SHAPER

Shaper is a reciprocating type of machine tool in which the ram moves the cutting tool backwards and forwards in a straight line. The basic components of shaper are shown in Fig. 23.1. It is intended primarily to produce flat surfaces. These surfaces may be horizontal, vertical, or inclined. In general, the shaper can produce any surface composed of straight-line elements. The principal of shaping operation is shown in Fig. 23.2 (a, b). Modern shapers can also generate contoured surface as shown in Fig. 23.3. A shaper is used to generate flat (plane) surfaces by means of a single point cutting tool similar to a lathe tool.

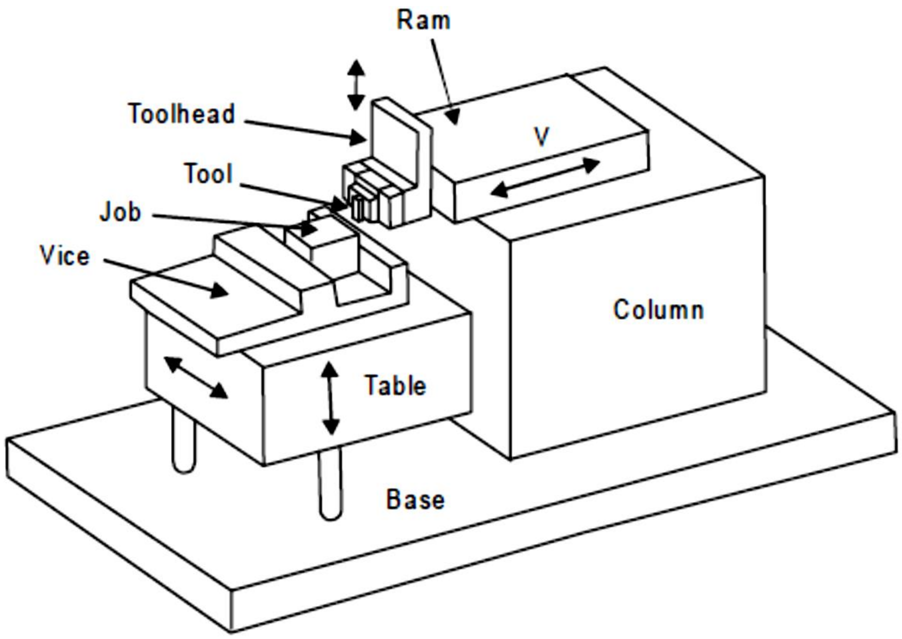


Fig. 23.1 Principal components of a shaper

WORKING PRINCIPLE OF SHAPER

A single point cutting tool is held in the tool holder, which is mounted on the ram. The work piece is rigidly held in a vice or clamped directly on the table. The table may be supported at the outer end. The ram reciprocates and thus cutting tool held in tool holder moves forward and backward over the work piece. In a standard shaper, cutting of material takes place during the forward stroke of the ram. The backward stroke remains idle and no cutting takes place during this stroke. The feed is given to the work piece and depth of cut is adjusted by moving the tool downward towards the work piece. The time taken during the idle stroke is less as compared to forward cutting stroke and this is obtained by quick return mechanism. The cutting action and functioning of clapper box is shown in Fig.23.4 during forward and return stroke.

