REVIEW OF MACHINE TOOLS SUCH AS MILLING, SHAPING AND PLANING MACHINES, VARIOUS CUTTERS OF MACHINE TOOLS

SHAPER

Shaper is a reciprocating type of machine tool in which the ram moves the cutting tool backwards and forwards in a straight line. 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. A shaper is used to generate flat (plane) surfaces by means of single point cutting tool similar to a lathe tool.

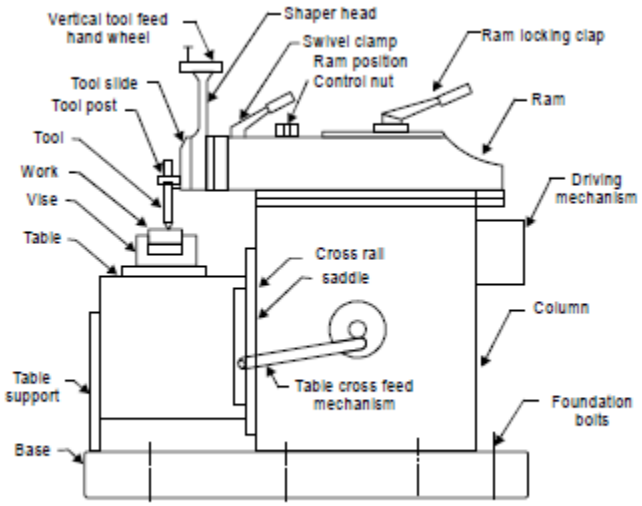


Fig. 1: Parts of a standard shaper

WORKING PRINCIPLE OF SHAPER

A single point cutting tool is held in the tool holder, which is mounted on the ram. The workpiece 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 workpiece. The time taken during the idle stroke is less as compared to forward cutting stroke and this is obtained by quick return mechanism.

SHAPER MECHANISM

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 returning stroke goes idle and no metal is removed during this period. 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 any of the following methods: crank and slotted link mechanism, Whitworth quick return mechanism and hydraulic shaper mechanism.

SURFACES PRODUCED ON SHAPER

Surfaces produced on shaping machine are horizontal plain surface, vertical plain surface, inclined surface, grooved surface, slotted surface, stepped surface.

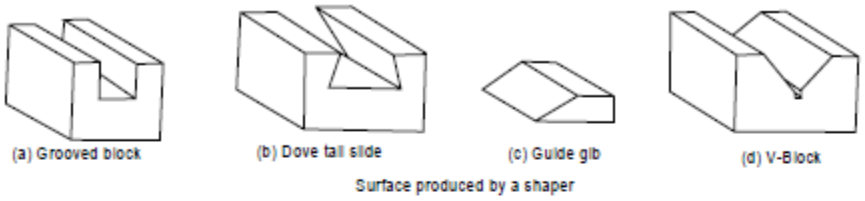


Fig. 2: Job surfaces generated by shaper

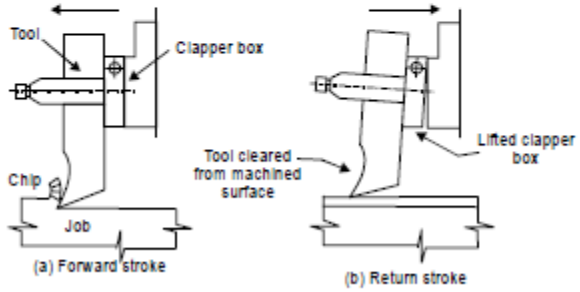


Fig. 3: Cutting action and functioning of clapper box

PLANER

Like a shaper, planer is used primarily to produce horizontal, vertical or inclined flat surfaces by a single cutting tool. However, it is used for machining large and heavy work-pieces that cannot be accommodated on the table of a shaper. In addition, it is used in machining multiple small parts held in line on the platen. Planer is mainly of two kinds namely open housing planer and double housing planer. The bigger job is fixed with the help of the grooves on the base of the planer and is accurately guided as it travels back and forth. Cutting tools are held in tool heads of double housing planer and the work piece is clamped onto the worktable.

