanks etc is known as point.
- 6. Lip or Cutting edge:** It is the main cutting part of the drill and is formed by the intersection of each flank and face. There will be so many lips in a drill as the number of flutes and the faces. In a commonly used twist drill there are two lips, because it carries two flutes and two corresponding flanks. For correct drilling it is essential that both lips should be of equal length and be equally inclined with axis of the drill.
- 7. Body Clearance:** A small reduction in the diameter of the body is provided on the drill adjacent to the land is called body clearance. It helps in reducing friction between the drill and the walls of the hole and thus helps in both metal cutting and increasing tool life.
- 8. Land or Margin:** It is a narrow flat surface which runs all along the flutes of the drill on its leading edges. The diameter of the drill measured across its lands determines its correct size. The functions of the lands are to keep the drill aligned during the operation and produce the correct size hole.
- 9. Lip clearance:** That part of the conical surface of point, which is ground to provide relief near the cutting edge, is called lip clearance.
- 10. Face:** The curved surface of the flute near the lip is called face. The chips cut from the material, slide up wards along this surface.
- 11. Flutes:** The helical grooves in the body of the drill are known as flutes. Commonly used drills carry two flutes, while special drills carry four. These flutes make the chips curl and provide passage for their exit. Cutting edges are formed on the point due to machining of these flutes and the cutting fluid reaches the cutting area through these flutes only.
- 12. Flank:** It is the curved surface, on either side of the dead centre, which is confined between the cutting edge on its one side and the face of the other flutes on the other side.
- 13. Web:** The central metal column of the drill body that separates the flutes from one another is known as web. Its thickness gradually increases from the tip side towards the shank side, where it is maximum. This will provide strength and rigidity to the drill.
- 14. Chisel edge corner:** The point of intersection of the chisel edge and the lip is known as chisel edge corner.
- 15. Outer Corner:** The extreme of the dead centre, where the face and flank intersect to form a corner is called outer corner.
- 16. Neck:** The smaller diameter cylindrical portion, which separates the body and shank of a drill, is called neck. All necessary particulars of the drill are engraved on this portion.
- 17. Tang:** The flat portion of rectangular cross-section provided at the end of the tapered shank is known as tang. This fits into a matching slot in the holding device, such as socket,

sleeve or spindle to provide a positive drive. Also for driving the drill out of the sleeve or spindle, the drift is applied over this part of the drill.

18. Heel: An edge is formed where the body clearance and the flute of the drill intersect. This edge is known as Heel.

DRILL DIMENSIONS:

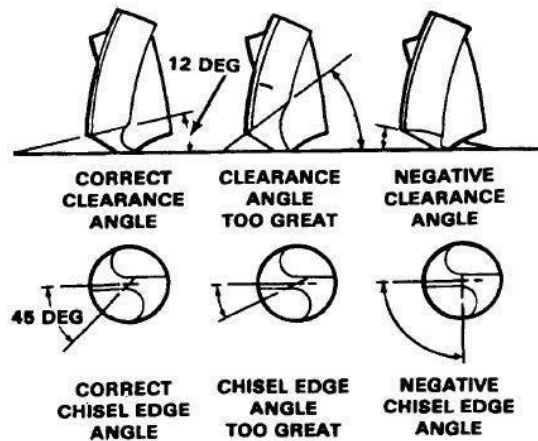
The important dimensions of drill are:

- 1. Diameter:** The linear measurement perpendicular to the axis and across the lands of a drill, at the outer corners.
- 2. Length of body:** It is the length measured along the axis between the dead centre and start of neck of the drill.
- 3. Flute length:** The length measured parallel to the axis between the dead centre and the point of termination of the flute near the neck.
- 4. Lip length:** The distance between the chisel edge corner and the outer corner is called lip length.
- 5. Overall length:** The distance measured along the axis between the dead centre and the extreme end of the tang is known as overall length. In the case of parallel shank drills, which carry no tang, it is the distance between dead centre and extreme end of shank measured along the axis of drill.
- 6. Depth of body clearance:** The body diameter is slightly reduced either side and is measured along the radius of the drill, perpendicular to axis.
- 7. Core taper:** It is the measure of the increase in web thickness or core thickness, starting from the minimum at the point end and to the maximum at the shank end of the drill.
- 8. Lead of helix:** It is the axial distance measured between two corresponding points on a flute in its one complete turn.