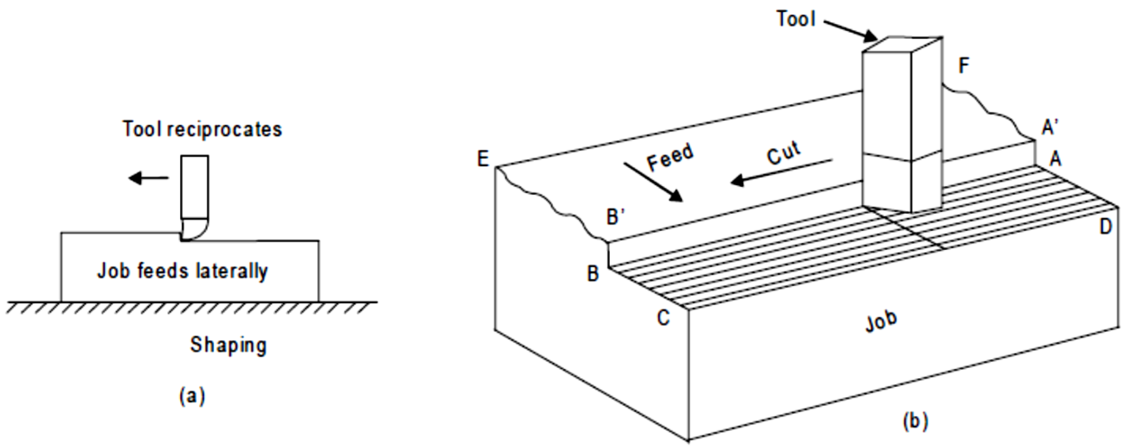


Fig. 23.2 (a, b) Working principal of shaping machine

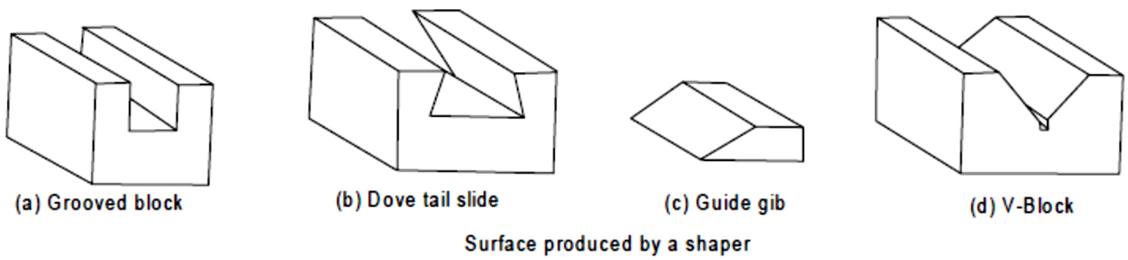


Fig. 23.3 Job surfaces generated by shaper

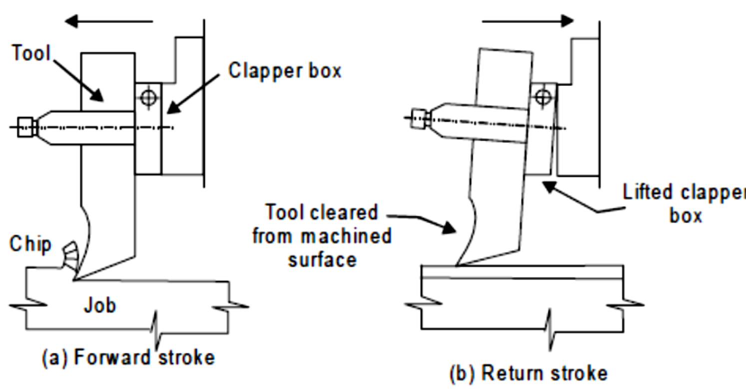


Fig. 23.4 Cutting action and functioning of clapper box

TYPES OF SHAPERS

Shapers are classified under the following headings:

According to the type of design of the table:
(*a*) Standard shaper
(*b*) Universal shaper

According to the position and travel of ram:
(*a*) Horizontal type
(*b*) Vertical type

According to the type of mechanism used for giving reciprocating motion to the ram
(*a*) Crank type
(*b*) Hydraulic type

Crank Shaper
This is the most common type of shaper. It employs a crank mechanism to change circular motion of a large gear called "bull gear" incorporated in the machine to reciprocating motion of the ram. The bull gear receives power either from an individual motor or from an overhead line shaft if it is a belt-driven shaper.

Hydraulic Shaper
In hydraulic shaper, reciprocating motion of the ram is obtained by hydraulic power. For generation of hydraulic power, oil under high pressure is pumped into the operating cylinder fitted with piston. The piston end is connected to the ram through piston rod. The high pressure oil causes the piston to reciprocate and this reciprocating motion is transferred to the ram of shaper. The important advantage of this type of shaper is that the cutting speed and force of the ram drive are constant from the very beginning to the end of the cut.

Standard Shaper
In standard shaper, the table has only two movements, horizontal and vertical, to give the feed.

Universal Shaper
A universal shaper is mostly used in tool room work. In this type of shaper, in addition to the horizontal and vertical movements, the table can be swiveled about an axis parallel to the ram ways, and the upper portion of the table can be tilted about a second horizontal axis perpendicular to the first axis.

Horizontal Shaper
In this type of shaper, the ram holding the tool reciprocates in a horizontal axis.

Vertical Shaper
In vertical shaper, the ram reciprocates in a vertical axis. These shapers are mainly used for machining keyways, slots or grooves, and internal surfaces.

PRINCIPAL PARTS OF SHAPER
Fig. 23.5 shows the parts of a standard shaper. The main parts are given as under.
1. Base
2. Column
3. Cross-rail
4. Saddle
5. Table
6. Ram
7. Tool head
8. Clapper box

9. Apron clamping bolt
10. Down feed hand wheel
11. Swivel base degree graduations
12. Position of stroke adjustment hand wheel
13. Ram block locking handle
14. Driving pulley
15. Feed disc
16. Pawl mechanism
17. Elevating screw
Some of important parts are discussed as under.