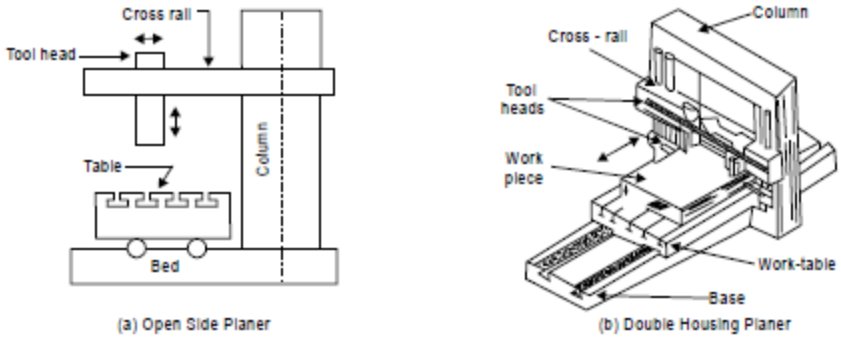


Fig. 4: Principle parts of double housing planer

WORKING PRINCIPLE OF PLANER

In a planer, the work which is supported on the table reciprocates past the stationary cutting tool and feed is imparted by the lateral movement of the tool holder and work on the table. Like shaper, the planer is equipped with clapper box to raise the tool in idle stroke. The different mechanisms used to give reciprocating motion to the table are: Reversible motor drive, Open and cross belt drive and hydraulic drive.

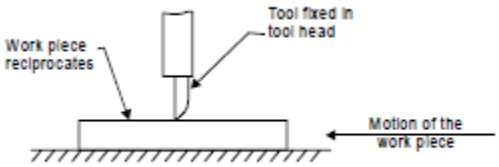


Fig. 5: Working principle of a planer

DIFFERENCES BETWEEN SHAPER AND PLANER

1. In shaper, the work is held stationary and the cutting tool on the ram is moved back and forth across the work whereas in a planer, the tool is stationary and the work piece travels back and forth under the tool.
2. A shaper is used for shaping much smaller jobs whereas a planer is meant for much larger jobs than can be undertaken on a shaper.
3. A shaper is a light machine whereas a planer is a heavy machine.
4. Shaper can employ light cuts and finer feed whereas planer can employ heavier cuts and coarse feed.
5. A shaper uses one cutting tool at a time whereas several tools can cut simultaneously on a planer.
6. The shaper is driven using quick return link mechanism whereas the drive on the planer table is either by gears or by hydraulic means.
7. Shaper is less rigid and less robust whereas because of better rigidity of planer, as compared to that of shaper, planer can give more accuracy on machined surfaces.

SLOTTER

The slotter or slotting machine is also a reciprocating type of machine tool similar to a shaper or a planer. It may be considered as a vertical shaper. The chief difference between a shaper and a slotter is the direction of the cutting action. The machine operates in a manner similar to the shaper, however, the tool moves vertically rather than in a horizontal direction. The job is held stationary. The slotter has a vertical ram and a hand or power operated rotary table.

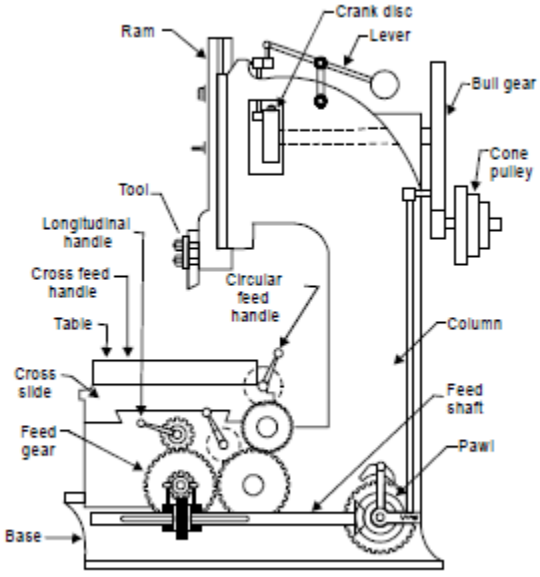


Fig.6: Slotter and its various parts

OPERATIONS PERFORMED ON A SLOTTING MACHINE

A slotter is a very economical tool when used for certain classes of work given.