IMPORTANT ANGLES OF A DRILL

Different angles are provided on a drill for efficient metal cutting. The main angles are:

- 1. Rake angle:** It is also known as helix angle. It is the angle formed between a plane containing drill axis and the leading edge of the land. It can be positive, negative and zero value. For right hand flutes it is positive, for left hand flute it is negative and for parallel flutes it is zero. For most drills the rake angle varies from 0° to 48° . However 16° to 32° is common for normal materials. High values are suitable for soft material and lower value for hard materials. Larger the value of this angle, lesser will be the torque required and vice-versa.
- 2. Point angle:** It is also known as cutting angle. The most commonly used value for large variety of materials is 118° . However it varies from 80° to 140° smaller cutting angle for brittle materials and larger for harder and tougher materials. It is the angle included between the two opposite lips of a drill measured in a plane containing the axis of the drill and both the lips.
- 3. Lip Clearance angle:** The angle formed between the flank and a plane normal to the axis, measured at the periphery of the drill. Its value varies from 8° to 15° for most of the drills but 12° are most common. It enables easy entry of the drill.
- 4. Chisel edge angle:** When the drill is viewed from its end, there appears to be an obtuse angle formed between the lip and chisel edge. This is called chisel edge angle. It determines the clearance on the cutting lip near the chisel edge. The greater this angle larger will be the clearance. Normally this angle varies between 120° to 135° .



STRAIGHT FLUTED DRILLS:

Twist drill is not suitable for drilling holes in softer materials like brass as it will pull through the back of the metal. A straight fluted drill is proper tool for such work. The only disadvantage is chips clog in the flutes then in spiral flutes. Mainly used for drilling holes in sheet metal.

BORING MACHINES:

The operation of a boring is enlargement of an already existing hole. This hole can be due to previous drilling, or produced in casting or forging. Small holes, particularly in small jobs the boring operation can easily done on centre lathe or capstan and turrets of medium size. For large and heavy jobs special boring machines are used, which make the operation easy and efficient. These machines are production machines for boring on a large scale.

Classification of Boring Machines:

Boring machines are manufactured in various different designs & sizes. They can be broadly classified into the following three types.

1. Horizontal Boring Machines.
2. Vertical Boring Machine.
3. Jig Boring Machine.

The first two types are production machines used in general production work, the last one is a precision machine, used for precision boring operations, such as Jig Boring.

Horizontal Boring Machine:

Horizontal boring machines are of various types such as **Table type, Planer type, Floor type, and Multiple head type** etc each of these suitable for a certain range of operations, but of all these the table type or universal type is most versatile and commonly used. The spindle of this machine is capable of holding drills, and milling cutters as well to perform the operations of drilling and milling hence this machine is called horizontal boring, drilling and milling machine.

The principal parts of this type of machine are:

1. Two vertical columns, one on each end of the table.
2. A headstock which can be moved vertically, along the main column.
3. A horizontal spindle, suitably housed in the headstock, which can be rotated and fed forward and backward according to requirement.
4. A load bearing end support, for supporting the end of a long boring bar, which can be adjusted vertically along the end support column.
5. A horizontal table, mounted on a saddle that can be moved horizontally forward and backward and sideways by moving the saddle.

6. A heavy and strong bed, which carries the entire load of different parts, work piece and tooling over it.

Floor type Horizontal Boring Machine:

This machine is comparatively heavier type of horizontal boring machine. The operating and spindle supporting units are not mounted on a bed, as in the table type machine, but are carried on separate run ways, which facilitates the movement of these units, together with the spindle past the work. The work does not move at all, but is kept stationary at a platform floor plate. It is this relative movement of work with respect to the other units of the machine in which it differs from the table type machine. This type of the machine is very suitable for long and heavy jobs.