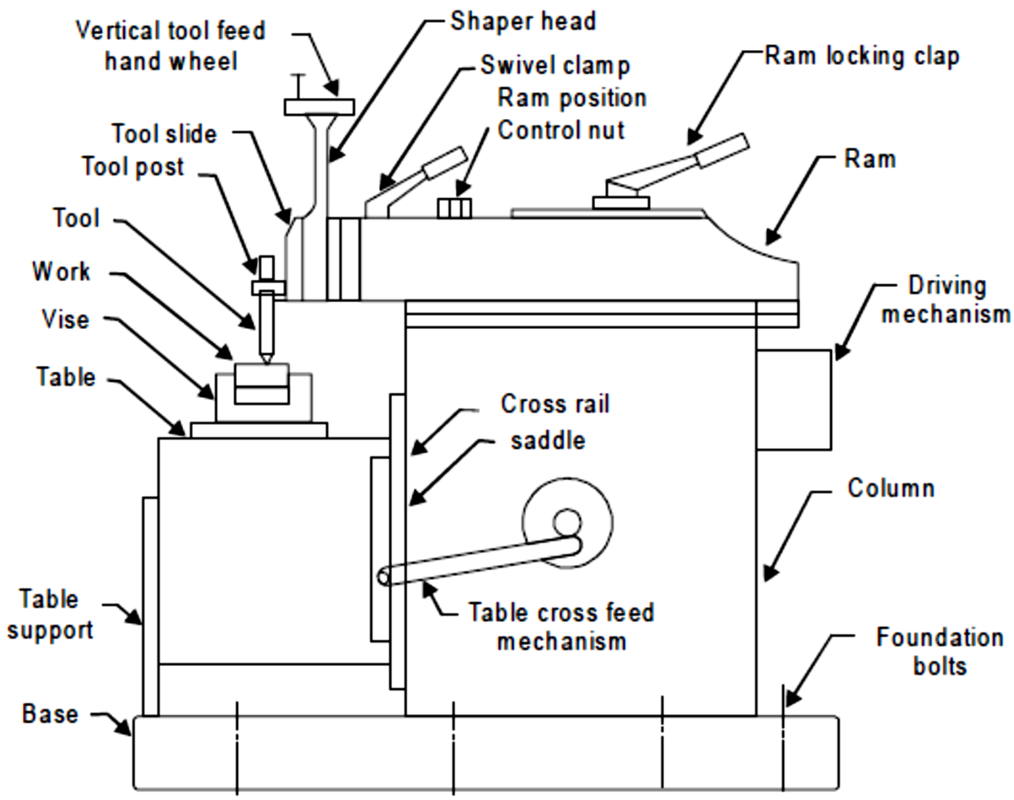


Fig. 23.5 Parts of a standard shaper

Base

It is rigid and heavy cast iron body to resist vibration and takes up high compressive load. It supports all other parts of the machine, which are mounted over it. The base may be rigidly bolted to the floor of the shop or on the bench according to the size of the machine.

Column

The column is a box shaped casting mounted upon the base. It houses the ram-driving mechanism. Two accurately machined guide ways are provided on the top of the column on which the ram reciprocates.

Cross rail

Cross rail of shaper has two parallel guide ways on its top in the vertical plane that is perpendicular to the rai1 axis. It is mounted on the front vertical guide ways of the column. It consists mechanism for raising and lowering the table to accommodate different sizes of jobs by rotating an elevating screw which causes the cross rail to slide up and down on the vertical face of the column. A horizontal cross feed screw is fitted within the cross rail and parallel to the top guide ways of the cross rail. This screw actuates the table to move in a crosswise direction.

Saddle

The saddle is located on the cross rail and holds the table on its top. Crosswise movement of the saddle by rotation the cross feed screw by hand or power causes the table to move sideways.

Table

The table is a box like casting having T -slots both on the top and sides for clamping the work. It is bolted to the saddle and receives crosswise and vertical movements from the saddle and cross rail.

Ram

It is the reciprocating part of the shaper, which reciprocates on the guide ways provided above the column. Ram is connected to the reciprocating mechanism contained within the column.

Tool head

The tool head of a shaper performs the following functions-

(1) It holds the tool rigidly,

(2) It provides vertical and angular feed movement of the tool, and

(3) It allows the tool to have an automatic relief during its return stroke.

