CHAPTER 2

SHAPER AND SLOTTER

2.1 INTRODUCTION

Machine tools are metal removing devices. They remove excess material to shape the products. They remove the material in the form of chips. They produce flat or cylindrical surfaces. They may be reciprocating type or rotary type machines.

Shaper is a reciprocating type of machine tool. It is used to produce flat surfaces. The surfaces may be horizontal, vertical or inclined. The surfaces are machined by single point cutting tool. It is generally not used as a production machine. But widely used in machine shop and tool rooms since it is very easy to setup and operate.

2.2 PRINCIPLE OF OPERATION

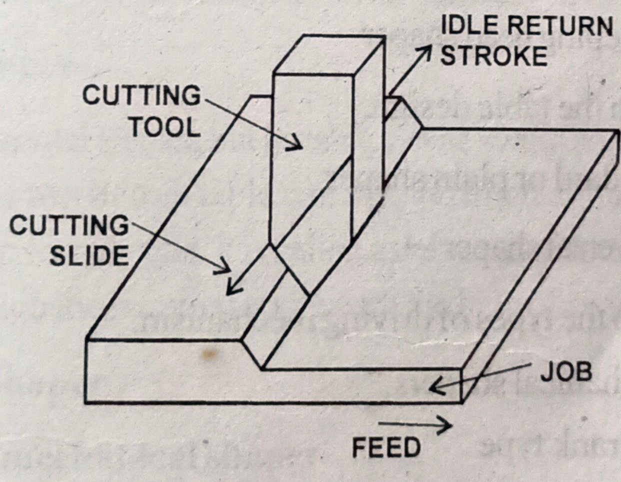


Figure 2.1 Working principle of Shaping Machine

The above figure (2.1) shows the basic principle involved in shaping. The job is held in a vice and clamped rigidly on the machine table. The cutting tool is held in the tool post mounted on the ram of the shaper. The ram reciprocates to and fro and cuts the material from the job in cutting stroke. Generally cutting action takes place in forward stroke known as cutting stroke. The return stroke of the ram is called idle stroke. At the end of one cycle, consisting of one to and fro motion of the cutting tool, the job is given a feed motion perpendicular to the direction of tool movement. The depth of cut is given by lowering the tool relative to the job.

To produce horizontal surfaces, the table is moved in a crosswise direction. To produce vertical surfaces, the tool head is moved in downward direction. To produce inclined surfaces the tool head is fed at an angle.

2.3 CLASSIFICATION OF SHAPERS

Shapers may be classified as follows:

1. According to the length of stroke.
   - (a) 30cm shaper
   - (b) 45cm shaper
   - (c) 60cm shaper
2. According to the position of ram.
   - (a) Horizontal shaper
   - (b) Vertical shaper
   - (c) Travelling head shaper
3. According to the table design.
   - (a) Standard or plain shaper
   - (b) Universal shaper
4. According to the types of driving mechanism.
   - (a) Mechanical shapers.
     - (i) Crank type
     - (ii) Geared type
   - (b) Hydraulic shaper.
5. According to the type of cutting stroke.
   - (a) Push cut type
   - (b) Draw cut type

2.4 TYPES OF SHAPER

2.4.1 30cm Shaper

These types of shapers are older models with fixed length of stroke. The designation 30 represents the length of stroke in centimetres. Later the shapers are designed with variable length of stroke. 45cm and 60cm shapers are defined in a similar manner.

2.4.2 Horizontal Shaper

In this type, the ram holding the total reciprocates in a horizontal axis. This is mainly used to produce flat surfaces.

2.4.3 Vertical Shaper

In a vertical shaper, the ram holding the total reciprocates in a vertical axis. In appearance and operation it resembles a slotting machine. Vertical shaper and slotter are frequently used interchangeably but the marked difference is, the ram of a vertical movement, can also be adjusted from its vertical position to about 10° on either side, but the ram of a slotter always moves in a vertical direction.

2.4.4 Standard Shaper

In standard shaper, 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. Some machines have a provision for the table to swivel around a horizontal axis parallel to the ram.

2.4.5 Universal Shaper

This is also a horizontal shaper, but its table can be swing about a horizontal axis parallel to the ram ways. The top of this table can also be tilted about another horizontal axis, which is normal to the former axis. It is called a universal shaper. Since the job can be tilted in any direction through the required angle with the help of swivel vice.

2.4.6 Mechanical Shaper

2.4.6.1 Crank type mechanical shaper

This is the most common type of shaper in which crank and slotted link mechanism is used to give a reciprocating motion of the ram.

2.4.6.2 Geared type mechanical shaper

The reciprocating motion of the ram is given by means of a rack and pinion. The rack teeth that are cut directly below the ram mesh with a spur gear.

2.4.7 Hydraulic Shaper

The 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 of oil acts on one side of piston causing piston to reciprocate and the motion is transmitted to the ram.

2.4.8 Push cut type shaper

This is the most general type of shaper used in practise. The metal is removed in forward stroke of the ram.

2.4.9 Draw cut type shaper

In this type the metal is removed in the backward stroke of the ram. The tool is set in reverse direction to that of a standard shaper. Vibrations in these machines are eliminated.

2.5 PRINCIPLE PARTS OF A SHAPER

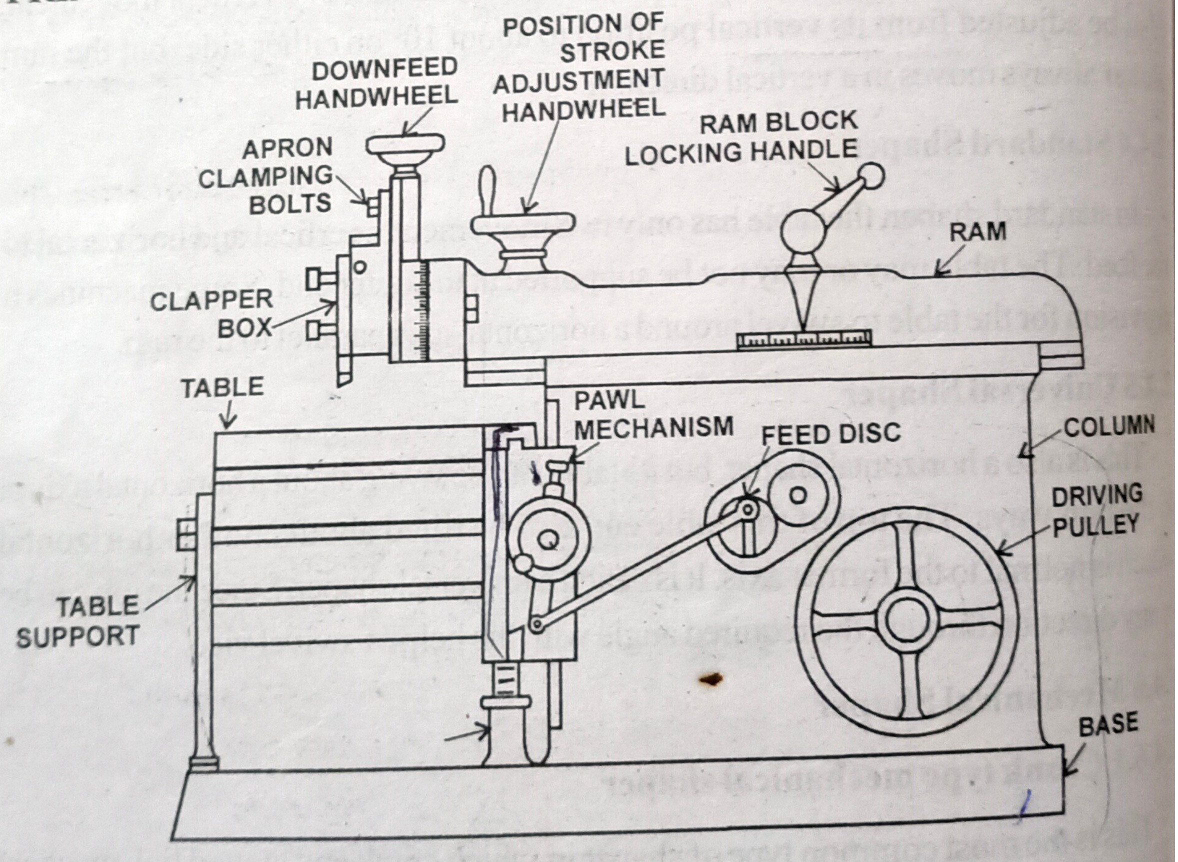


Figure 2.2 Standard Shaper

The different parts of a shaper are explained below:

Base:

It consists of a heavy robust cast iron structure, which supports all the other parts of the machine.

Column:

It is a box type structure. It is made of cast iron. It is mounted on the base. It houses the ram driving mechanisms. It has two guide ways on the top. The ram reciprocates on this guide ways. The front face also has two machined guide ways. A cross rail moves vertically along these guide ways.

