CHAPTER 05

Milling Machine

Learning Objectives

- Students to know about the inventor of milling machine merits and demerits of it. Isometric view of milling machine, important parts and milling operations.
- To understand, types of milling machine and their explanation, difference between plain and universal milling machine.
- To know about the size of the milling machine, basic milling process, work-holding devices and tool-holding devices in milling machine.
- To understand about the cutting speed, feed depth in milling machine and the structure of indexing head, its working principle, indexing method and safety precautions for milling machine.

Ellarkkum nandraam panidhal avarullum
Selvarkkae selvam thakaiththu. –Kural 125

Humility is good in all, but especially in rich it is (the excellence of) higher riches.

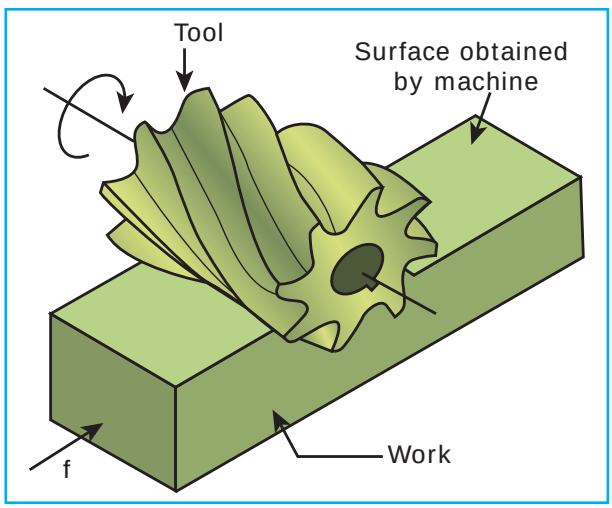
CONTENTS

Milling machine was invented by Eli Whitney in 1818.

In 1861, it was developed by Brown & sharp, Joseph R. Brown to provide various special features of the machine.

5.1 Introduction

Milling is a process of removing metal by feeding the work against a rotating multipoint cutter. The machine tool intended for this purpose is known as milling machine.



It is found in shops where tools and cutters are manufactured. The surface obtained by this machine tool is superior in quality and more accurate and precise. Eli Whitney designed a complete milling machine in 1818. In the year 1861 Joseph Brown, a member of Brown and Sharp Company developed the first universal milling machine.

Advantages

1. The metal is removed at a faster rate as the cutter has got multiple cutting edges and rotates at a higher speed.
2. It is possible to perform machining by mounting more than one cutter at a time.
3. The able of the machine can be moved to an accuracy of 0.02 mm.
4. It is very useful since various cutters and precise tools can be machined.
5. Special attachments can be mounted on the machine to perform operations that are performed in other machine tools.

Disadvantages

1. The cost of the milling machine is high.
2. As milling cutters cost high, the investment for procuring tools is more.
3. The production cost will increase if we carry out the operations performed in a shaper or a drilling machine with a milling machine.

5.2 Horizontal Milling Machine

Base

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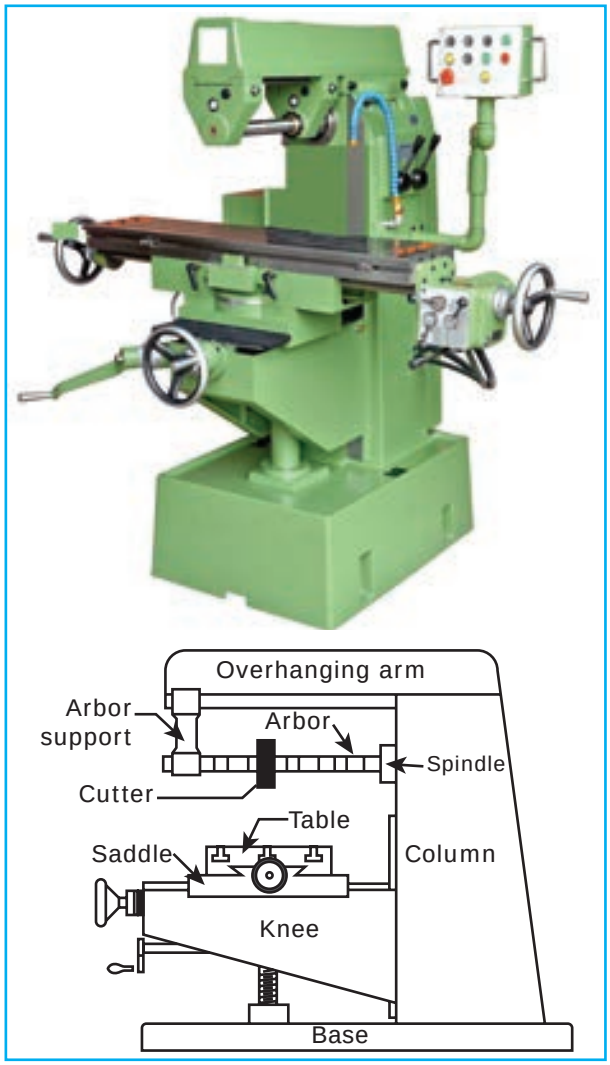
It is made of cast iron and supports all the other parts of the machine tool. A vertical column is mounted upon the base. In some machines, the base serves as a reservoir for cutting fluid.