The various parts of tool head of shaper are apron clamping bolt, clapper box, tool post, down feed, screw micrometer dial, down feed screw, vertical slide, apron washer, apron swivel pin, and swivel base. By rotating the down feed screw handle, the vertical slide carrying the tool gives down feed or angular feed movement while machining vertical or angular surface. The amount of feed or depth of cut may be adjusted by a micrometer dial on the top of the down feed screw. Apron consisting of clapper box, clapper block and tool post is clamped upon the vertical slide by a screw. The two vertical walls on the apron called clapper box houses the clapper block, which is connected to it by means of a hinge pin. The tool post is mounted upon the clapper block. On the forward cutting stroke the clapper block fits securely to the clapper box to make a rigid tool support. On the return stroke a slight frictional drag of the tool on the work lifts the block out of the clapper box a sufficient amount preventing the tool cutting edge from dragging and consequent wear. The work surface is also prevented from any damage due to dragging.

SPECIFICATION OF A SHAPER

The size of a shaper is specified by the maximum length of stroke or cut it can make. Usually the size of shaper ranges from 175 to 900 mm.

Besides the length of stroke, other particulars, such as the type of drive (belt drive or individual motor drive), floor space required, weight of the machine, cutting to return stroke ratio, number and amount of feed, power input etc. are also sometimes required for complete specification of a shaper.

3.9.1 Specification of a Shaper

The size of the shaper is specified by one of the following criteria:

- Maximum length of stroke of ram, say 700 *mm*.
- Maximum travel of worktable, say 700 *mm* in horizontal direction and 320 *mm* in vertical direction.
- Dimensions of table working surface, say 700 × 450 *mm*.
- Power of motor ranging from 2–5 *hp*.

SHAPER MECHANISM

In a shaper, rotary motion of the drive is converted into reciprocating motion of the ram by the mechanism housed within the column or the machine. In a standard shaper metal is removed in the forward cutting stroke, while the return stroke goes idle and no metal is removed during this period as shown in Fig. 23.4. The shaper mechanism is so designed that it moves the ram holding the tool at a comparatively slower speed during forward cutting stroke, whereas during the return stroke it allow the ram to move at a faster speed to reduce the idle return time. This mechanism is known as quick return mechanism. The reciprocating movement of the ram and the quick return mechanism of the machine are generally obtained by anyone of the following methods:

(1) Crank and slotted link mechanism
(2) Whitworth quick return mechanism, and
(2) Hydraulic shaper mechanism
The crank and slotted link mechanism is discussed as under.

Crank and Slotted Link Mechanism

In crank and slotted link mechanism (Fig. 23.6), the pinion receives its motion from an individual motor or overhead line shaft and transmits the motion or power to the bull gear. Bull gear is a large gear mounted within the column. Speed of the bull gear may be changed by different combination of gearing or by simply shifting the belt on the step cone pulley. A radial slide is bolted to the centre of the bull gear. This radial slide carries a sliding block into which the crank pin is fitted. Rotation of the bull gear will cause the bush pin to revolve at a uniform speed. Sliding block, which is mounted upon the crank pin is fitted within the slotted link. This slotted link is also known as the rocker arm. It is pivoted at its bottom end attached to the frame of the column. The upper end of the rocker arm is forked and connected to the ram block by a pin. With the rotation of bull gear, crank pin will rotate on the crank pin circle, and simultaneously move up and down the slot in the slotted link giving it a rocking movement, which is communicated to the ram. Thus the rotary motion of the bull gear is converted to reciprocating motion of the ram.