Cross Rail:

It slides on the front vertical guide ways of the column. It contains two mechanisms. One for elevating the table and the other for cross travels of the table. It has two guide ways on its side. The sadde slides over it. An elevating screw is provided to move the cross rail vertically. The cross wise movement of table is obtained by the horizontal cross feed screw.

Saddle:

It is mounted on the cross rail. It holds the table firmly on its top.

Table:

It is a box type cast iron block. It slides along the cross rail. It holds the work. It has T-slots on the top and sides for clamping the work. The front of the table is clamped to a table support.

Ram:

It is the reciprocating part of the shaper, semi-circular in shape and carries the tool head in front of it. It gets its drive from the quick return mechanism, which is inside the column.

Tool Head:

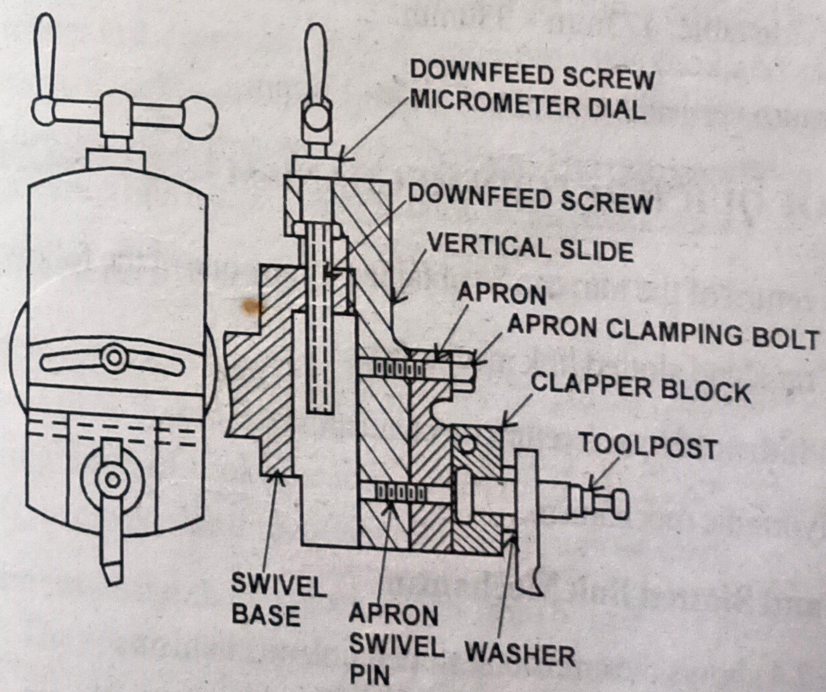


Figure 2.3 Toolhead of a shaper

The tool head of a shaper is used for holding the tool rigidly. It also provides vertical and angular feed movement of the tool and allow the tool to lift automatically to provide relief during its idle of return stroke. The vertical feed to the tool is provided by rotating the down feed screw handle.

2.6 SPECIFICATION OF A SHAPER

Generally a shaper may be specified by its maximum length of stroke.

The other specifications are:

1. Type of drive (Mechanical or hydraulic)
2. Power of motor. 3HP.
3. Speed and feed available.
4. Ratio of cutting stroke time and return stroke time. 2:1.
5. Floor area required - 1981mm × 1067mm.
6. Net weight. Approximately. 1750kg.
7. Maximum vertical travel of table - 475mm.
8. Maximum horizontal travel of table - 450mm.
9. Size of side table. 473mm × 330mm.
10. Maximum vertical travel of tool slide - 150mm.

2.7 TYPES OF QUICK RETURN MECHANISM

The quick return of the ram can be obtained by any one of the following mechanisms

1. Crank and slotted link mechanism.
2. Whithworth quick return mechanism.
3. Hydraulic mechanism.

2.7.1 Crank and Slotted link Mechanism

The figure 2.4 shows the crank and slotted link mechanism.

An electric motor drives the pinion. The pinion drives the bull gear.

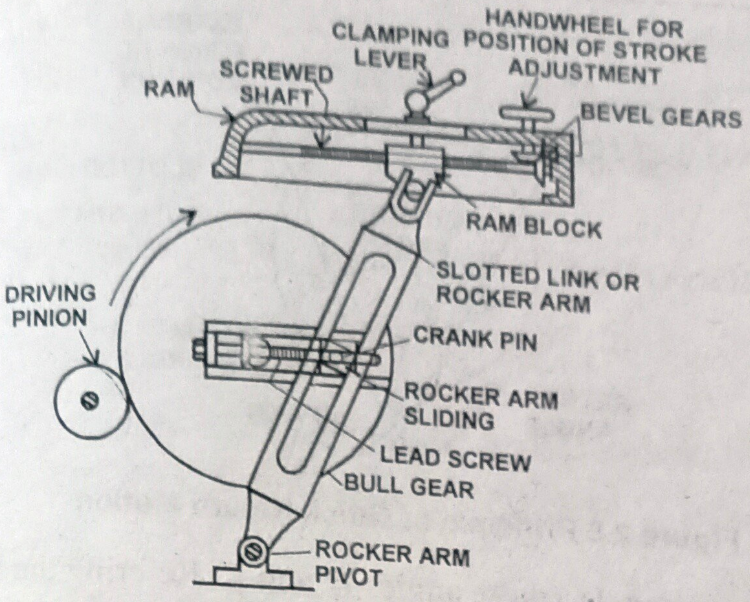


Figure 2.4 Crank and slotted link mechanism

The bull gear has a radial slide. In this radial slide a bull gear sliding block is assembled. This block can be adjusted in radial direction, by rotating the stroke adjustment screw. This screw receives motion through bevel gears by rotating the handle fram outside.

The sliding block carries a crank pin. A rocker arm sliding block is freely fitted to the crank pin. The rocker arm sliding block fits in to the slot pivoted at the bottom end. Its upper end is forked. It is freely connected to the ram block by a pin.

The rotation of bull gear makes the crank pin to rotate in a circle. The rocker arm sliding block also rotates in the same circle. At the same time, this sliding block also moves up and down in the slot of rocker arm. This gives oscillation (rocking motion) to the rocker arm. The rocking movement is transmitted to the ram. The ram reciprocates. Thus the rotary motion is converted into reciprocating motion by this mechanism.

Principles of Quick Return Motion

Dotted line circle represents the path of crank pin. AP_1 and AP_2 represent rear and forward positions of link. S_1 and S_2 represents two extreme position of crank pin with sliding block. During forward stroke the link moves from AP_1 to AP_2. The sliding block moves from S_1 to S_2 in clockwise direction it rotates through an angle 'α'.

During the return stroke the sliding block moves from S_2 to S_1 in clockwise direction. It coves the angle β. The speed of bull gear is constant. So the time taken during these two

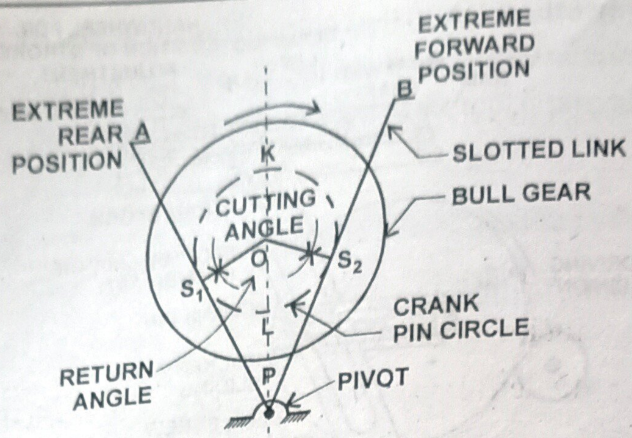


Figure 2.5 Principle of Quick Return Motion

strokes will be proportional to these angles α and β. Refering the figures angle β is smaller than α. So the time taken for the return stroke will be less.

$$\frac{\text{Cutting Time}}{\text{Return Time}} = \frac{\alpha}{\beta} = \frac{\text{Cutting Angle}}{\text{Return Angle}}$$

This ratio will vary from 2:1 to 3:2.

Stroke length adjustment

The stroke length is adjusted by moving the crank pin in radial direction. The Crank pin with sliding block can be moved radially with the help of adjustment screw. This adjustment screw is rotated by a handle through bevel gears.

When the crank pin is nearer to the centre of the bull gear, the rocker arm oscillates for a smaller angle α_1. So the length of stroke is smaller. Refer figure 2.6(a).

