CHAPTER 8

GEAR CUTTING MACHINES

8.1 INTRODUCTION

Milling is the process of removing metal by feeding the work against a rotating multi point cutter. In milling operation the rate of metal removal is rapid as the cutter rotates at a high speed and has many cutting edges.

The first milling machine came into existence in about 1770. Milling cutter was first developed by Jacques de vaucanson in 1782. First successful plain milling machine was designed by Eli whitney in 1818. Joseph R Brown a member of Brown and sharpe co. invented the first universal milling machine in 1861.

8.2 PRINCIPLE OF WORKING

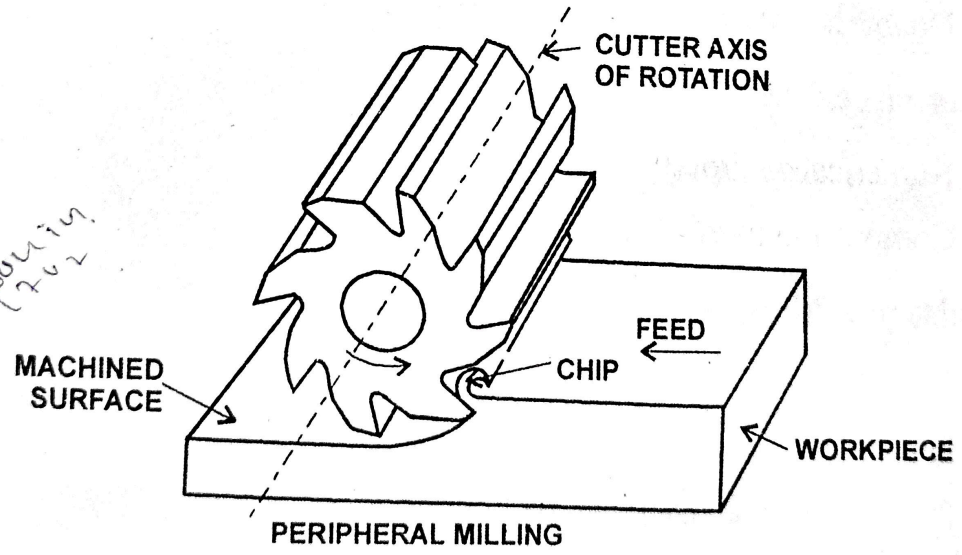

Figure 8.1 Schematic diagram of a milling operation

The working principle, employed in the metal removing operation on a milling machine, is that the work is rigidly clamped on the table of the machine, or held between centres, and revolving multiteeth cutter mounted either on a spindle or an arbor. The cutter revolves at a fairly high speed and the work fed slowly past the cutter. The work can be fed in a

vertical, longitudinal of cross direction. As the work advances, the cutter teeth remove the metal from the work surface to produce the desired shape.

8.3 CLASSIFICATION OF MILLING MACHINES

8.3.1 Column and knee type milling machine

(i) Hand milling machine.
(ii) Plain milling machine.
(iii) Universal milling machine.
(iv) Omniversal milling machine.
(v) Vertical milling machine.

8.3.2 Manufacturing or fixed bed type

(i) Simplex milling machine.
(ii) Duplex milling machine.
(iii) Triplex milling machine.

8.3.3 Planer type milling machine

(i) Single column machine.
(ii) Double housing plano miller.

8.3.4 Machining centres

(i) Numerical control type.
(ii) Computer numerical control type.

8.3.5 Special type milling machines

(i) Rotary table milling machine.
(ii) Drum milling machine.
(iii) Planetory milling machine.
(iv) Pantograph, profilling, tracer control milling machine.
(v) Gear milling or gear hobbing machine.
(vi) Cam milling machine.
(vii) Thread milling machine.
(viii) Spar milling machine. etc.,

8.3.1 Column and knee type milling machine

The column and knee type is the most commonly found in shops. It derives its name from the fact that the work table is supported on a knee like casting, which can slide in a vertical direction along a vertical column. Based on the spindle position and table movements, it is classified as follows:

(i) Hand milling machine.

(ii) Horizontal or plain milling machine.

(iii) Universal milling machine.

(iv) Omuniversal milling machine.

(v) Vertical milling machine.