Horizontal Milling Machine

Column

It is mounted upon the base and it is box shaped. It houses the mechanism for providing drive for the spindle. The front vertical face of the column is machined accurately to form dovetail guideways for the knee to move up and down. The top of the column holds an overhanging arm.

Knee

It slides up and down on the guideways of the column. An elevating screw mounted on the base obtains this movement. Saddle is mounted upon the knee and moves in a crosswise direction.

Saddle

It is mounted on the guideways of the knee and moves towards or away from the face of the column. This movement can be obtained either by power or by hand. The top of the saddle has guideways for the table movement.

Table

The table is moved longitudinally either by power or manually on the guideways of the saddle. The trip dogs, placed on it, control the movement of the table. The table of a universal milling machine can be swiveled horizontally to perform helical works. The top surface of the table has got 'T' – slots on which the workpieces or other work holding devices are mounted.

Spindle

It is located in the upper part of the column. It receives power from the motor through belt, gears and clutches. The front end of the spindle has got a taper hole into which the cutters are held with different cutter holding devices.

Over arm

It supports the arbor from the top of the column. The arbor is supported by the bearing fitted within the arbor support. It is also useful while using some special attachments.

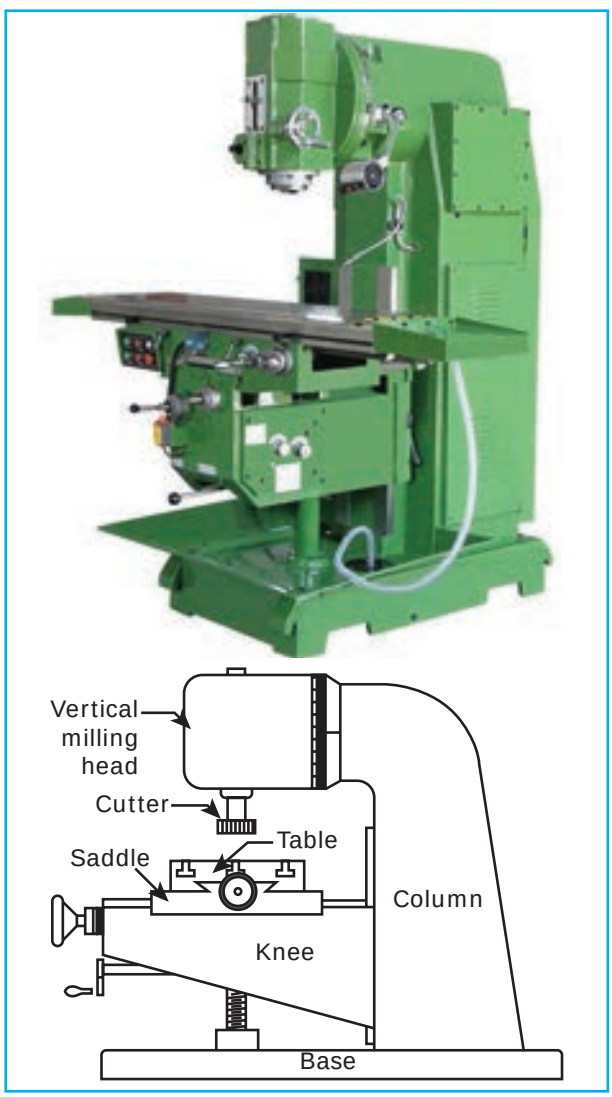
Arbor

It supports the different types of cutters used in the machine. It is drawn into the taper hole of the spindle by a draw bolt. One or more cutters are mounted on the arbor by placing spacing collars between them. The arbor is supported by an arbor support. The arbor is provided with a morse taper or self-releasing taper.

A column and knee type milling machine is illustrated in fig.

5.3 Vertical milling machine

It is very similar to a horizontal milling machine in construction as it has the same parts of base, column, knee, saddle and table. The spindle of the machine is positioned vertically. The cutters are mounted on the spindle is rotated by the power obtained from the mechanism placed inside the column. Angular surfaces are machined by swiveling the spindle head.



Vertical milling machine

5.4 Types of milling machine

The milling machines are classified according to the general deign of the machine.

1. Column and knee type
   a. Plain milling machine
   b. Universal milling machine
   c. Omniversal milling Machine
   d. Vertical milling machine
2. Table types milling machine
3. Planer type milling machine
4. Special type milling machine

Column and knee type milling machine

The column of a column and knee type milling machine is mounted vertically upon the base. Knee is mounted on the accurately machined guideways of the column. It is designed to move up and down accurately. Saddle and table are mounted on the knee.