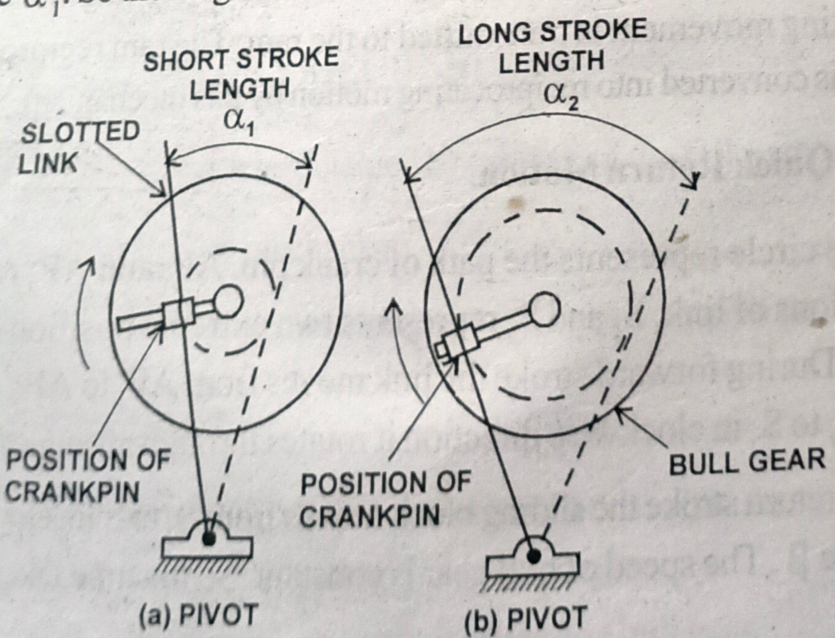


Figure 2.6 Adjusting Stroke length

When the crank pin is away from the centre of bull gear, the rocker arm oscillates for a larger angle α_2. The length of stroke is also longer. Refer figure 2.6(b).

The length of stroke should be always greater than the length of cut. If should be nearly 20mm. Largen than the work.

This is for following reasons:

(1) To obtain good surface finish.

(2) To give sufficient time for cross feed.

(3) To give sufficient time for the clapper block to reach its proper seat for cutting.

(4) To allow the ram to get the proper cutting speed.

Position adjustments

For adjusting the position of stroke, first loose the clamping handle. Rotate the stroke position hand wheel. Now the screw inside the ram will rotate. This makes the ram to move forward and backward. After adjusting the position, tight the clamping handle. By doing so the position of stroke should be adjusted to a distance of 12 to 15mm. Before the beginning of cut and 5 to 8mm after the end of cut.

2.7.2 Whitworth Quick Return Mechanism

An electric motor drives the pinion. The pinion rotates bull gear. The bull gear has a crank pin. A sliding block is fitted freely over the crank pin. It also slides in the slot of a crank plate. This crank plate is pivoted eccentrically on a pin 'O' fixed to tha body of the machine. The crank plate is connected to the ram by a connecting rod through the pins P and M.

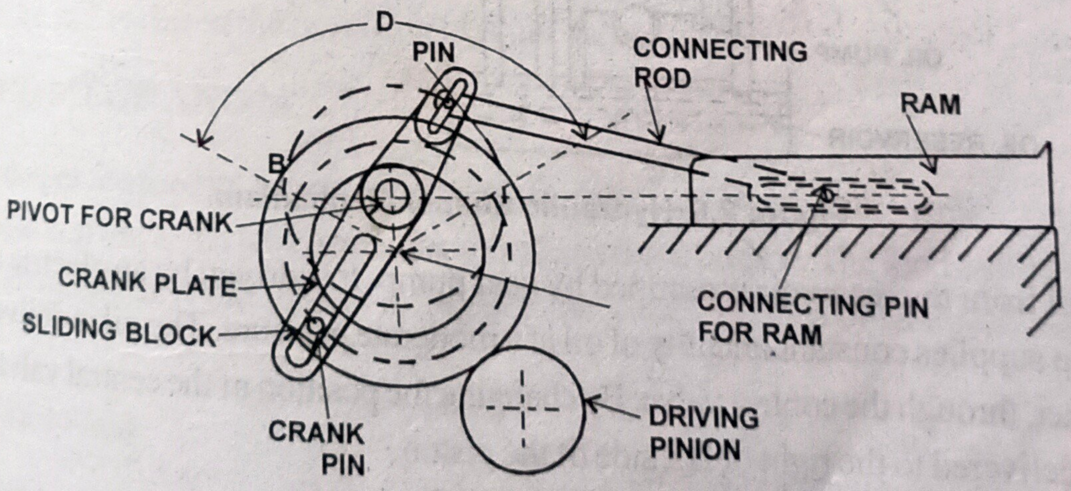


Figure 2.7 Whitworth quick return mechanism

The crank pin rotates about the centre of bull gear 'C'. At the same time, the sliding block slides along the slot of the crank plate. This makes the crank plate to rotate about its centre 'O'. The crank pin 'P' will also rotates about the centre 'O'. Its rotary motion is converted in to reciprocating motion of ram by the connecting rod.

When the pin A is at X, the ram is at the starting position of forward stroke. When the bull gear rotates in anti-clockwise direction, the pin moves through the angle L, and rotates the point Y. It is the end position of cutting stroke. When the bull gear rotates further, from Y to X, it makes angle of B. It is return stroke. The angle B is smaller than angle L. The speed of bull gear is uniform, so the time taken for the return stroke is less than cutting stroke.

$$\frac{\text{Cutting Time}}{\text{Return Time}} = \frac{\text{Angle L}}{\text{Angle B}}$$

2.7.3 Hydraulic Mechanism

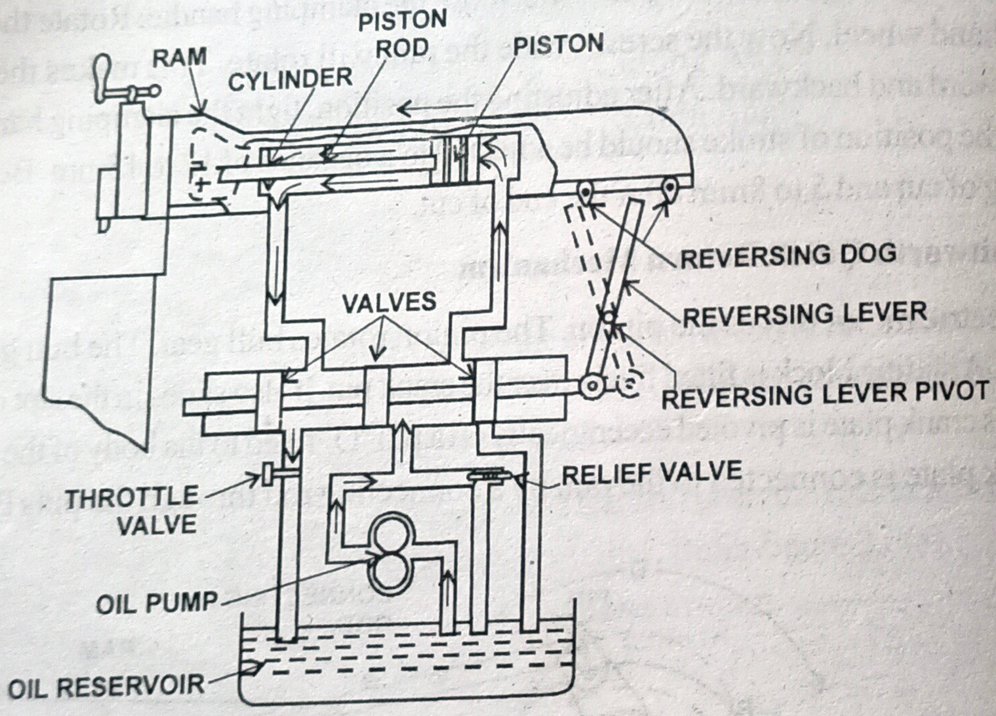


Figure 2.8. Hydraulic Shaper Mechanism

The oil from the reservoir is pumped by gear pump. It is driven by an electric motor. The pump supplies constant quantity of oil at a moderate pressure. The oil is delivered to the cylinder, through the control valve. By changing the position of the central valve lever, the oil is delivered to the right or left side of the piston.

When the lever is in the position P_1, oil is delivered to the left side of the cylinder. Due to the oil force, the piston moves right to left. The piston is connected to the ram through

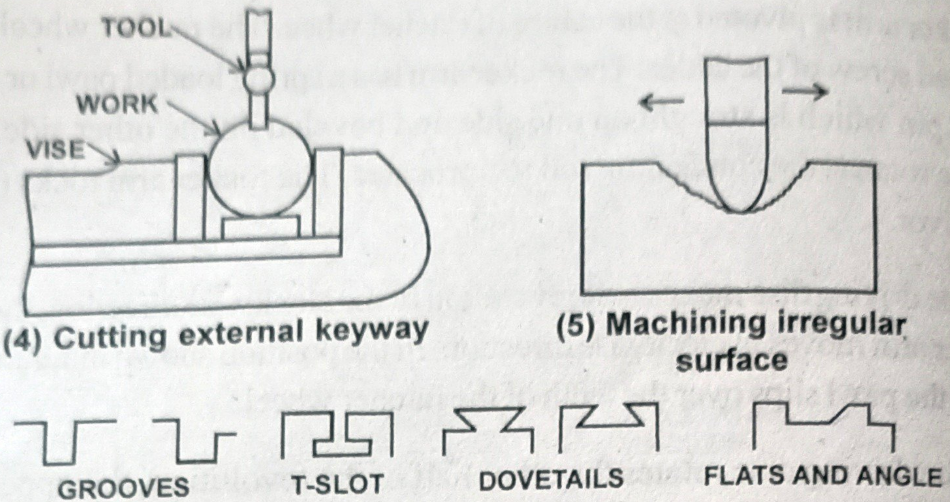


Figure 2.11 Surface machined in shaping

In a shaper, the following operations can be done.