1. It is used for machining vertical surfaces.
2. It is used for angular or inclined surfaces.
3. It is used to cut slots, splines, keyways for both internal and external jobs such as machining internal and external gears.
4. It is used for machining dies and punches.
5. It is used for shaping internal and external forms or profiles.
6. It is used for works as machining concave, circular, semi-circular and convex surfaces.
7. It is used for internal machining of blind holes.

Since a slotter works slowly, it has less use in mass production work. It can be substituted by the broaching machine.

MILLING

A milling machine is a machine tool that removes metal as the work is fed against a rotating multi-point cutter. The milling cutter rotates at high speed and it removes metal at a very fast rate with the help of

multiple cutting edges. One or more numbers of cutters can be mounted simultaneously on the arbor of milling machine. This is the reason that a milling machine finds wide application in production work. Milling machine is used for machining flat surfaces, contoured surfaces, surfaces of revolution, external and internal threads and helical surfaces of various cross-sections. Due to higher production rate and accuracy, milling machine has even replaced shapers and slotters.

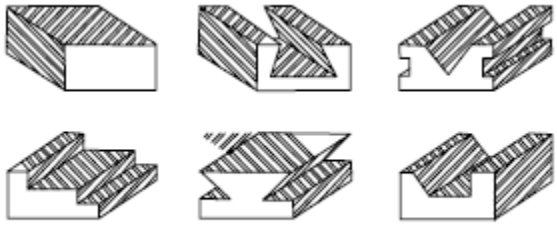


Fig.7: Job surfaces generated by milling machine

PRINCIPLE OF MILLING

In milling machine, the metal is cut by means of a rotating cutter having multiple cutting edges. For cutting operation, the work piece is fed against the rotary cutter. As the work piece moves against the cutting edges of milling cutter, metal is removed in form of chips of trochoid shape. Machined surface is formed in one or more passes of the work. The work to be machined is held in a vice, rotary table, a three jaw chuck, an index head, between centres, in a special fixture or bolted to machine table. The rotational speed of the cutting tool and feed rate of the work piece depend upon the type of material being machined.

MILLING METHODS

1. **Up-Milling or Conventional Milling Procedure**
   The metal is removed in form of small chips by a cutter rotating against the direction of travel of the work piece. In this type of milling, the chip thickness is minimum at the start of the cut and maximum at the end of the cut. As a result, the cutting force also varies from zero to the maximum value per tooth movement of the milling cutter. The major disadvantages of up-milling process have the tendency of cutting force to lift the work from the fixtures and poor surface finish obtained. But being a safer process, it is commonly used method of milling.

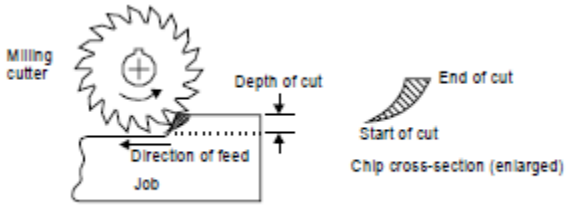


Fig.8: Principle of up-milling

2. **Down-Milling or Climb Milling**
   The metal is removed by a cutter rotating in the same direction of feed of the work-piece. The effect of this is that the teeth cut downward instead of upwards. Chip thickness is maximum at the start of the cut and minimum in the end. In this method, it is claimed that there is less

friction involved and consequently less heat is generated on the contact surface of the cutter and work-piece. It is used to increase the number of pieces per sharpening and to produce a better finish. Also slightly lower power consumption is obtainable by climb milling, since there is no need to drive the table against the cutter.