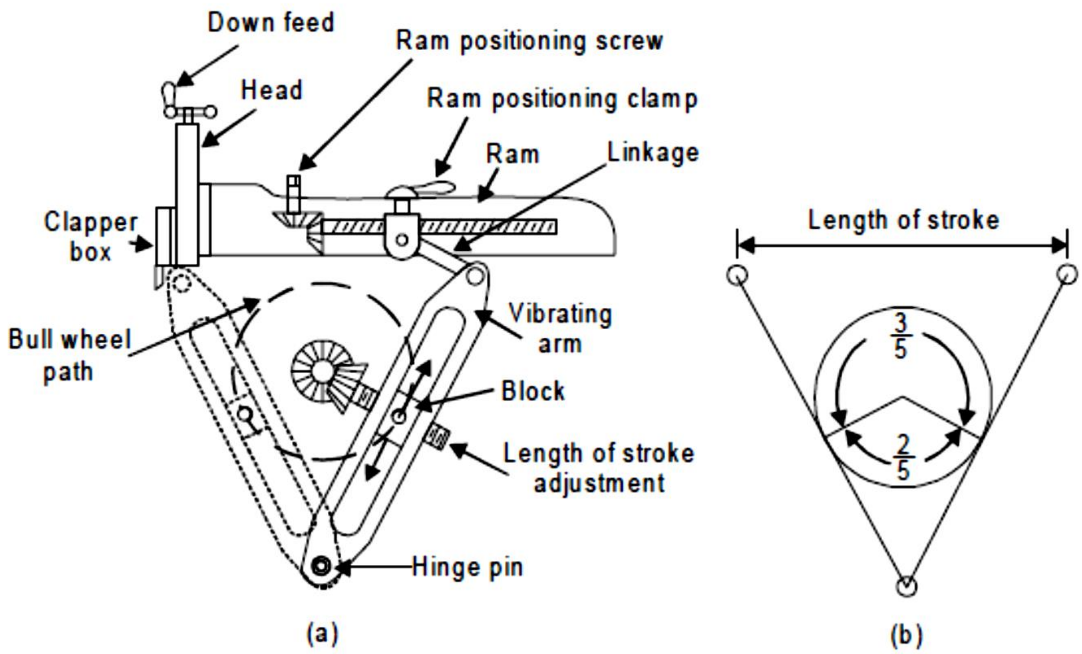


Fig. 23.6 Crank and slotted link mechanism

SHAPER OPERATIONS

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

1. Machining horizontal surface (Fig. 23.7)
2. Machining vertical surface (Fig. 23.8)
3. Machining angular surface (Fig. 23.9)
4. Slot cutting (Fig. 23.10)
5. Key ways cutting (Fig. 23.11)
6. Machining irregular surface (Fig. 23.12)

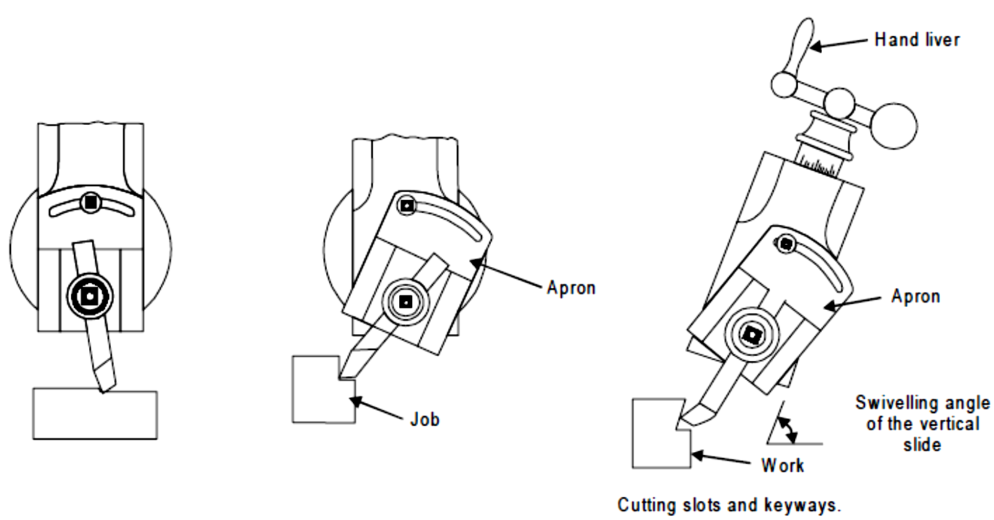
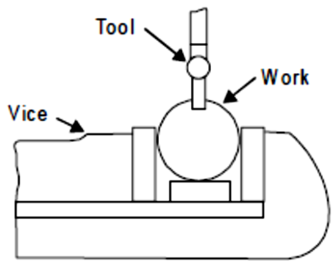
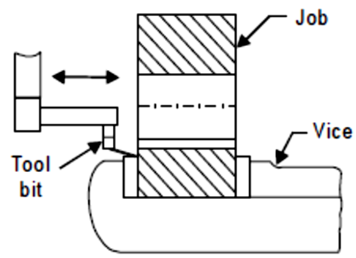


Fig. 23.7 Machining horizontal vertical surface on shaper **Fig. 23.8** Machining vertical surface on shaper **Fig. 23.9** Machining angular surface on shaper



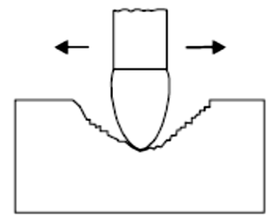
Slot cutting

Fig. 23.10 Slot cutting on shaper



Keyway cutting

Fig. 23.11 Keyway cutting on shaper



Irregular machining

Fig. 23.12 Machining irregular surface on shaper

7.9 CUTTING SPEED, FEED AND DEPTH OF CUT

Cutting speed : In a shaper, the cutting speed is the rate at which the metal is removed by the cutting tool. This is expressed in metre per minute. In a lathe as the cutting action is continuous the cutting speed is expressed by the peripheral speed of the work. But in a shaper the cutting action is intermittent. In a shaper the cutting speed is considered only during the forward cutting stroke.