There are different types of column and knee type machines.

a. Plain milling machine

It is rigid and sturdy. Heavy workpieces are mounted and machined on the machine. The work mounted on the table is moved vertically, longitudinally and crosswise against the rotating cutter. The table cannot be rotated. It is also called as horizontal milling machine because the cutter rotates in horizontal plane.

b. Universal milling machine

The table of a universal milling machine can be swiveled by 45^0 on either side and so helical milling works can be performed.

It is named so because it can be adapted for a very wide range of milling operations.

Various milling attachments like index head, vertical milling head, slot milling head and rotary table can be mounted. It can be machine drills reamers, gears, milling cutters with a very high degree of accuracy and so it finds an important place in workshop.

c. Omniversal milling machine

In addition to the table movement obtained in a universal milling machine, the knee can be fited to a required angle. It is useful for machining helical grooves, reamer and bevel gears. It is mostly used in tool room work.

d. Vertical milling machine

A spindle of a vertical milling machine is positioned at right angles to the table. The cutter is moved vertically or at an angle by swiveling the vertical head of the machine.

The machine is adapted for machining slots and flat surfaces by moving the table. By mounting end mills and face milling cutters on the spindle, vertical milling and internal milling are preformed.

5.5 Differences between a plain milling machine and a universal milling machine

S.No.	Plain milling machine	Universal milling machine
1.	The table can be moved vertically, longitudinally and crosswise.	Apart from the three movements of a plain milling machine. It can be swiveled about 45^0.
2.	Helical milling works cannot be done as the table cannot be swiveled.	The table can be swiveled and helical milling and spiral milling can be performed.
3.	As there are no special attachments, operations like gear cutting, slotting and vertical milling operation cannot be performed.	Special attachments like indexing head, rotary table, vertical milling attachment, slotting head are available with this machine.
4.	It is more rigid and suitable for machining on heavy and large workpiece and for simple milling operations.	It is meant for light workpieces, a wide range of operations can be performed in this machine. It is mainly used in tool rooms.
5.	The cost is less.	It is very costly.

5.6 size of a milling machine

The size of a milling machine is specified as follows

1. The size of the table (Length and width)
2. The maximum lengths of longitudinal, cross and vertical travel of the table.

3. Number of spindle speeds, number of feeds.
4. Spindle nose taper.
5. Power required
6. Nett weight of the machine
7. The floor space required
8. Type of the machine

5.7 Fundamental milling process

The various milling process may be grouped under two headings

1. Peripheral milling
2. Face milling

Peripheral milling

The machining is performed by the cutting edges on the periphery of the milling cutter. It is classified under two headings.

1. Up milling
2. Down milling.

Up milling

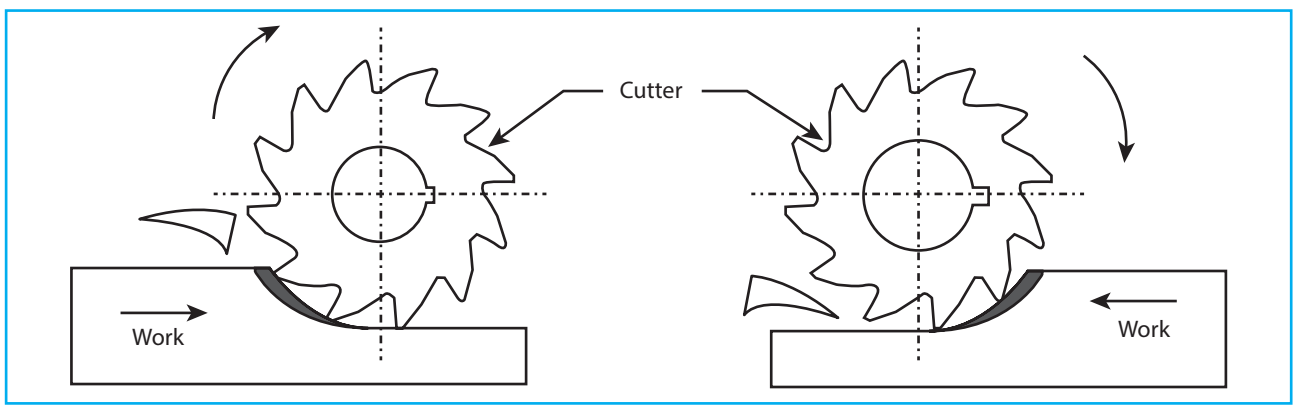
In this method, the workpiece mounted on the table is fed against the direction of rotation of the milling cutter. The cutting force is minimum during the beginning of the cut and maximum at the end of cut. The thickness of chip is more at the end of the cut. At the cutting force is directed upwards. It tends to lift the workpiece from the fixtures. A difficulty is felt in pouring coolant on the cutting edge. Due to these reason the quality of the surface obtained by this methods is wavy. This processes being safer is commonly used and sometimes called conventional milling.