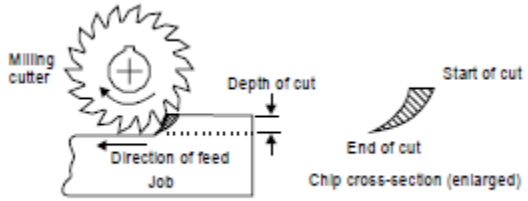


Fig. 9: Principle of down-milling

TYPES OF MILLING CUTTERS

The figures below show some types of milling cutters along with work-pieces. Milling cutters are made in various forms to perform certain classes of work, and they may be classified as:

1. Plain milling cutters
2. Side milling cutters
3. Face milling cutters
4. Angle milling cutters
5. End milling cutters
6. Fly cutter
7. T-slot milling cutter
8. Formed cutters
9. Metal slitting saw

Milling cutters may have teeth on the periphery or ends only, or on both the periphery and ends. Peripheral teeth may be straight or parallel to the cutter axis, or they may be helical, sometimes referred as spiral teeth.

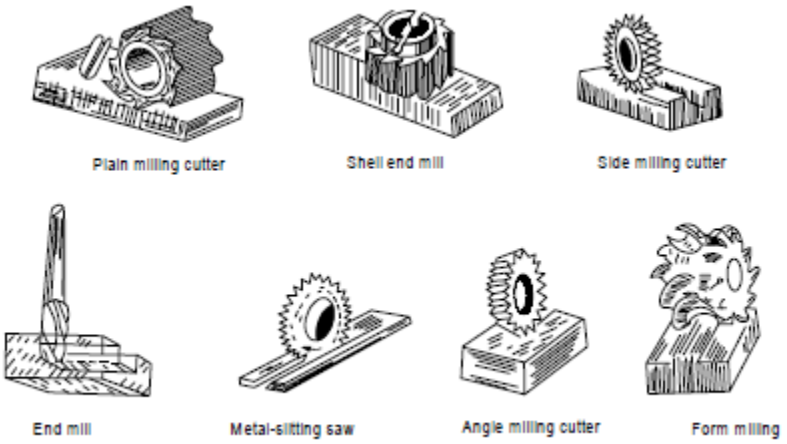
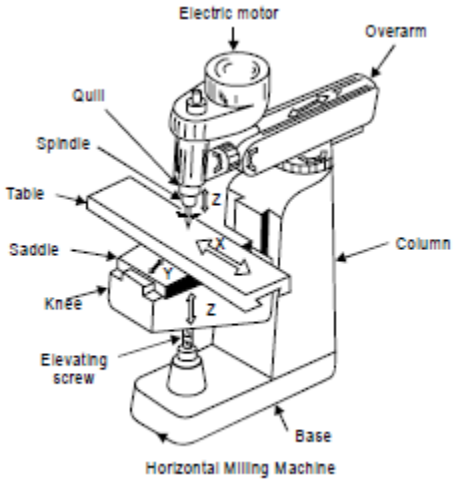


Fig. 10: Types of milling cutters

TYPES OF MILLING MACHINE

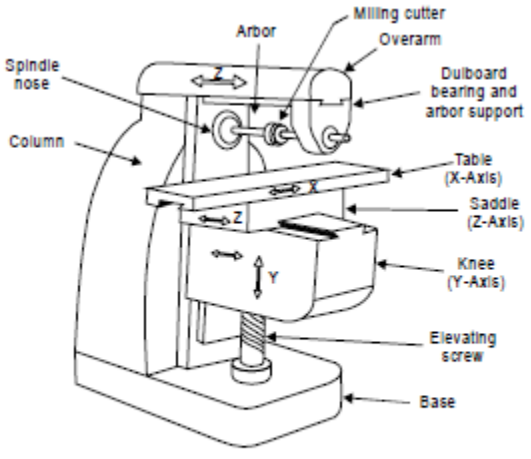
Milling machine rotates the cutter mounted on the arbor of the machine and at the same time automatically feed the work in the required direction. The milling machine can be classified in several forms, but choice of any particular machine is determined primarily by the size of the work-piece to be undertaken and operations to be performed. Milling machines are made in variety of types and sizes. They are:

1. **Column and knee type milling machines** which include hand milling machine, horizontal milling machine, Universal milling machine and vertical milling machine. It is the most commonly used milling machine used for general shop work.