Cutting speed calculations : The cutting speed in a shaper is expressed by the formula :

$$\text{Cutting speed} = \frac{\text{length of the cutting stroke}}{\text{time required by the cutting stroke}}$$

Feed : Feed (s) is the relative movement of the tool or work in a direction perpendicular to the axis of reciprocation of the ram per double stroke and is expressed in mm. The feed is always given at the end of return stroke when the tool is not cutting the metal. The selection of feed is dependent upon the kind of metal, type of job, etc.

Depth of cut : Depth of cut (t) is the thickness of metal that is removed in one cut. It is the perpendicular distance measured between machined surface and non-machined surface of the workpiece.

Machining horizontal surface : Fig.7.19 illustrates machining horizontal surface on a workpiece. A shaper is mostly used to machine a flat, true surface on a workpiece held in a vise or other holding devices. After the work is properly held on the table, a planing tool is set in the tool post with minimum overhang. The table is raised till there is a clearance of 25 to 30 mm between the tool and the workpiece. The length and position of stroke are then adjusted. The length of stroke should be nearly 20 mm longer than the work and the position of stroke is so adjusted that the tool begins to move from a distance of 12 to 15 mm before the beginning of the cut and continues to move 5 to 8 mm after the end of the cut. Proper cutting speed and feed is then adjusted. Short strokes should be given with high speed while long strokes with slow speed. Both roughing and finishing cuts are performed to complete the job. For roughing cut speed is decreased but feed and depth of cut is increased. Depth of cut is adjusted by rotating the down feed screw of the toolhead. The amount of depth of cut is adjusted by a micrometer dial. The depth of cut for roughing work usually ranges from 1.5 to 3 mm, while for finishing work it ranges from 0.075 to 0.200 mm. Feed is adjusted about one half the width of the cutting edge of the tool so that each cut will overlap the last cut giving a smooth surface finish.

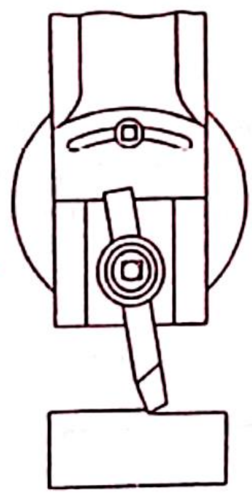


Figure 7.19 Machining horizontal surface

Machining vertical surface : Fig7.20 illustrates machining vertical surface on a workpiece. A vertical cut is made while machining the end of a workpiece, squaring up a block or cutting shoulder. The work is mounted in the vise or directly on the table and the surface to be machined is carefully aligned with the axis of the ram. A side cutting tool is set on the tool post and the position and length of stroke is adjusted. The vertical slide is set exactly at zero position and the apron is swivelled in a direction away from the surface being cut. This is necessary to enable the tool to move upwards and away from the work during return stroke. This prevents the side of the tool from dragging on the planed vertical surface during return stroke. The downfeed is given by rotating the down feed screw by hand. The feed is about 0.25 mm given at the end of each return stroke. Both roughing and finishing cuts are performed to complete the job.

Machining angular surface: Fig.7.21 illustrates machining of an angular surface on a workpiece. An angular cut is made at any angle other than a right angle to the horizontal or to the vertical plane. The work is set on the table and the vertical slide of the toolhead is swivelled to the required angle either towards left or towards right from the vertical position. The apron is then further swivelled away from the work so that the tool will clear the work during return stroke. The downfeed is given by rotating the downfeed screw. Angular surface can also be machined in a universal shaper or by using a universal vise without swivelling the toolhead.

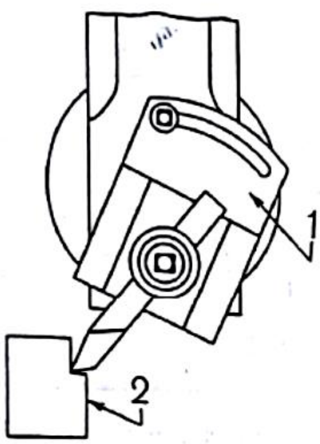


Figure 7.20 Machining vertical surface
1. Apron, 2. Work.