Down milling

The workpiece mounted on the table is moved in the same directions as that of the rotation of the milling cutter. The cutting force is maximum at the beginning and minimum at the end of cut. The chip thickness is more at the beginning of the cut the workpiece is not disturbed because of the bite of the cutter on the work. The coolant directly reaches to the cutting point. So the quality of surface finish obtained is high. Because of the backlash error between the feed screw of the table and the nut, vibration is set up on the workpiece.

Face milling

During face milling, the machining is performed by the peripheral cutting edges. The surface obtained by the processes is perpendicular to the axis of rotation of the cutter.



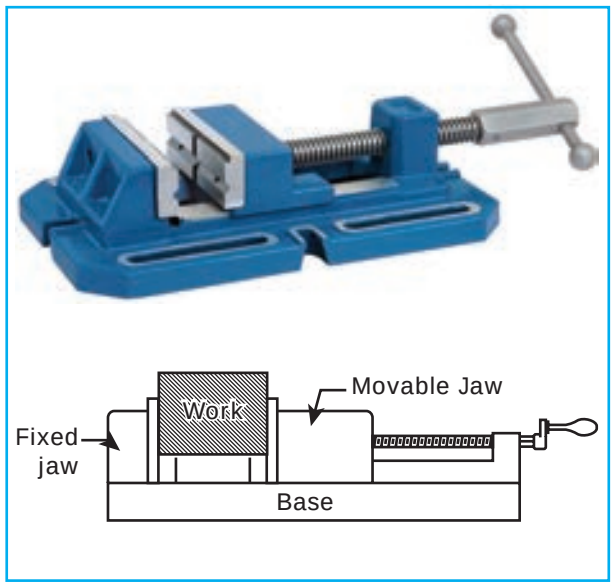
Up Milling Down Milling

End milling

End milling is a process of the machining by milling cutters which have cutting edges both on the end face and on the periphery.

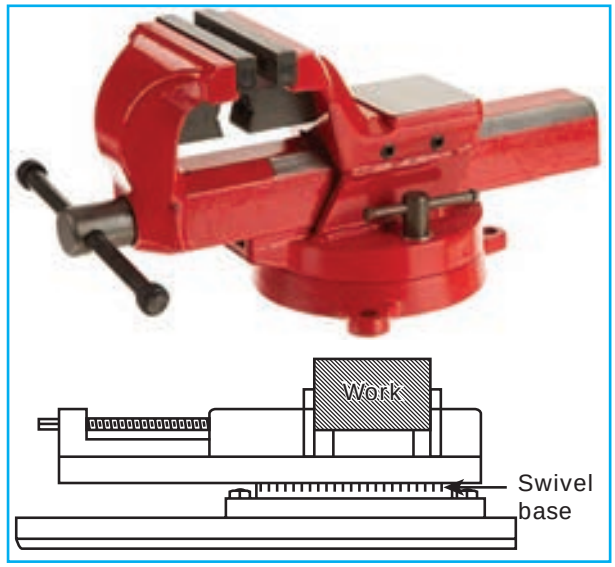
5.8 Work holding devices

For effective machining operations, the workpieces need to be properly and securely held on the machine table. The following are the usual methods of holding work on the table. Large and irregular shaped workpieces are held on the milling machine table by 'T' –bolts and clamps. 'V' – blocks are used for holding cylindrical workpieces on the machine table in which key ways, slots and flats are to be machined. Angle plates are used to support the work when surfaces are to be milled at right angles to another machined surfaces.