1. Machining horizontal surface.
2. Machining Vertical surface.
3. Machining Angular surface.
4. Machining Slots, Grooves and Keyways.
5. Machining Irregular surface.

All the above mentioned operations are discussed briefly in next chapter-III.

2.10 WORK HOLDING DEVICES

For machining in a shaper, the work piece must be clamped firmly by using work holding devices. These devices used depend upon the shape and size of job and the type of operation. For this the following methods are commonly used.

(1) Clamped in a vice

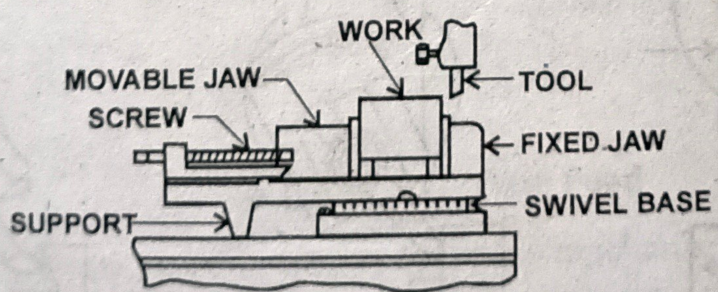


Figure 2.12 Vise

It is used to hold small and regular shaped work. The work is clamped between two jaws

(2) Clamping directly on the table

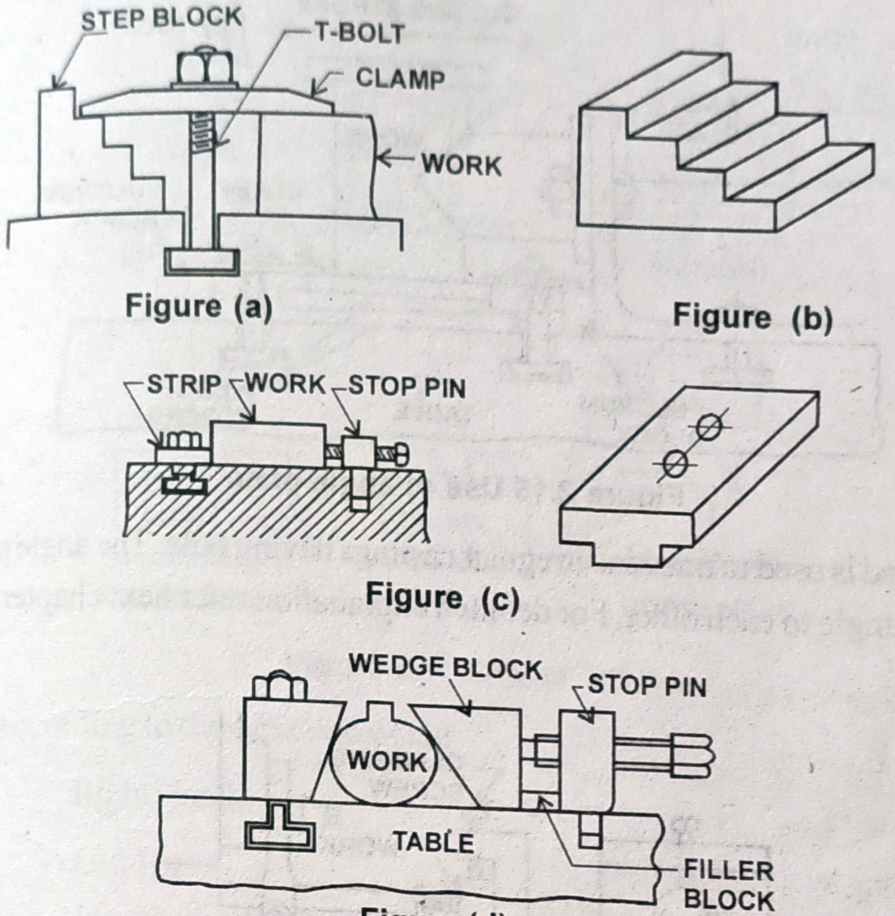


Figure (a)

Figure (b)

Figure (c)

Figure (d)

Figure 2.13

Large and irregular shape work may be clamped directly on the table using T-bolts and clamps and by using strips and stop pins and also by using wedge strip and stop pin.

(3) Clamping on a V-block

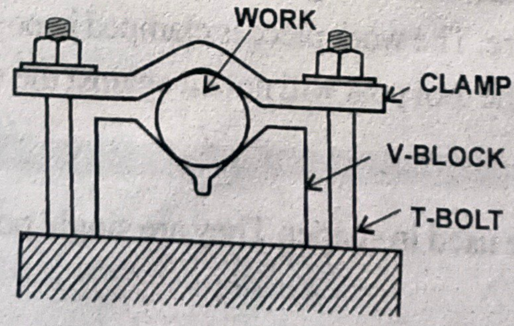


Figure 2.14 Use of Block

This method is used for clamping cylindrical work pieces. V-block is kept over the table, work is placed over. V-blocks and clamped with T-blots.

(4) Clamping on an angle plate

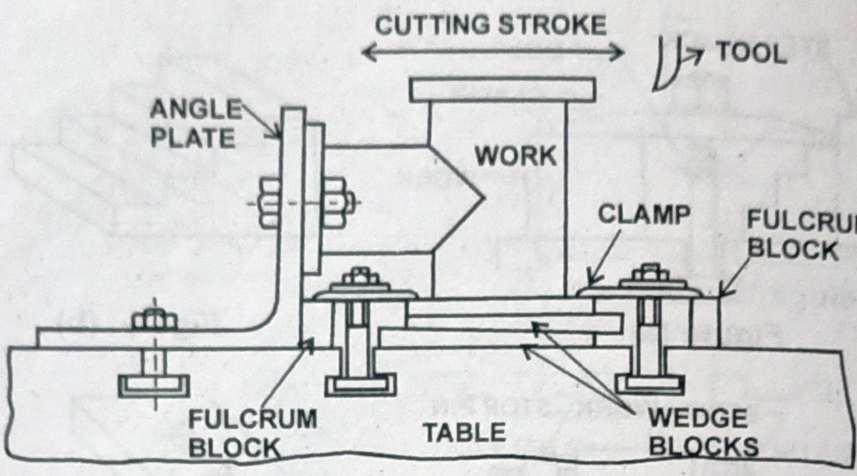


Figure 2.15 Use of angle plate

This method is used to machine irregular castings having hole. The angle plate has two faces at right angle to each other. For detailed explanation refer next chapter.

(5) Fixture

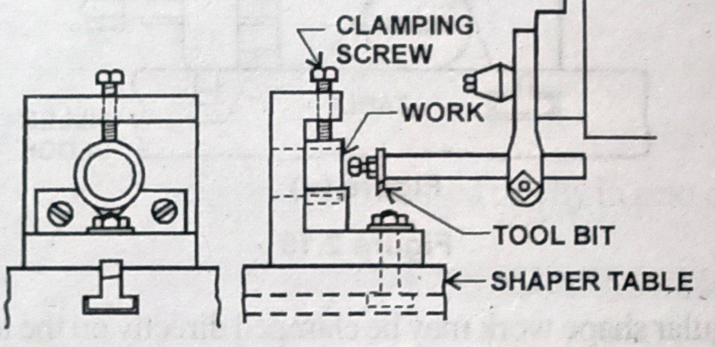


Figure 2.16 Shaping Fixture

The figure (2.16) shows a fixture for cutting internal key way in a hallow work piece. The fixtures is clamped to the table using T-blots. The work piece is located by means of a V-block fitted to the fixture. The work piece is clamped in position by a screw. A special tool holder is used so that the tool post will not hit against the work.

2.11 TYPES OF TOOLS

HSS or forged tools are used in shaper. They are single point tools. Shaper tools are classified as follows:

(1) According to the shape.

- Straight
- Cranked
- Goose neck etc.