Planer type Horizontal Boring Machine:

This machine resembles in construction with the table type. The only difference in the construction and operation of the work supporting mechanism. In this a heavy cross-bed is incorporated between the spindle column and the end support column. This bed is mounted across the axis of the spindle and carries a table over it. On its two sides it carries two columns. The main column carrying the head stock, is rigidly fixed, whereas the end-support column can move towards or away from this bed along the horizontal ways provided on the top of the cross bed, at right angles to the former bed. The job is mounted on the table. In operation, it resembles a planer in that the tool is held between the two columns or mounted on the head stock only and the work, mounted on the table, moves past the tool. This type of machine is very suitable for long jobs.

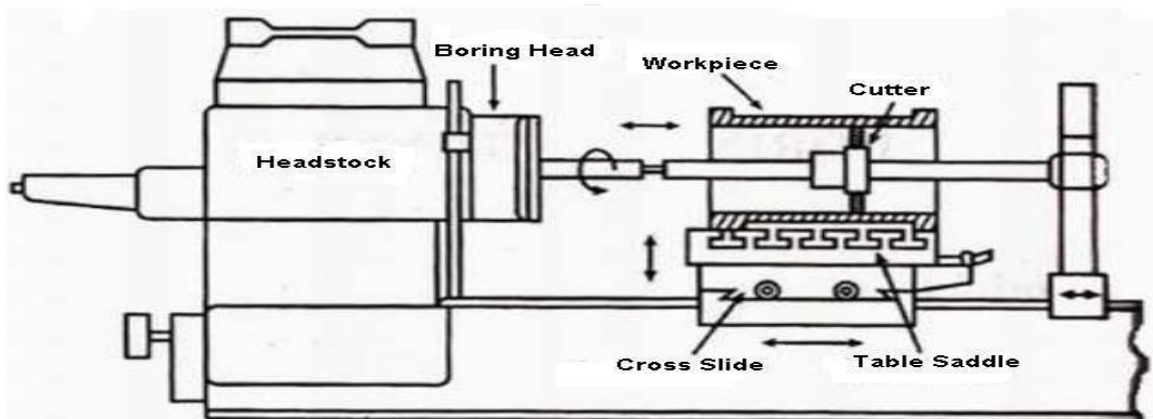
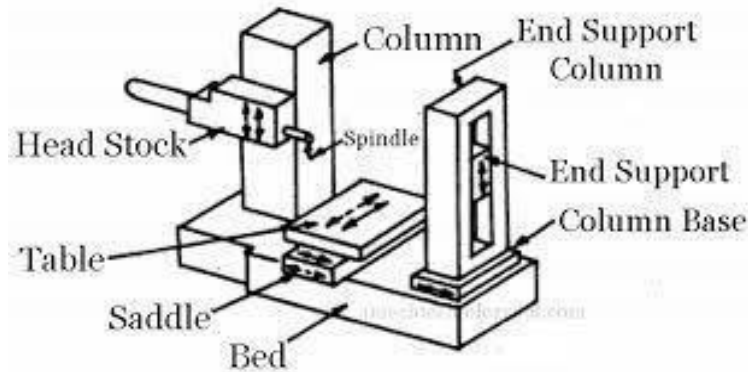


Table Type Horizontal Boring Machine

Multiple Head type Horizontal Boring Machine:

It consists of two vertical columns mounted on the sides of a stationary bed. The columns are bridged by means of a cross-rail. As a maximum four head stock can be mounted on the machine, one each on the two vertical columns and two on the cross-rail. The head stock on the columns will have horizontal spindles and those on the cross-rail vertical spindles. In this way maximum four tools can be mounted simultaneously on this machine. The work is mounted on the table, which is supported and moved on the bed. This machine resembles a planer type milling machine. The head stocks can be swiveled to desired angles if angular cuts are required to be taken. Machining on more than one surface on a job is possible simultaneously as up to four tools can operate simultaneously on the job from different angles and at different locations.



Vertical Precision Boring Machine:

It is a production machine basically designed for boring holes in cylinder blocks and liners of automobile engines, fine boring of parts in Ferrous and non ferrous metals etc.