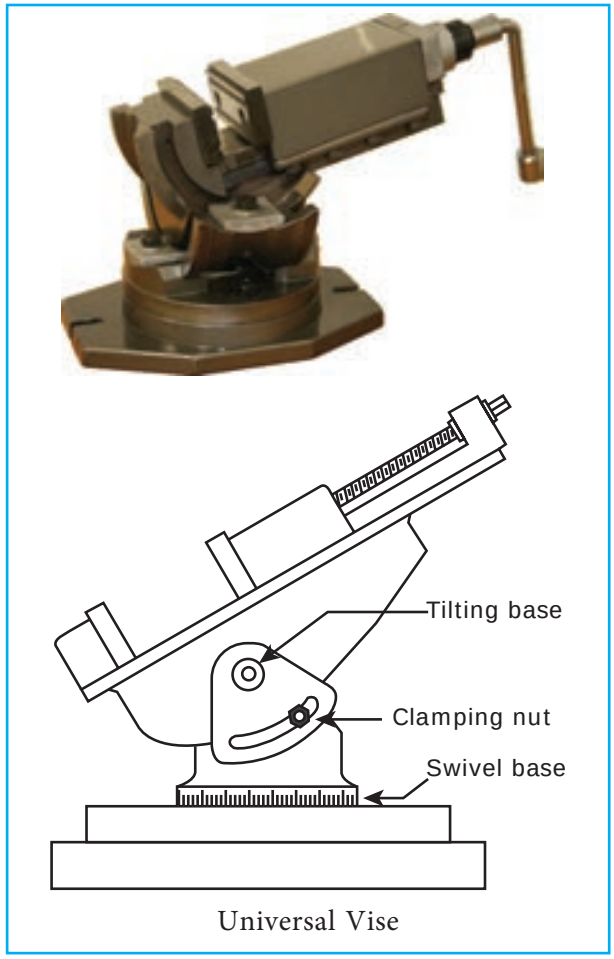


Plain Vise

Vises are commonly used for holding work on the table due to its quick loading and unloading arrangement. There are mainly three types of vises namely plain vise, swivel vise and universal vise.



Swivel Vise



Universal Vise

Milling fixtures are useful when large numbers of identical workpieces are to be machined workpieces are held easily, quickly and accurately by milling fixtures.

5.9 Cutter holding devices

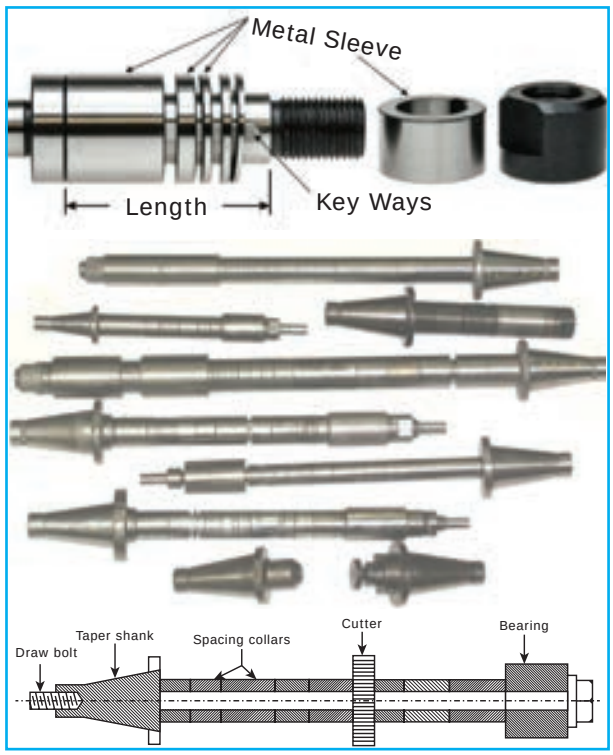
Depending on the design of the cutter there are several methods of supporting milling cutters on the machine spindle.

1. Arbor 2. Collet 3. Adapter
4. Screwed on cutters

Arbor

Milling cutters with central holes are mounted and keyed on a shaft called arbor. There are three different types of arbor namely pilot end arbor, 'A' type arbor and stub arbor.

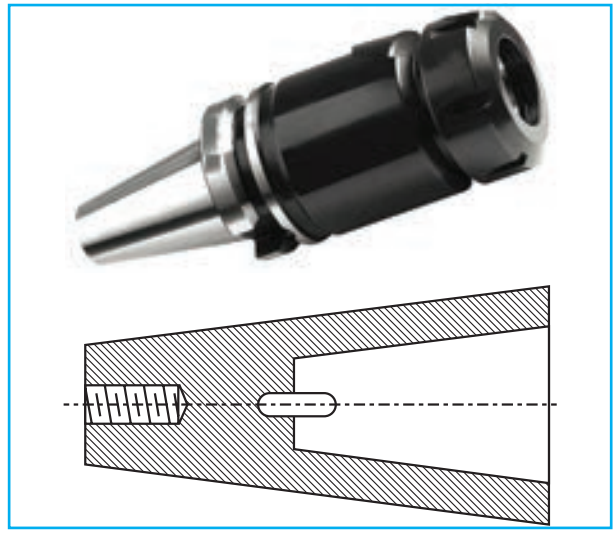
The arbours are made with taper shanks for correct alignment with the machine spindle the left side of the arbor is threaded internally to receive a draw bolt. This draw bolt connects the arbor with the spindle. A long key way is cut on the entire length of the arbor. Cutters are mounted at desired positions on the arbor by placing spacing collars between them. The spindle rotation is transmitted to the arbor and the cutter is rotated. An arbor is illustrated in figure