Horizontal Milling Machine

Fig. 11: Horizontal column and knee type milling machine



Vertical Milling Machine

Fig. 12: Vertical column and knee type milling machine

2. **Planer milling machine**: It is a heavy duty machine. It resembles a planer and like a planing machine it has a cross rail capable of being raised or lowered carrying the cutters, the heads, and the saddles, all supported by rigid uprights. The use of the machine is limited to production of work only and is considered ultimate in metal removing capacity.

3. **Fixed-bed type milling machine** which include Simplex milling machine, Duplex milling machine and Triplex milling machine
4. **Machining centre machines**
5. **Special types of milling machines** such as Rotary table milling machine, Planetary milling machine, Profiling machine, Duplicating machine, Pantograph milling machine, Continuous milling machine, Drum milling machine and Profiling and tracer controlled milling machine. It is developed to suit special purposes.

DEPTH OF CUT

The depth of cut in milling machine is defined as "the thickness of the material removed in one pass of the work under the cutter". Thus, it is the perpendicular distance measured between the original and final surface of the work-piece, and is expressed in mm.

INDEXING AND DIVIDING HEADS

Indexing is the operation of dividing the periphery of a piece of work into any number of equal parts. In cutting spur gear equal spacing of teeth on the gear blank is performed by indexing. Indexing is accomplished by using a special attachment known as dividing head or index head. The dividing heads are of three types:

i. Plain or simple dividing head
ii. Universal dividing head
iii. Optical dividing head

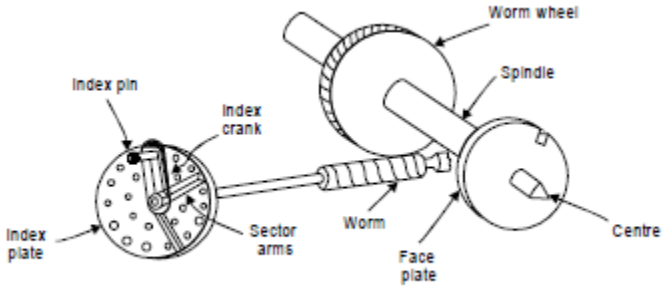


Fig. 14: Dividing head

OPERATIONS PERFORMED ON MILLING MACHINE

A milling cutter does not give a continuous cut, but begins with a sliding motion between the cutter and the work. Then follows a crushing movement, and then a cutting operation by which the chip is removed. The various operations that can be performed on a milling machine include:

i. **Plain milling or slab milling**: It is a method of producing a plain, flat, horizontal surface parallel to the face of the axis of rotation of the cutter.
ii. **Face milling**: It is a method of producing flat surface at right angles to the axis of the cutter.
iii. **Side milling**: It is the operation of a flat vertical surface on the side of a work-piece by using a side milling cutter.

iv. **Angular milling**: It is a method of producing flat surface making an angle to the axis of the cutter.

v. **Gang milling**: It is a method of milling by means of two or more cutters simultaneously having the same or different diameters mounted on the arbor of the milling machine.

vi. **Form milling**: It is a method of producing a surface having an irregular outline.

vii. **End milling**: It is a method of milling slots, flat surfaces and profiles by end mills.

viii. **Profile milling**: it is the operation of reproduction of an outline of a template or complex shape of a master die on a work-piece.

ix. **Saw milling**: It is a method of producing deep slots and cutting materials into the required length by slitting saws.

x. T-slots milling

xi. Keyway milling

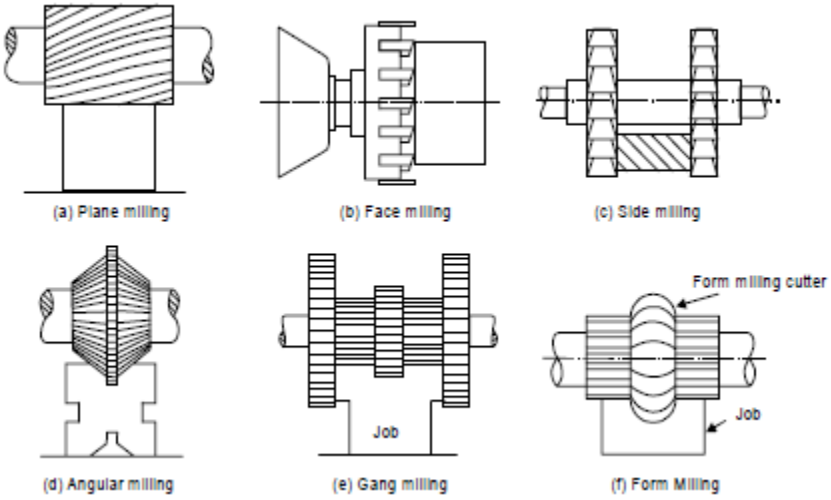
xii. Gear cutting milling: It is a method of producing gears.