Constructional Features:

Column and Base: The vertical column is a cast Iron box type casting with stiffening ribs inside. The base is another massive cast Iron structure and carries guide ways at its top face, along which table traverse column and base are fastened together rigidly. Prismatic guide ways are provided on the front face of the column along which the spindle head moves up and down. Lead screw of the spindle head is located between the two vertical ways at the front face of the column.

Spindle Head: It traverses in vertical direction along the column ways. The spindle head housing carries inside it the v- belt drive for spindle and hand traverse mechanisms. According to the size of the hole to be bored, one of the three inter changeable spindles, provided with the machine is mounted on the spindle head. A screw is provided with the machine is mounted on the spindle head. A screw is provided on the tool holder face for adjustment of overhang of the boring tool. A special dial is provided to show precision adjustment of the tool up to 0.02mm.

Speed and feed gear box: It is mounted inside the column on the machine base. It transmits the motion from the electric motor to the shaft of the spindle drive and to the lead screw of the spindle head. The gear box provides 6 spindle speeds and 4 feeds and also rapid traverse to the spindle.

Table: It is made in two parts. The lower part moves in cross direction along ways provided on the base and the upper one in longitudinal direction along the ways provided on the top of the lower part. During the operation the table can be locked by means of stops to prevent its movement in either direction.

Salient Features:

1. The machine is highly rigid and vibration proof, maintains its initial accuracy of performance over a long period of time.
2. The control of speed and feed gear box is conveniently grouped in an easy to reach place and is performed by means of three levers.
3. Most of the machine units are assembled in independent housings which facilitates easy repair.
4. The table being movable in two directions permits to bore several holes in a work piece at one setting.
5. The upper limit of the spindle speed, ample power of motor and rigidity of the machine permit the use of carbide cutting tools.
6. Precision anti friction spindle bearings ensure machined durability, accuracy and surface finish.

Vertical Boring Machines:

In this the work is held on a rotary table, rotates about a vertical axis, while the tool remains stationary, except for feeding. The table together with the work rotates in a horizontal plane. Thus if the table is considered to have replaced the chuck or face plate of a centre lathe, this machine can be considered as a vertical lathe with its bed working as a head stock mainly the following three types of boring machines in this category.

1. Standard Vertical boring mills.
2. Vertical Turret Lathes.
3. Vertical Precision Boring Machines.

Standard Vertical Boring Mills: It consists of a heavy Cast iron bed, which carries a circular table over it. On the sides of the bed are two vertical columns which are bridged together by means of a cross-rail. As a maximum four tool heads can be mounted on the machine one each on the two columns and two on the cross-rail. This number can also be reduced according to the requirements. Usually the tool heads carry the provision for being swiveled to a certain angle for taking angular cuts. The work is mounted on the table which rotates about its vertical axis. The rotating work is thus, fed against fixed tools, which results in circular cuts being taken on the job. The table is provided with T-slots for clamping the work.

Usually large symmetrical work pieces, such as cylindrical objects are bored on these machines. A few examples are the casings for steam turbines, tables for machine tools and pressure vessels. Vertical housing on the two sides of the table limits the size of the work. The maximum size of the work would be equal to dia. of the table and same will represent the size of the machine.

Vertical Turret Lathe: It has a special advantage that many tools can be simultaneously mounted on the turret head, and therefore, a large number of different operations can be performed in addition to boring a single setting of work. The table of the machine is of rotary type and carries adjustable jaws for clamping the work.

The rotary table rotates over the bed, about a vertical axis. The work piece is held over this table. Maximum two side tool posts can be mounted, one each on each column. These tool posts can be adjusted vertically and they can also move forward and backward. One or two vertical tool heads can be mounted on the cross-rail, which can be adjusted horizontally along the cross-rail. Each vertical tool head will carry a turret head enabling to mount a number of tools in sequence on it to enable different operations to be performed in a single setting of tools. The turret head can be indexed after each operation, to bring the proper tool in position for the next operation. The vertical tool head can also be moved, upwards and downwards, according to requirement.