Arbor

Collet

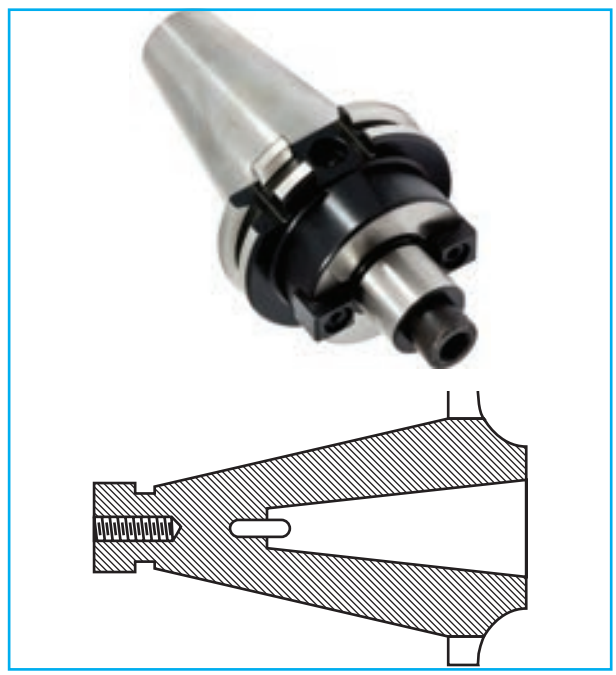
It is form of sleeve bushing used to hold arbor or cutters having a smaller shank than the spindle taper. Collets are connected to the spindle by a draw bolt and the rotary motion is transmitted to the cutters.



Collet

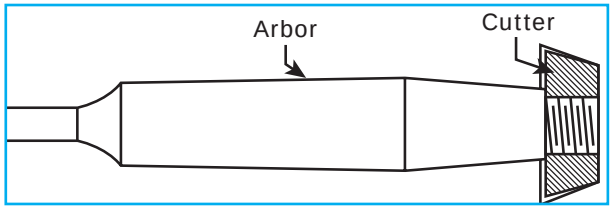
Adapters

Milling cutters having shanks are generally mounted on adapter. The outside taper of the adapter confirms to the taper hole of the spindle. The shank of the cutter fits into the taper hole of the adapter.



Adapter

Screwed arbor



The small cutters having threaded holes at the center are held by screwed arbors. It has a threaded nose at one end and adapters shank at the other end the shank of the arbor is mounted on the spindle.

5.10 Milling machine attachments

Milling machine attachments are intended for purpose of developing the range of operations, versatility, production capacity and accuracy of machining process. The different milling machine attachments are

1. Vertical milling attachments
2. Universal milling attachments
3. High speed milling attachments
4. Slotting attachments
5. Rotary table attachments
6. Indexing head attachments

Vertical Milling Attachment

Vertical milling attachments

A horizontal milling machine is converted into a vertical milling machine by the vertical milling attachment. Vertical milling attachment is mounted on the face of the column of the horizontal milling machine. The attachment along with the spindle can be swiveled to any angle for machining angular surfaces.

Universal milling attachments

By having the universal milling attachments the spindle of the machine can be swiveled about two perpendicular axes. This arrangement permits two spindle axis to be swiveled at practically any angle to machine any angular surface of the work.

Universal Milling Attachment

High speed milling attachment

This attachment is used to increase the regular spindle speeds by four to six times milling cutters of smaller diameters are operated efficiently at higher cutting speeds. This attachment is bolted to the face of the column and enables the cutter to be operated at speeds beyond the scope of the machine.

High Speed Milling Attachment

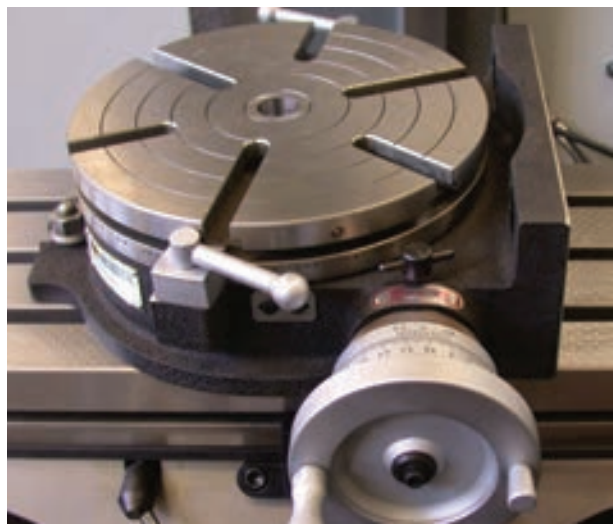
Slotting attachment

The rotary movement of the spindle is converted into reciprocating movement of the ram by a crank arrangement. This attachment makes the milling machine to be converted into a slotting machine by accepting a single point slotting tool. The tool is mounted on the ram and used for cutting internal or external keyways, spline etc. It can also be swiveled for machining angular surfaces.