xiii. Helical milling: It is a method of producing helical.

xiv. **Flute milling**: It is a method of grooving or cutting of flutes on drills, reamers, taps, etc.

xv. **Straddle milling**: It is a method of milling two sides of a piece of work by employing two side-milling cutters at the same time.

xvi. **Thread milling**: It is a method of milling threads on dies, screws, worms, etc. both internally and externally.



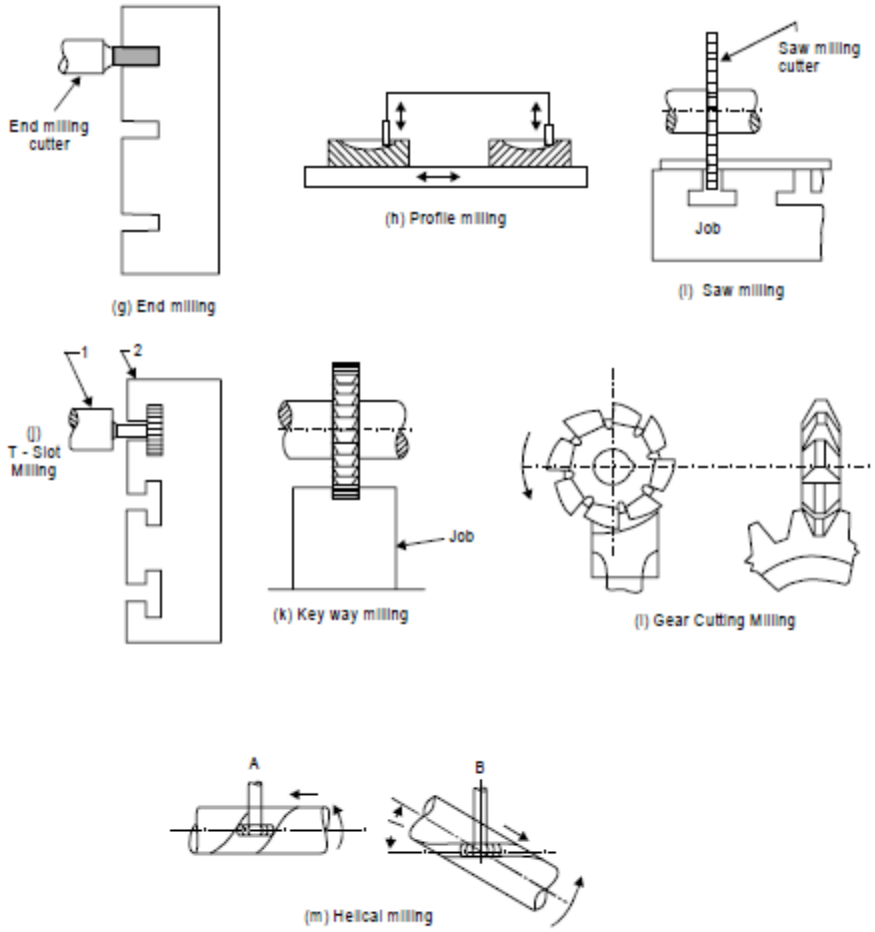


Fig. 13: Various types of milling operations

REVIEW QUESTIONS

1. Differentiate between planer and slotter
2. State the working principle of planer, slotter and milling machine.
3. What is depth of cut?
4. Sketch and describe the indexing head used for gear cutting.
5. Explain various types of milling operations using neat sketches
6. Differentiate between up milling and down milling.