(i) Hand milling machine

It is the simplest of all the milling machines and smallest in size. All the operations except the rotation of arbor,are performed by hand. The tables carrying the work over it is moved by hand to feed the work.This machine is specially useful in producing small components like hexagonal or square heads on bolts, cutting slots on screw heads, cutting key ways etc.,

(ii) Horizontal or plain milling machine

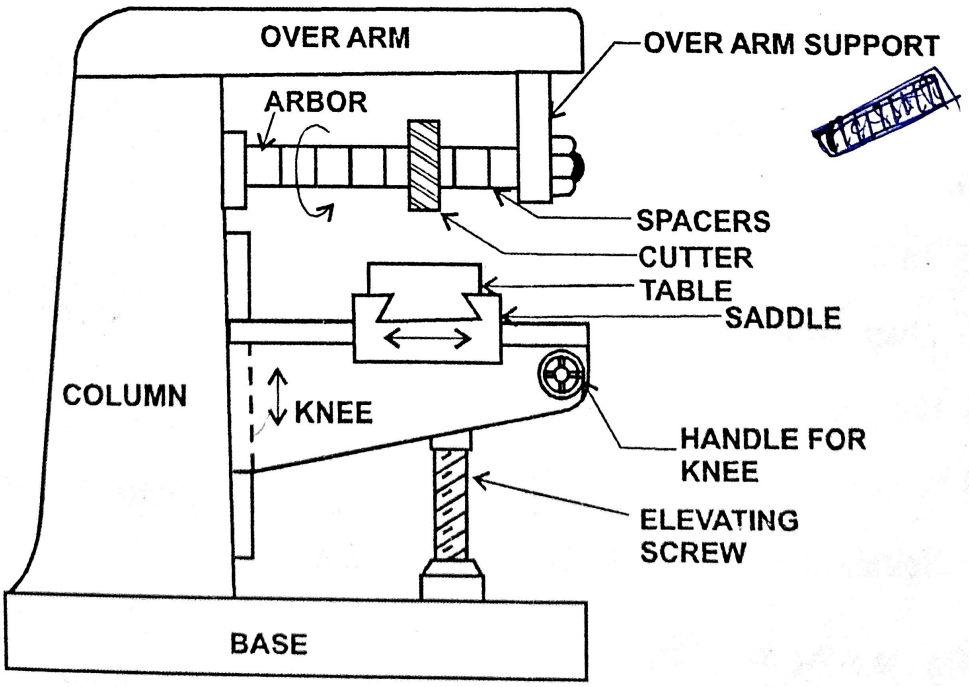

Figure 8.2 Plain milling machine

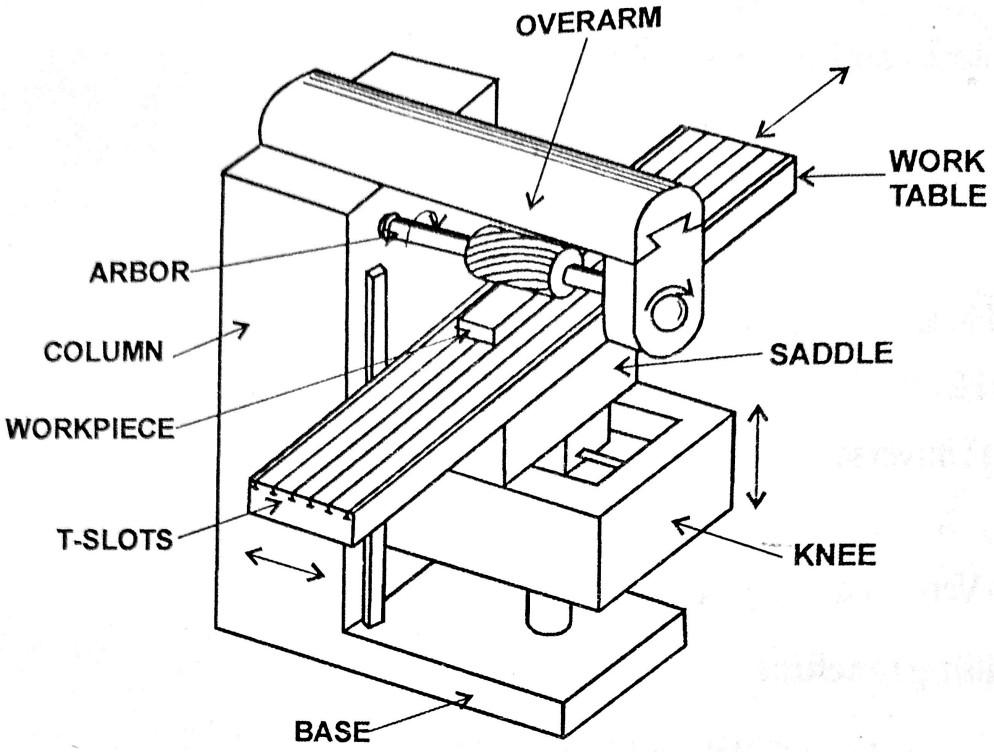

Figure 8.3 3D View Horizontal milling machine

In horizontal or plain milling machine the spindle of the machine is horizontal. The principal parts of horizontal milling machine are:

1. Base
2. Column
3. Knee
4. Saddle
5. Table
6. Over-arm
7. Spindle
8. Arbor
9. Spindle drive and table feed mechanisms

1. Base:

It is the foundations of the machine. All other parts are mounted on it. It carries th column at its one end. It also serves as a reservoir for the cutting fluid.

2. Column:

It is the main supporting frame. The motor and the other driving mechanisms are housed on it. It supports and guides the knee in its vertical travel. The top of the column is holding an over arm that extends outwards at the front of the machine.

3. Knee:

The knee has a horizontal guide ways perpendicular to the front face of the column. The knee projects from the column and moves up and down on the vertical guideways of the column face. It supports the saddle and the table. The saddle slides on the horizontal guide ways towards or away from the column.

4. Saddle:

The saddle supports and carries the table. The top of the saddle has horizontal guideways parallel to the face of the column. The table travels longitudinally along these guideways.

5. Table:

It is provided with T-slots for clamping the work. The table rests on the ways on the saddle. A lead screw is provided under the table when it is engaged with the nut provided in the saddle the table moves longitudinally by hand or power. The longitudinal travel of the table is perpendicular to the axis of the spindle. In an universal milling machine the table may also be swivelled horizontally.