Slotting attachment

Rotary table attachments

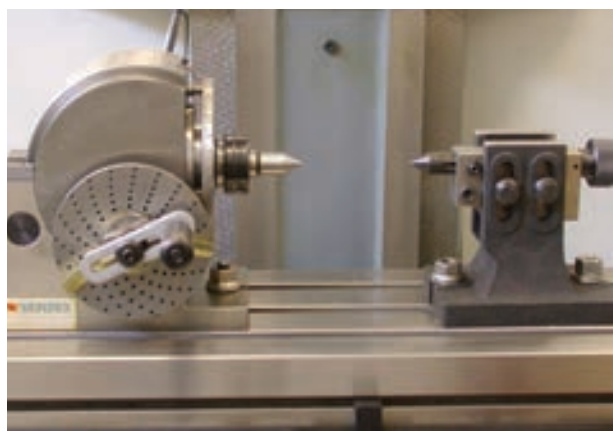
It is special device bolted on top of the machine table to provide rotary motion to the workpiece in addition to the longitudinal cross and vertical movements of the table. It consists of a circular table provided with 'T'- slots mounted on a graduated base. The driving mechanism of this attachment is made possible by worm and worm gear.



Rotary Table Milling Attachment

Indexing head attachment

It is a special work holding device used for dividing the periphery of the work into any number of equal divisions. The work is held in a check of the dividing head spindle or supported between

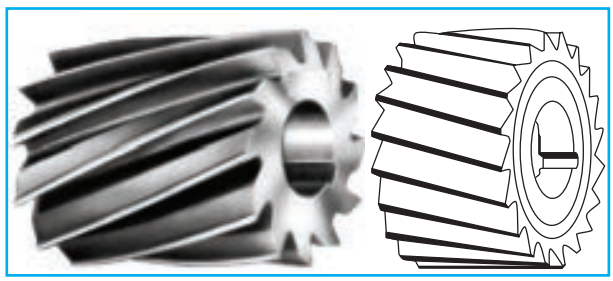


Indexing head attachment

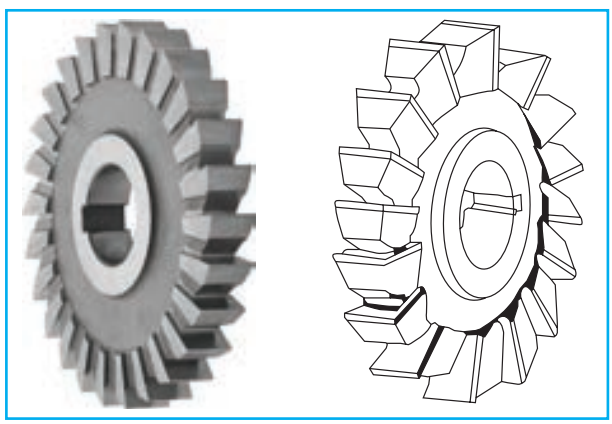
centres. It is also used in shaping machines and slotting machines. While machining gears, spirals, clutches and ratchets this dividing head is used to divide the circumference of the work into any number of equal parts.

5.11 Isometric view of milling cutters

Milling cutters are multipoint cutters. Thease cutters are used to remove excess material of given job by milling



Isometric view of milling cutters



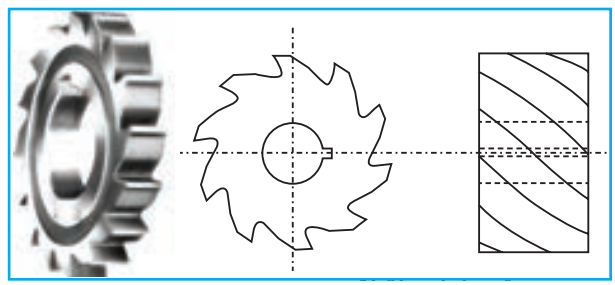
Milling cutters

5.12 Standard Milling Cutter

There are different types of milling cutters used in a milling machine. A suitable milling cutter is selected according to the need.

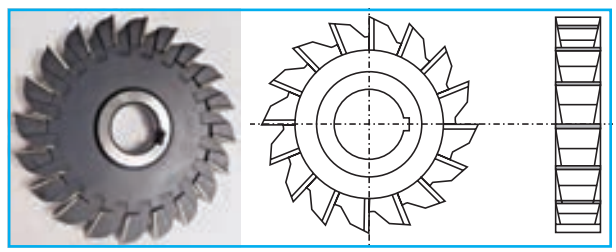
Plain milling cutter

Plain milling cutters are cylindrical in shape and have teeth on the circumferential surface only. They are used for producing flat surfaces parallel to the axis of rotation of the spindle. The teeth of the cutter may be straight or helical according to the size. If the width of the cutter is more, it is called as slabbing cutter in order to be mounted on the arbor. Plain milling cutters have nicked teeth to break the chips into small pieces. Helical plain milling machine cutters are superior to a straight plain milling cutter.