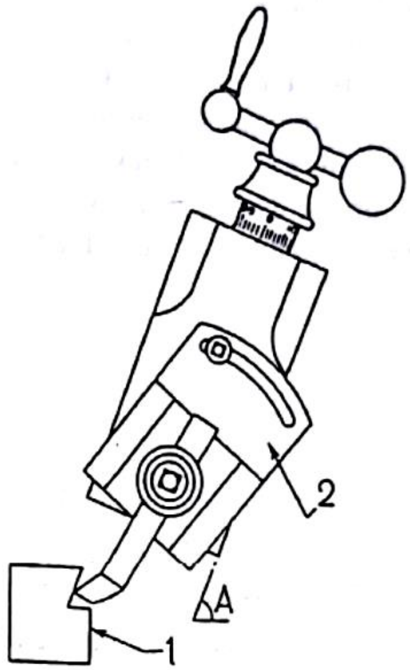


Figure 7.21 Machining angular surface
1. Work, 2. Apron, A, Swivelling angle of the vertical slide.

Cutting slots and keyways : With suitable tools a shaper can very conveniently machine slots or grooves on a work or cut external keyways on shafts and internal keyways on pulleys or gears. For cutting slots or keyways a square nose tool similar to a parting tool is selected. Fig.7.22 illustrates cutting of external keyways and Fig.7.23 shows cutting of internal keyways in a shaper. External keyways are cut on a shaft by first drilling a hole at the blind end of the keyway. The diameter of the holes should be 0.5 to 0.8 mm oversize than the width of the keyway and the depth should be about 1.5 mm larger than the depth of the keyway. This is necessary to leave a clearance on the tool at the end of the stroke. The length and position of stroke is carefully adjusted so that the stroke will terminate exactly at the clearance hole. The speed is reduced while cutting a keyway. Internal keyways are cut by holding the tool on a special tool holder so that the tool post will not hit against the work at the end of the stroke. The clapper block is locked in the clapper box to prevent the tool from lifting during return stroke. Lubrication is necessary on the work to prevent the cutting edge of the tool from wear due to dragging.

1. Tool bit, 2. Work., 3. Vise

Machining irregular surface : A shaper can also produce a contoured surface, i.e. a convex or concave surface or a combination of any of the above surfaces. To produce a small contoured surface a forming tool is used. If the curve is sufficiently large, power-crossfeed in conjunction with manual downfeed is so adjusted that the tool will trace the required contour. If the contour has too many ups and downs both the feeds are operated by hand. A round nose tool is selected for machining irregular surfaces. For a shallow cut the apron may be set vertical but if the curve is quite sharp, the apron is swivelled towards right or left away from the surface to be cut. Fig.7.24 shows machining of a concave surface using a round nose tool.

7.8 SHAPER TOOLS

The cutting tool used in a shaper is a single point cutting tool having rake, clearance and other tool angles similar to a lathe tool. It differs from a lathe tool in tool angles. Shaper tools are much more rigid and heavier to withstand shock experienced by the cutting tool at the commencement of each cutting stroke. In a lathe tool the effective angle of rake and clearance may be varied by raising or lowering the point of the tool in relation to the centre of the work, but in a shaper the tool angles cannot be changed as the tool is always clamped perpendicular to the surface of the work. When it becomes necessary to change the tool angles it can only be done by grinding. In a lathe tool sufficient amount of side clearance angle must be provided as the tool is continually fed sideways tracing a helical path, but in a shaper tool as the feed is given at the end of cutting stroke, a very small clearance angle is necessary to give relief to the side cutting edge. In a shaper tool the amount of side clearance angle is only 2° to 3° and the front clearance angle is 4° for cast iron and steel. Small clearance angle adds strength to the cutting edge. As the tool removes metal mostly from its side cutting edge, side rake of 10° is usually provided with little or no front rake. The side rake angle to be provided is dependent upon the kind of metal being cut, the hardness of the tool material, type of cut: roughing or finishing , and other factors which influence the rake angle. A shaper can also use a right hand or left hand tool. The left hand tool is more common because it permits the operator to see the cut better than the right hand tool. High speed steel is the most common material for a shaper tool but shock resistant cemented carbide tipped tool is also used where harder material is to be machined. As in a lathe, tool holders are also used to hold the tool bits. Some of the most common cutting tools are :