6. Over-arm:

The over arm is mounted on the top of the column. It serves as a bearing support for the other end of the arbor. More than one bearing support may also be provided for the arbor.

7. Spindle:

The front end of the spindle, called nose projects from the column face. It is provided with a tapered hole for inserting either arbor or shank type milling cutter. The milling cutters are connected either directly to the spindle nose or mounted on the arbor. The spindle obtains its power from the motor through belts and gears and transmits it to the arbor or cutter.

8. Arbor:

Arbor is an accurately machined shaft cutters are mounted on the arbor which is rigidly supported by the over-arm spindle and end braces. It is tapered at one end to fit the spindle nose and has two slots to fit the nose keys for locating and driving it.

9. Spindle drive and table feed mechanisms:

The spindle receives power from the combination of belts, gears and clutch assembly. Multiple speeds of spindle may be obtained by changing the gear ratio. The feeding mechanism is housed by the knee. The vertical movement of knee longitudinal movement of table and cross feed movement of saddle can be obtained by hand or power.

Salient features

1. The milling machine yields high production of different varaities of jobs, viz., facing operations of all kinds, slotting key way cuting, groooving, making of hexagonal and other heads of bolts machining concave and convex surfaces, indexing operations for cutting spur, helical gears etc., and forming of cam profiles. Hence it can largely replace other machine tools like shaper, drilling machine and slotter,etc.,
2. It produces better surface finish and all operations can be performed on it with high accuracy. Heavy cuts can be taken with no appreciable sacrifice in finish or accuracy.
3. It can hold can or more number of cutters at a time, this is why the milling machine. finds wide applications in production work.
4. Milling cutters are efficient in their action and can be used for a considerably long time before re-sharpening.