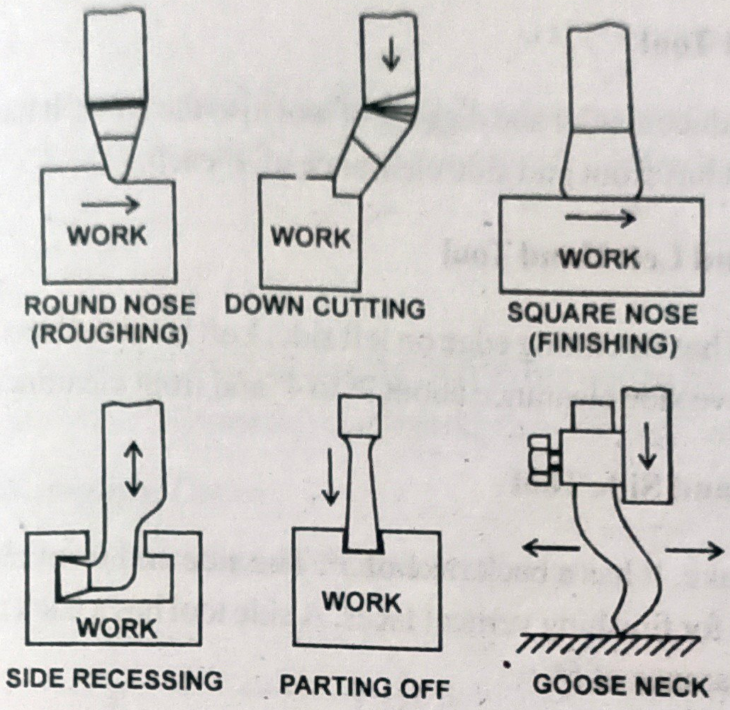


Figure 2.17 Shaper Tools

(2) According to the direction of cut.

- Right Hand
- Left Hand

(3) According to the operations.

- Surfacing
- Side Recessing
- Parting off
- Squaring, etc...

(4) According to the degree of finish.

- Roughing
- Finishing

(5) According to the shape of cutting edge.

- Round Nose
- Square Nose

(i) Goose Necked Tool

This tool will reduce chatler and digging of tool in to the work. It has no top rake. It has back rake of 12°. It has front and side clearance of 4° each.

(ii) Right Hand and Left Hand Tool

Right hand tool has its cutting edge on left side. Left hand tool has its cutting edge on right side. They have side clearance about 2° to 4° and front clearance upto 4°.

(iii) Pasting Tool and Side Tool

It has no side rake. It has a back rake of 3°. The side and front clearance is 3° each. Side tools are used for finishing vertical faces. A side tool has a back rake of 5°, side rake of 15° and side clearance of 5°.

(iv) Roughing and Finishing Tool

Roughing tool has no top rake. The side rake may be 10° to 20° for hard metals. The side clearance is 2° to 4°. Front clearance is upto 4°. Finishing tool has front and side clearance between 2° to 4°, the back rake is 2°.

(v) Round Nose and Square Nost Tools

Round nose tool is used for cutting down. It can cut down equally on right and left. Square nose tools are used to machine side and bottom of key ways, grooves, etc...

2.12 CUTTNG SPEED, FEED AND DEPTH OF CUT, ESTIMATING MACHINE TIMES

(i) $$\text{Cutting Speed}(v) = \frac{\text{Length of Cutting Stroke}}{\text{Time taken for Cutting}}$$

$$= \frac{nL(1+m)}{1000} \text{ in m/min}$$

Where, n = number of cutting stroke per minute of bull gear in rpm.

L = Length of cutting stroke in mm.

m = ratio between return time and cutting time.

(ii) Feed:

It is the relative movement of tool or work in the direction perpendicular to the movement of ram. It is expressed in mm per stroke for roughing cut, faster feed is given for finishing, slow feed is given.

(iii) Depth of Cut:

It is thickness of metal removed in one cut. It is expressed in mm. For roughing cut, more depth of cut is given. For finishing cut, less depth of cut is given.

(iv) Estimating Machining Time:

Figure (2.18) illustrates adjustment of the tool travel.

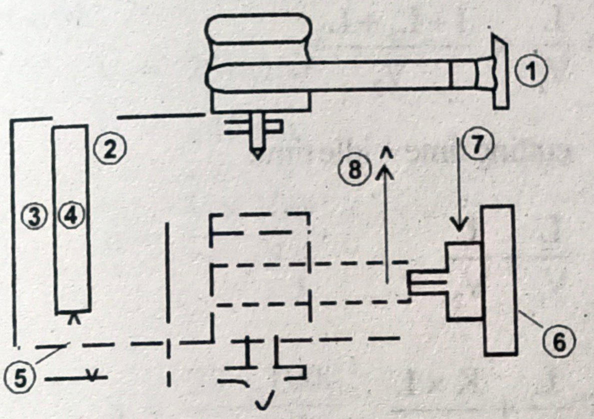


Figure 2.18 Working principles of shaping machine

Let L_1 = The distance the tool has to travel before starting the cutting stroke.

L_2 = The distance the tool has to travel after completion of the work.

L = Length of the stroke or tool travel in metres.

m = Feed per cycle in mm.

V_1 = Actual cutting speed in m/min

V_2 = Return stroke speed in m/min

n = Number of cycles required.

f = Feed per cycle in mm.

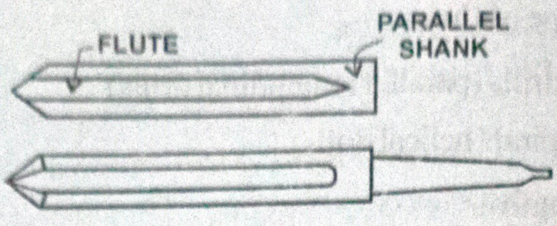


Figure 4.30 Straight fluted drill

inconvenenient in standard practice as the chips do not come out from the hole automatically. It is mailny used in drilling brass, copper or other soft materials. In drilling brass, the twist drill tends to advance faster than the rate of feed and the drill, digs into the metal. No such difficulty occurs in the use of a straight fluted drill when driling sheet metal. The straight fluted drill does not tend to lift the sheet as does the twist drill. Figure (4.30) shows a straight fluted drill.

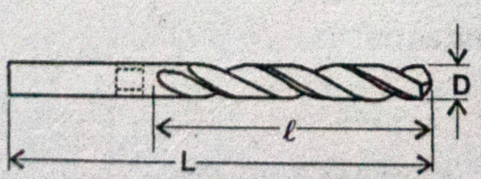
ii) Twist Drills

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

Twist drill is an end cutting tool. Different types of twist drills are classified by Indian standand institution according to the type of the shank, length of the flure and overall lenght of the drill. Small drill, say upto 12.7 mm diameter, are provided with parallel shank and the larger sizes with tapered shank. Morse is commonly used for the tapered shank, other types of shanks used on twist drill an bit shank and rachet shank.

(a) Parallel Shank (Short Series or "Jobber") Twist Drill

The drill has two helical flutes with a parallel shank of approximately the same diameter as the cutting end. The diameter of the drill ranges from 0.2 to 16 mm increasing by 0.02 to 0.03 mm in lower series to 0.25mm in higher series figure (4.31) illustrates the drill.



ℓ - FLUTE LENGTH, L - OVERALL LENGTH
D - DIAMETER

Figure 4.31 Parallel Shank short series twist drill

Boring tools usually operate with a large overhang from the tool holder. This factor does not allow shank type boring tools to cut a heavy chip. For this reason, deep holes are commonly bored by bar type tools (aften called bits) held is a holder or a bar refer the above figure.

Whole reaming is widely used to size holes more accurately than is possible with drills, boring as a rule must be resorted to in order to obtain the maximum in precision sizing, location and surface finish accuracy. Boring operation is used for machining holes with precise centre to centre distance in housing type parts (large pulleys, fly wheels, steam engine cylinders, machine housing etc.,). Boring is also used for machining large diameter holes.

6.3 TYPES OF BORING MACHINES

The boring machines may be classified under the four headings.

1. Horizontal boring machines [HBM]
   a) Table type HBM
   b) Floor type HBM
   c) Planer type HBM
   d) Multiple head type HBM
2. Vertical boring machines
   a) Vertical turret lathe
   b) Standard vertical boring mill
3. Fine/Precision boring machine
   a) Horizontal type
   b) Vertical type
4. Jig boring machines
   a) Vertical milling machine type
   b) Planer type jig boring machine

6.3.1 Horizontal boring machines [HBM]

Four principle types are:

a) Table type HBM
b) Floor type HBM
c) Planer type HBM
d) Multiple head type HBM

In a horizontal boring machine the work is supported on a table which is stationary and the tool revolves in a horizontal axis. A horizontal boring machine can perform boring, reaming, turning, threading, facing, milling, grooving, recessing and many other operations with suitable tools. Workpieces which are heavy, irregular unsymmetrical or bulky can be conveniently held and machined. Different types of horizontal boring machines have been designed to suit different purposes. Figure (6.2) illustrates a horizontal boring machine.