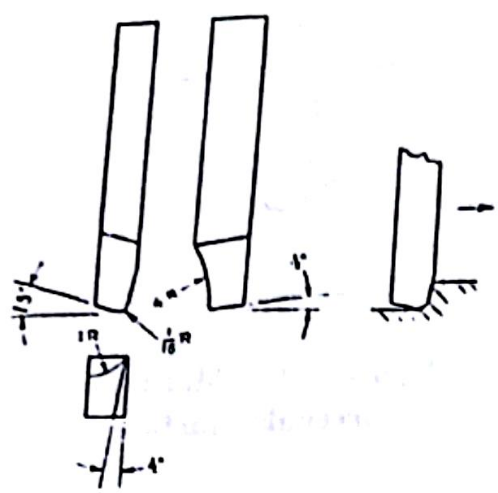


Figure 7.25 A left hand roughing tool for planing

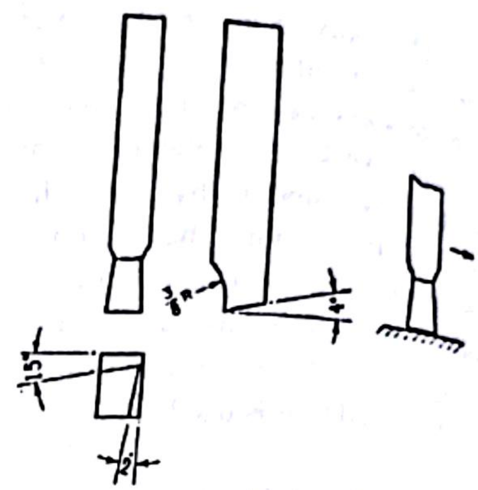


Figure 7.26 A left hand finishing tool for planing

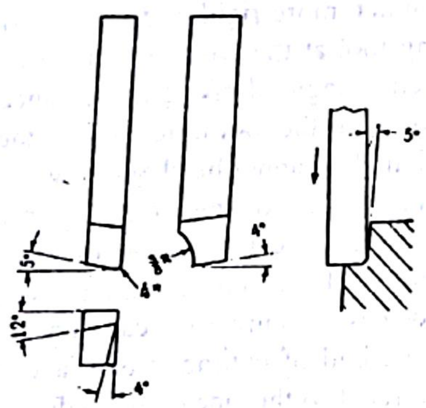


Figure 7.27 A left hand side roughing tool

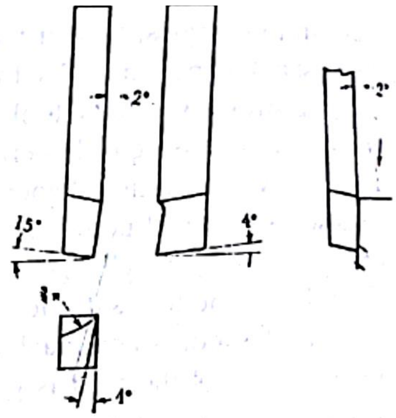


Figure 7.28 A left hand side finishing tool

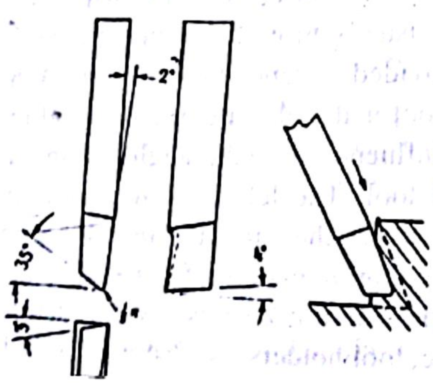


Figure 7.29 A left hand dovetail cutting tool for roughing

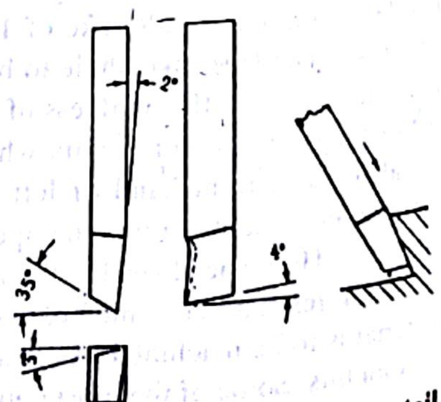


Figure 7.30 A left hand dovetail cutting tool for finishing

1. A left hand roughing tool for planing (Fig.7.25)
2. A left hand finishing tool for planing (Fig.7.26)
3. A left hand side facing tool for vertical shaping and for shaping sharp corner (roughing) (Fig.7.27)
4. A left hand side facing tool (finishing) (Fig.7.28)
5. A left hand dovetail cutting tool (roughing) (Fig.7.29)
6. A left hand dovetail cutting tool (finishing) (Fig.7.30)
7. A parting or slotting tool. (Fig.7.31.)

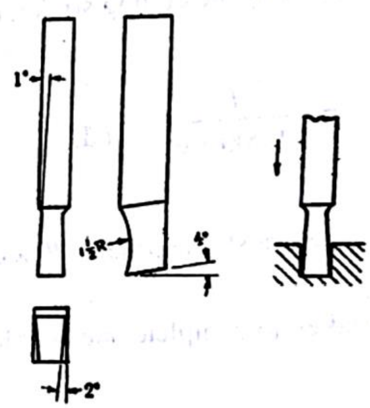


Figure 7.31 A parting or sloting tool