(iii) Universal milling machine

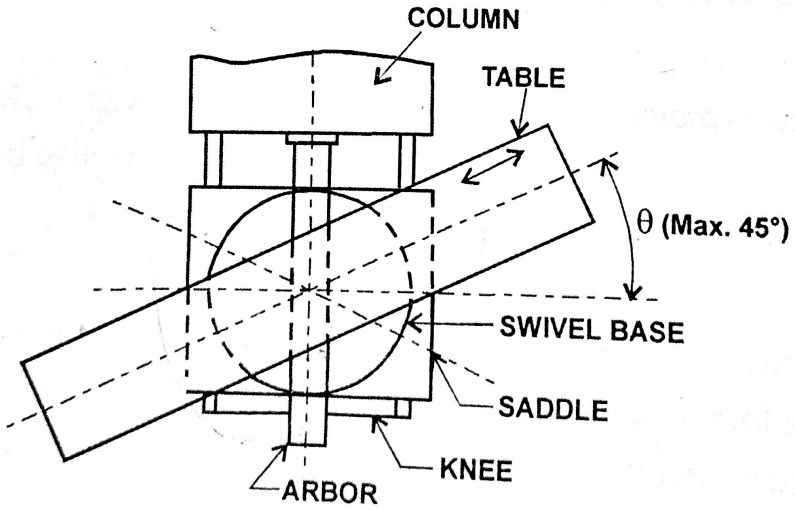

Figure 8.4 Universal milling machine

The Universal milling machine is similar in all respects to the horizontal plain milling machine except for additional swivellling movement for table. The table is mounted on a swivel base.

The swivel base has got degree graduations. The table can be swivelled about a vertical axis. It can be swivelled upto a maximum of 45° on either side of the normal position.Refer figure (8.4).

Thus the universal milling machine table has the following movements.

1. Vertical movement - through the knee
2. Cross wise movement - through the saddle
3. Longitudinal movement of the table.
4. Angular movement of the table - by swivelling the table on the swivel base.

By swivelling the table, the work can be fed at an angle to spindle axis. This is used in helical milling operations.

Special attachment like dividing head, vertical milling attachment, rotary table attachment are used in the universal milling machines. Using these attachmants the machine can produce spur gear, helical gear, bevel gear, twist drill and reamers.

(iv) Omuniversal milling machine

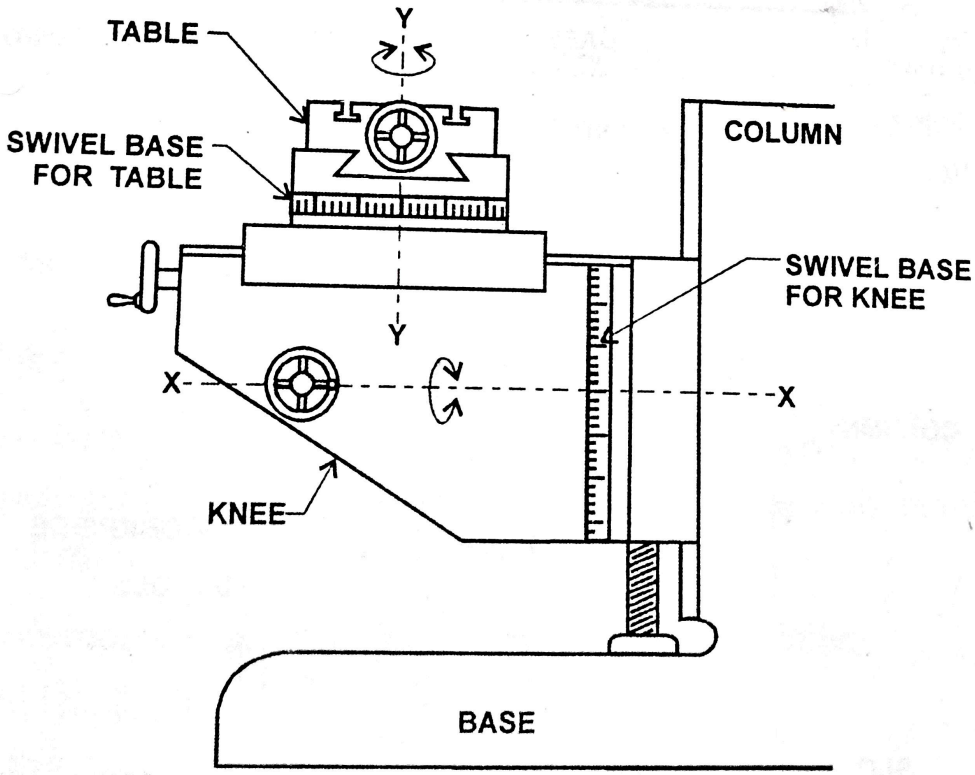

Figure 8.5 Omniversal milling machine

The table of this machine has all the four movements of the universal milling machine. See figure (8.5). In addition, it has one more adjustment for the table. The table can also be swivelled about a horizontal axis "xx" parallel to the spindle.