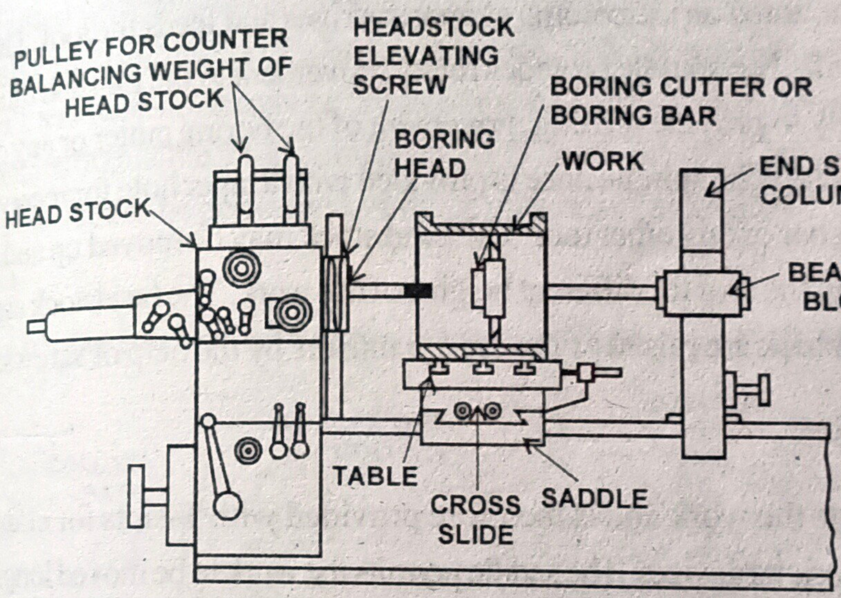


Figure 6.2 Horizontal boring machine (HBM)

These machines are widely used in piece and small-lot production for machining housing type parts (gear boxes, machine tool head stocks, etc).

Parts of horizontal boring machine

i) Bed: The bed is that part of the machine which is fitted on the floor of the shop and has a box like casting. The bed supports the columns, tables and other parts of the machine.

ii) Headstock supporting column

The column provides supports to the head stock and guides it up and down the guide ways provided on the face of the column. The column which is hollow houses the counter weights of the head stock, and is heavily ribbed to add rigidity. Some columns are stationary, others may be made to slide along the bed.

iii) End supporting column

The end supporting column situated at the other end of the bed houses the bearing block for supporting a long boring bar. The column may be adjusted on the sideways of the bed towards or away from the spindle for supporting different lengths of boring bars or it may be moved at right angles to the spindle as in the case of a floor type machine.

iv) Head stock

The headstock mounted on the column supports, drives and feeds the tool. The spindle revolves within a quill. The spindle provides rotary movement to the tool and quill may be moved longitudinally to provide feeding movement of the boring cutter or any other tool mounted on the spindle. The spindle nose is provided with a taper hole for receiving taper shanks of the boring bar or any other tool. The head stock may be moved up and down on the column for setting the tool for different heights of the work. The headstock and the end supporting bearing block are raised or lowered in unison by the help of screws.

v) Saddle and table

The table supports the work and is therefore provided with T-slots for clamping the work or for holding various devices. The saddle permits the work to be moved longitudinally on the bed. The table may be moved crosswise on the saddle. These movements may be slow or rapid and is performed by hand or power.

vi) Boring bars

The boring bar supports the cutter for boring operations on jobs having large bore diameters. For short holes the bar may be supported on the head stock spindle end only, whereas for long work the bar is supported on the spindle end and on the column bearing block.

6.3.1.1 Table type horizontal boring machine [Table type HBM]

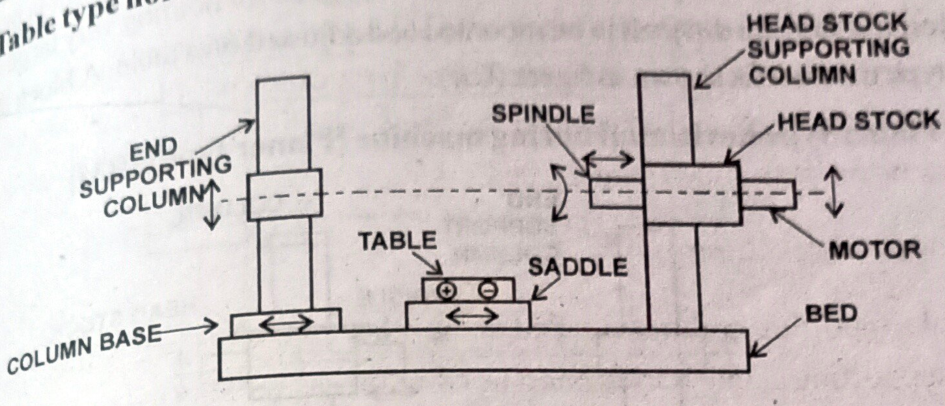


Figure 6.3 Table type horizontal boring machine

The table type is the most common of all horizontal boring machines. This is so named, because the work is mounted on the table which is adjustable and feed in given by hand or power, lengthwise or crosswise with respect to the bed of the machine. The headstock may be adjusted vertically on the column and the spindle has a horizontal feed motion. The machine essentially consists of a bed, head stock, saddle and table, and boring bar. The table, saddle and headstock may be adjusted by lead screws using micrometer dials. This type of machine is suitable for general purpose work where other operations, in addition to boring, are required to be performed. A block diagram of a table type machine is shown in figure (6.3).

6.3.1.2 Floor type horizontal boring machine [Floor type HBM]

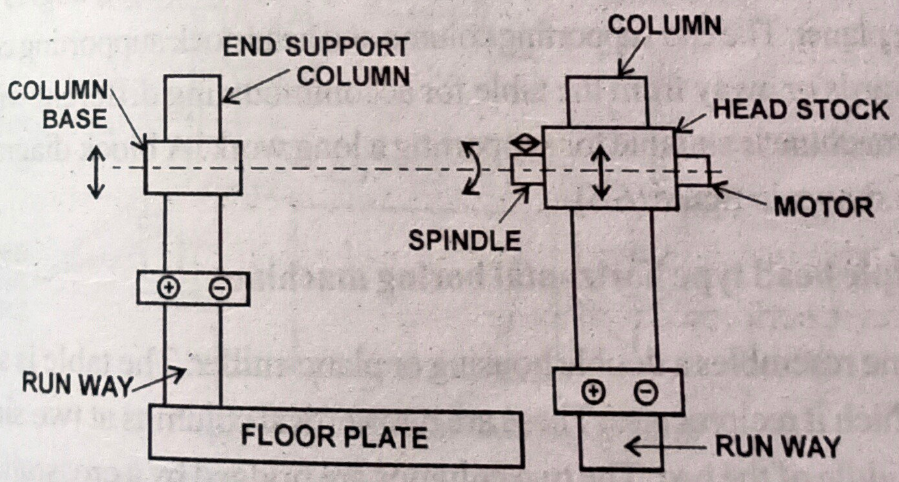


Figure 6.4 Floor type horizontal boring machine

The floor type horizontal boring machine having no table uses a stationary floor-plate on which T-slots are provided to hold the work. The head stock supporting column and the end supporting column are mounted on the runways which are placed at right angles to the spindle axis. Thus any crosswise adjustment or cross-feed movement is provided by the spindle itself and not by the work. This is so designed for holding very large and heavy workpieces which are difficult to be mounted and adjusted on a table. A block diagram of a floor type machine is shown in figure (6.4).

6.3.1.3 Planer type horizontal boring machine [Planer type HBM]

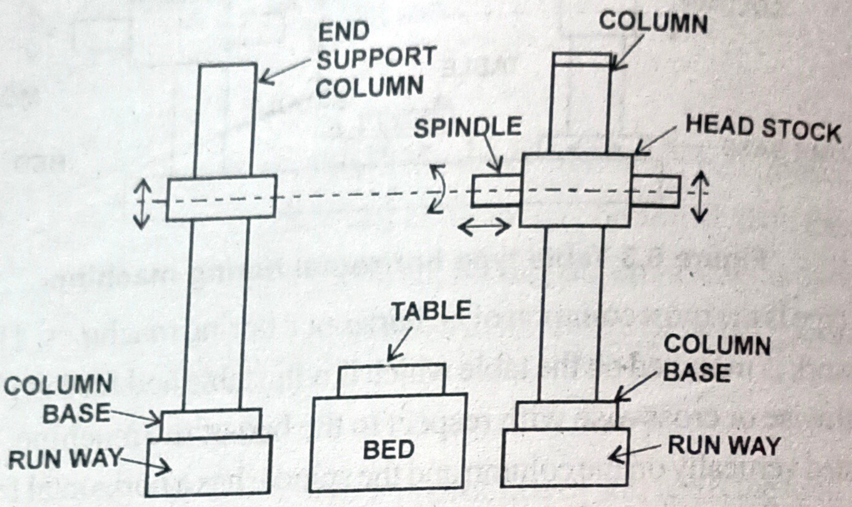


Figure 6.5 Planer type horizontal boring machine

This machine is similar to the table type HBM except that the work tables 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 HBM.