In this machine the knee has a swivelling arrangement. Using additional swivelling movement, we can machine tapered spiral grooves in reamers, bevel gears etc.,Omniversal milling machine is a tool room machine.

(v) Vertical milling machine

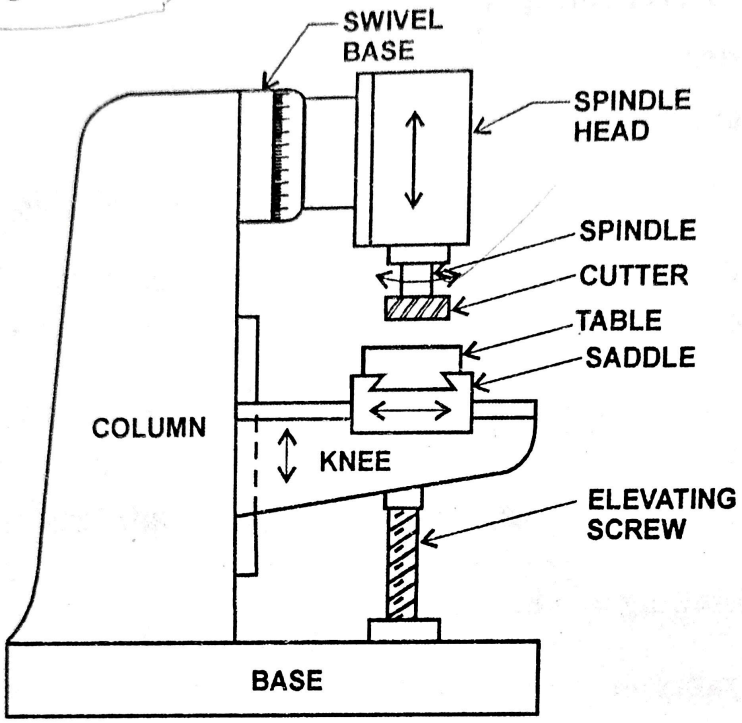

Figure 8.6 Vertical milling machine

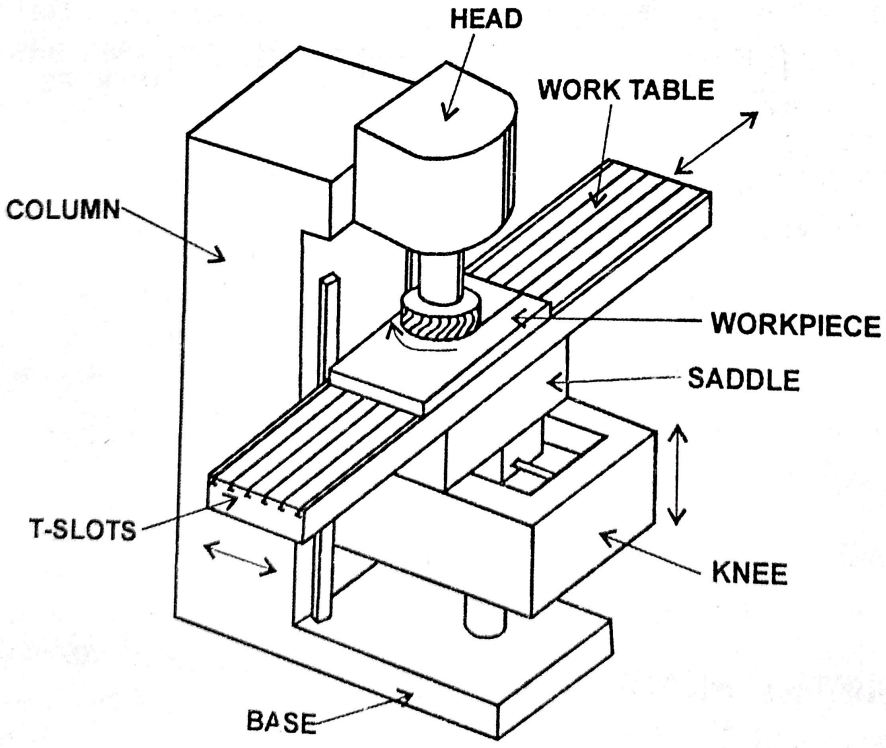

Figure 8.7 3D view of vertical milling machine

In vertical milling machine, the spindle is vertical. It may be of plain or universal type. It consists of :