The planer type horizontal boring machine resembles the table type but table slides directly on the bed instead of on a saddle and recriprocates at right angles to the spindle similar to the planer. The end supporting column and headstock supporting column may be adjusted towards or away from the table for accommodating different widths of work. This type of machine is suitable for supporting a long work. A block diagram of a planer type machine shown in figure (6.5).

6.3.1.4 Multiple head type horizontal boring machine

The machine resembles a double housing or plano-miller. The table is supported on a long bed on which it reciprocates. These are two vertical columns at two sides of the bed, nearly at the middle of the bed. The two columns are bridged by a crossrail. The machine may have two, three or four headstocks. This type of machine may be used both as horizontal and vertical machine. The machining operations can be performed simultaneously at different work surface. A block diagram of the machine is shown in figure (6.6) used for boring holes of larger diameter in mass production.

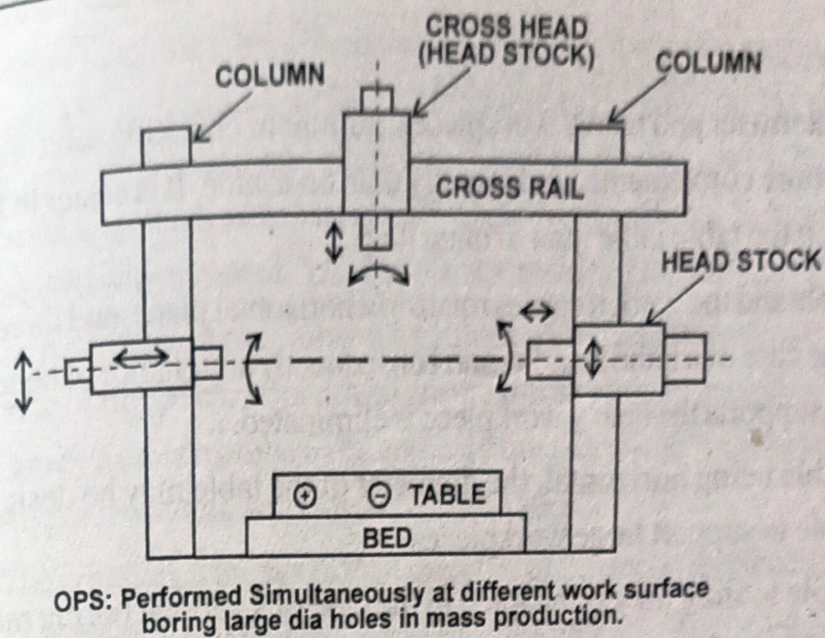


Figure 6.6 Multiple head type horizontal boring machine.

6.3.2 Vertical boring machine

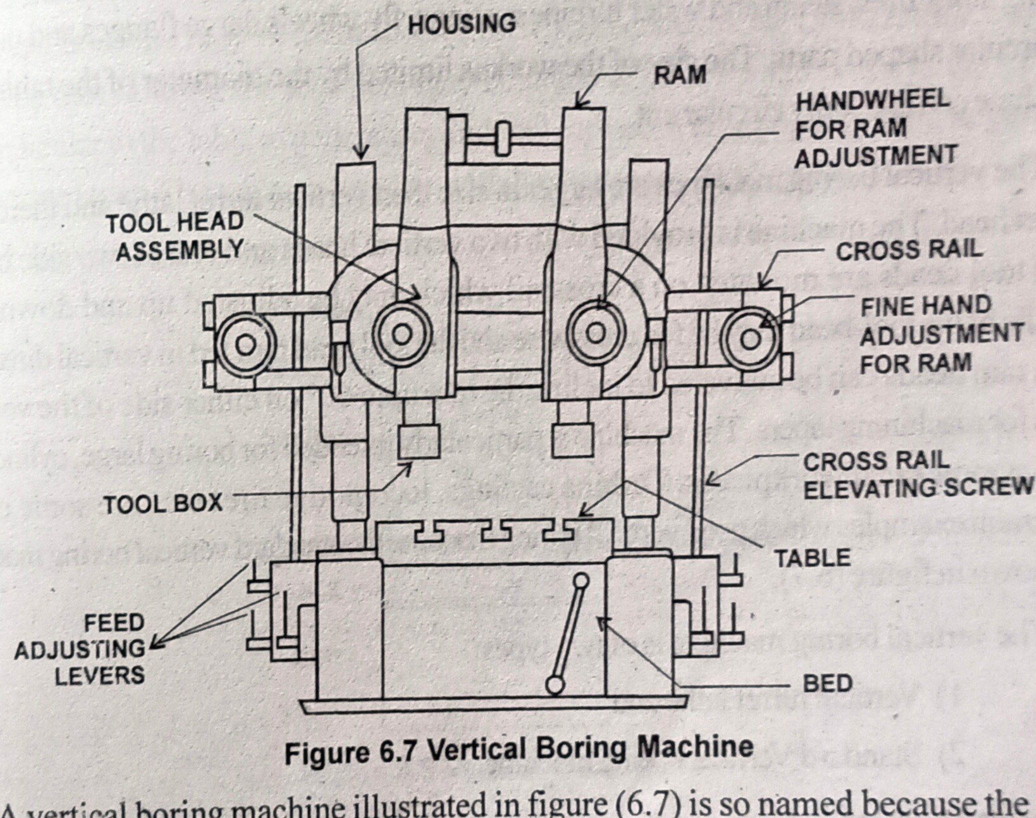


Figure 6.7 Vertical Boring Machine

A vertical boring machine illustrated in figure (6.7) is so named because the work rotates on a horizontal table about a vertical axis and the tool is stationary except for the feed. The machine may be looked upon as a vertical lathe with its head stock resting on the floor and its large faceplate or chuck lying in a horizontal plane. This specific design of the machine provides certain distinct advantages over a lathe for a particular class of work.

Advantages

1. Large diameter and heavy workpieces, similar to chucking jobs on a lathe, may be set up more conveniently and quickly than on a lathe. It is easier to lay a workpiece down on the table lathe than to hang it up.
2. The table and the work it carries rotate in a horizontal plane, and there is no overhang as in the case of a lathe spindle, and consequently any chance of bending the spindle which supports the heavy workpiece is eliminated.
3. The table being horizontal, the diameter of the table may be designed as large as possible to support large workpieces.
4. Multiple tooling may be adapted in the case of a vertical boring machine with its turret type tool post increasing rate of production.

A vertical boring machine is particularly adapted for holding and machining large, heavy and cumbersome workpieces. The typical works are large gear blanks, locomotive and rolling stock tires, steam and water turbine castings, fly wheels, large flanges and number of circular shaped parts. The size of the work is limited by the diameter of the table. The machine can take only circular cut.

The vertical boring machines are larger in size than vertical turret lathe and there is no turret head. The machine is provided with two vertical heads and one or two side heads. The tool heads are mounted on a crossrail which may be adjusted up and down. The saddle of the tool-head may be fed crosswise and the tool head ram fed in vertical direction. The ram heads can be swiveled to incline the ram upto 60° on either side of the vertical axis for machining tapers. The machine is particularly intended for boring large, cylindrical and symmetrical workpieces. Turbine castings, locomotive tires etc., are some of the common examples which need vertical boring machine the standard vertical boring machine is shown in figure (6.7).

The vertical boring machine is of two types:

1) Vertical turret lathe and
2) Standard Vertical boring machine

Parts of vertical boring machine

i) Bed: The bed of a boring machine consists of a hollow circular casting grouted on the floor. The top of the bed is finished to provide a bearing surface for the table. It houses the spindle and a pinion for rotating the table.

ii) **Table:** The boring machine table which may be rotated is a circular casting mounted on the top of the bed. The horizontal surface of the table is finished and is provided with T-slots or chuck jaws for holding and clamping the work. Underside of the table may be provided with bevel gear teeth which meshes with a driving pinion. In large machines, a helical pinion meshes with a gear attached to the underside of the table.

iii) **Housing:** The housings are two vertical members which rise from the two sides of the bed. They are made of ribbed construction to ensure rigidity of the machine. The housings are joined at the top by a cross member. The vertical front face of the housings are accurately machined to form guideways on which the crossrail slides.

iv) **Crossrail:** The crossrail is the horizontal member of the rectangular casting mounted on the two front faces of the housings. The crossrail may be moved up and down by rotating screws for accommodating different heights of work. The vertical front face of the crossrail is accurately finished for holding and sliding the saddle of the tool head.

v) **Tool head assembly:** It comprises saddle, ram and tool post. The saddle is mounted on the crossrail and may be made to slide on it is generate flat horizontal surface by the tool. The ram holding the tool post may be made to slide up and down in the saddle perpendicular to the table to generate cylindrical surface or at an angle to the table surface to generate taper. The ram are also counterbalanced for ease of operation.