1. Base
2. Column
3. Knee
4. Saddle
5. Table
6. Spindle drive and feeding mechanisms.
7. Spindle head.

7. Spindle head:

It is mounted on the top of the column. It has a swivel base and hence the spindle head can be swivelled at an angle for machining angular surfaces. The spindle has a taper socket for inserting the milling cutters. The other parts are already explained in horizontal milling machine.

In vertical milling machine milling head consists of a scale provided in degrees and can be swivelled and set at any oblique position. In construction and drive it is similar to a horizontal milling machine, except in spindle direction. Thus machine is usually used for end milling work with end mill cutters, and for producing flat surfaces. Also used for machining grooves and slots.

8.3.2 Fixed bed type milling machines

These are compartatively large heavy and rigid in construction. The vertical motion is imported to the spindle head instead of the table. Depending upon the number of spindle these are classified as,

(i) Simplex or plain type (with single horizontal spindle)
(ii) Duplex (with two horizontal spindle)
(iii) Triplex (with two horizontal and one veritcal spindle)

(i) Simplex milling machine:

The main parts of this type of machine are shown by means of a block diagram in figure (8.8). It differs fron the column and knee plain milling machine in that the table is mounted on a fixed bed instead of the saddle and knee and has a longitudinal travel only. It

Figure (8.16) illustrates a pantograph milling machine for tracing operations. Base 9 mounts column 3 with pivot 4 of pantograph 6. spindle 2 of the milling head and tracer spindle 7. carrying the stylus, rotate in bores of the pantograph. Bracket 5, joined to pivot 4, supports the pantograph.

In milling, the operator moves the stylus by hand along the template or model secured on table 8. At this, the cutter reproduces the motion of the stylus on a reduced scale (from 1:1:5 to1:10) and thus mills the blank clamped on table 1 to the required shape. The scale of reduction can be changed by shifting slide blocks 10 and 11 along the arms of the pantograph. Work table 1 and template table 8 can be adjusted in the vertical and horizontal directions. The cutter spindle is driven by a 0.4 KW motor running at 1480 rpm through two stepped belt transmissions which provide six spindle speeds in the range from 1750 to 9600 rpm.

It is necessary to ensure reliable contact between the stylus and the template in millers with mechanical tracing systems. Excess clearances and elastic deformation in the system and variations in the cutting force and chip cross section in milling may lead to a lack of contact or to vibrations, so that chatter marks are produced on the work.

(v) Gear milling machines

Gears can be used on all plain and universal type of milling machines. These specific classification gear milling actually includes gear hobbing machines which are recorded as milling machines for the reasons that the hobbing tools or hobs are in the shape of teeth milling cutters and are feed while revolving exactly in the same manner as the milling cutters.

8.4 SPECIFICATIONS OF A MILLING MACHINE

The size of the milling is specified by:

(a) The dimensions of the table and the maximum length of longitudinal, cross and vertical travels of the table .

Table length × width =1100 mm × 310mm

(b) Number of spindle speeds, feeds

(c) Power available, taper of spindle nose

(d) Floor space required

(e) Net weight of the machine.

8.5 WORKHOLDING DEVICES

A workpiece must be held securely and rigidly on the milling machine table for accurate milling operations. The most commonly used holding devices are different types of vices. These have been discussed in the chapter on shaping machines. We now proceed to discuss other holding devices used on a milling machine.

(i) T-bolts and clamps

(ii) Angle plates

(iii) V-blocks

(iv) Vises

(a) Plain or parallel vice

(b) Universal vice

(c) Precision Angle vice

(d) Swivel vice

(e) Vertical vice

(f) Compound vice

(v) Dividing head

(vi) Milling fixture

(vii) Circular table.