6.3.2.1 Vertical turret lathe

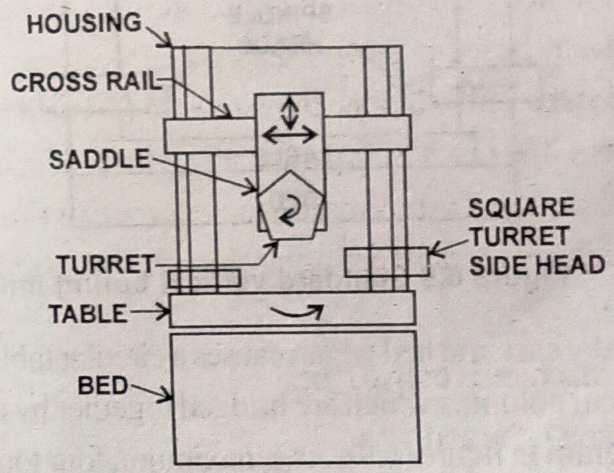


Figure 6.8 Vertical turret lathe

It carries 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, in a single setting of work. The table of the machine is of rotary type and carries adjustable jaws for clamping the work. That is why it is frequently called a chuck also in this particular case.

The main parts and their possible movements are shown in figure (6.8). The rotary table rotates over the bed about a vertical axis. The workpiece 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. Also, in some designs they can be made inclined 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 carry a turret head so as to enable mounting of 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 upward and downward according to requirement.

★ A four station square turret side-head which enables facing, turning, under-cutting and many other operations is mounted at the side of the lathe. The machine is suitable for boring and turning rail road wheels, piston rings, gear blanks etc.,

6.3.2.2 Standard vertical boring mill

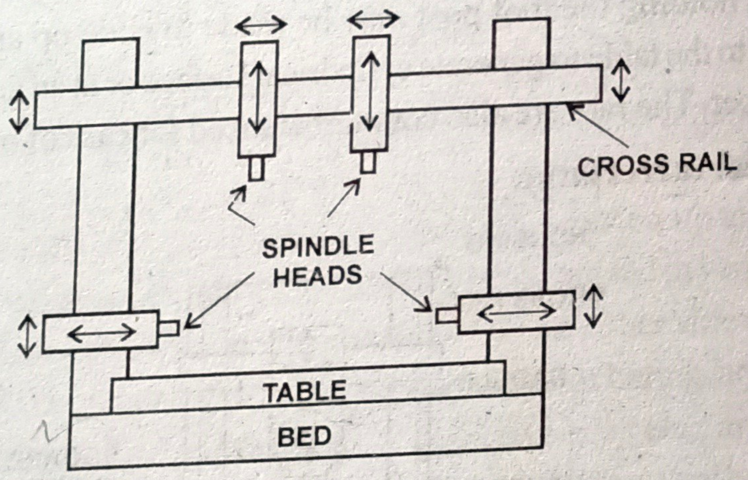


Figure 6.9 Standard vertical boring mill

It consists of a heavy cast iron bed which causes 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 shown in a block diagram in figure (6.9). As a maximum, four tool heads can be mounted on the machine, one each on the two column and two on the cross-rail. This number can also be reduced according to the requirements. Usually the tool heads carry the provion for being swivelled 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 workpieces, such as cylindrical objects, are bored on these machines. A few examples are the castings for steam turbines, tables for machine tools and pressure vessels. An important point to be noted here is that the vertical housings on the two sides of the table limit the size of the work that can be machined on this machine. This maximum size of the work would be nearly equal to the diameter of the machine table and the same will represent the size of the machine.

★ This machine will not undertake oversize work due to the above limitation.

6.3.3 Fine or precision boring.

Fine boring machines or precision boring machines built to machine components requiring a high degree of accuracy and surface finish. The boring spindle, which is the heart of these machines, can be of a ball, roller bearing, hydrostatic, or air bearing type. On these machines, diamond tools can be used to achieve a high degree of accuracy and surface finish.

There are various versions of these machines like the horizontal spindle, single-end machine, the horizontal spindle, double-end machine can be of the single or multi spindle type. As these machines are designed for specific needs, they are in variably built with automatic cycles. Axial feed by cam or hydraulic cylinder is quite popular and of late, numerical control with recirculating ball screw drive in also being employed to enhance the applicability of these machines.

The important features of a fine boring machines are,

1. The machine is made more rigid. The rigidity prevents vibration.
2. Anti friction bearings are used.
3. Micro dials are used for adjusting feed and depth of cut.
4. Very fine thread screws are used for giving accurate movement to the tool and workpiece.
5. Accurate guide ways are provided.
6. A precision gear box is used for getting different speeds.
7. Speed range available is more.
8. Carbide tipped or diamond tipped cutting tools are used.

Because of the above, the machine produces very accurate holes with a very fine surface finish. By using carbide tipped tools high cutting speed is possible. So the operation is quicker. Fine boring machines are available, in both horizontal type and vertical type.

6.3.4 Jig boring machines

A jig boring machine is specially designed machine tool. It is used for precision location and machining of holes in jigs, fixtures, dies and gauges. In jig boring machine, accurate setting, drilling, reaming, boring, counter boring, grinding, tapping and milling operations are also done. The holes can be machined with highly accurate centre to centre spacing. Machining accuracy is very high (0.0025mm). The most important feature of a jig boring machine is the accurate method of locating a hole.

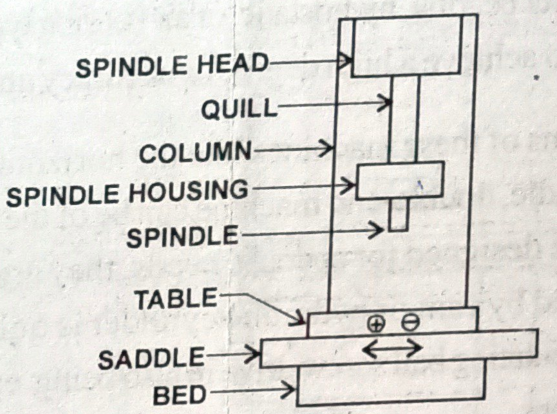


Figure 6.10 Jig boring machine

A block diagram of a jig boring machine is shown in the figure (6.10). It has a heavy base and column. The column carriers a spindle head at the top. The spindle head can slide up and down on the vertical guide ways of the column. There is a quill attached to the spindle head. The spindle housing is fitted at the bottom of the quill.

A saddle moves on the horizontal guide ways over the bed. The table is fitted over the saddle. The table can be adjusted crosswise. The machine spindle rotates in accurate antifriction bearings. The spindle housing is made of a special metal called invar. This metal has a law-coefficient of thermal expansion.

The machine is usually kept in an air conditioned room to eliminate the effects of atmosphere. The holes to be made on a jig or fixture can be accurately located by precise movement of the table.

motion is obtained by rising the work table. But the feed motion can also be obtained by lowering the drill head. Drill jigs are sometimes used to guide accurately into the work.

4.2.8. Deep hole drilling machine

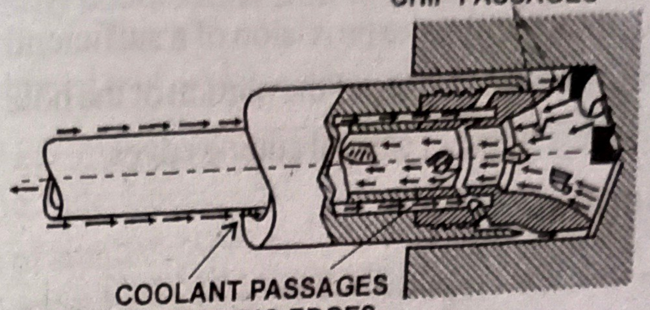


Figure 4.10 Deep Hole Drilling Machine

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. The machines can be obtained both in *(i) Vertical and (ii) Horizontal type*, according to the requirement. In these machines is provided a head stock and a carriage. The work is mounted between these two and the carriage carries the drill. On the headstock side, the work is supported on a spindle, which also rotates. A sectional (enlarged) view of the cutting area is shown in figure (4.10). Both vertical and horizontal machines are used, but the horizontal machines are more commonly used.

The operation is quite clearly shown in figure (4.10). While the drill is fed into the rotating workpiece, the coolant is simultaneously fed to the cutting edges through the passages provided in the hollow body of the drill for this, purpose. This coolant serves dual purpose of cooling the cutting edge during operation and taking away the chips alongwith it, while running. In case of very long workpieces the step feed method is preferred instead of continuous feed. This involves a length equal to its diameter. This helps in easy removal of chips from the hole. In most of the cases this operation is automatic. The vertical design of these machines are used for relatively shorter jobs.

Special Deep Hole Drills

The depth of the hole to be drilled divided by the diameter of the drills is the depth to diameter ratio. Most hole makers consider a ratio of 3 to 1 to be deep hole drilling, after while hole accuracy (location) drilling speed and tool life will be reduced. The bores of rifle barrels were once drilled using conventional drills.