A plain milling cutter

Side milling cutter



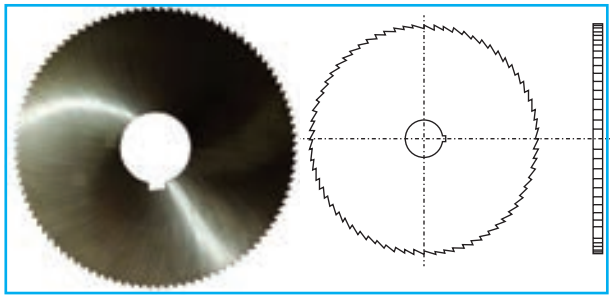
Side milling cutter

Side milling cutters have teeth on its periphery and also on one or both of its sides. They are intended for removing metal from the sides of the workpiece. There are different types of side milling cutters namely face and side milling cutter, half side milling cutter, staggered teeth side milling cutter and inter locked side milling cutter. Machining is performed by selections a proper milling cutter.

Metal Slitting saw

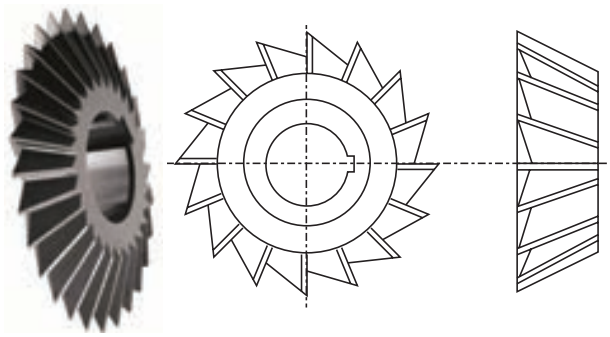
It is intended for cutting narrow, deep slots and for parting off operation. The teeth are cut on the circumference of the cutter. The width of the cutter ranges

from 0.75 mm to 7 mm. The side of the cutter is relieved so that side may not rub against the work.



Metal slitting saw

Angle milling cutters



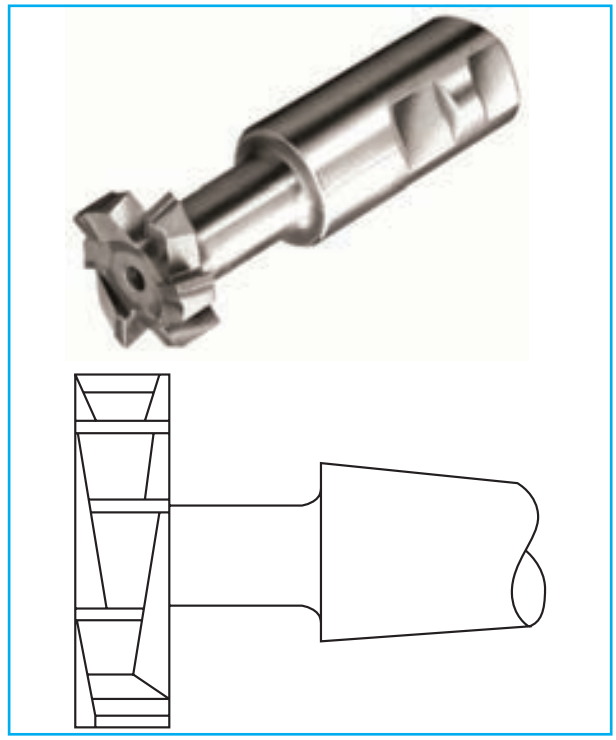
The teeth of the angle milling cutter are not parallel to the axis but are at an angle to it. By using angle milling cutter, inclined surfaces, bevels and helical grooves are machined. There are two types of angle milling cutter single angle milling cutters and double angle milling cutter.

'T' – Slot milling cutter

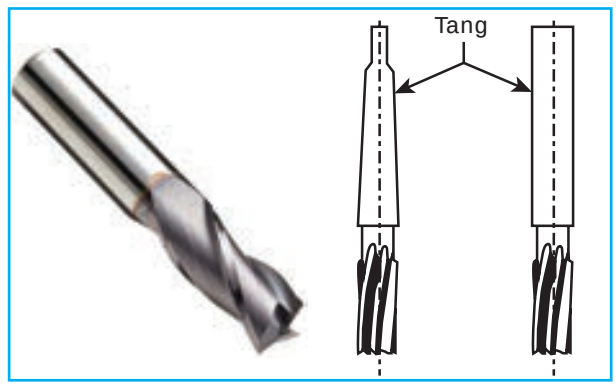
It is a special form of end mills intended for machining 'T' slots. It looks like a side milling cutter with a shank. The cutters have cutting teeth on the periphery as well as on both sides of the cutter.

End mill Cutter

These cutters have cutting teeth on the end as well as on the periphery of the cutter. It is made of two parts – body and shank. The shanks of the cutter may be straight or taper. If the cutter doesn't have a shank it is called shell end milling cutter. These cutters are useful in machining long narrow slots, holes and flat surface.



'T' – Slot milling cutter

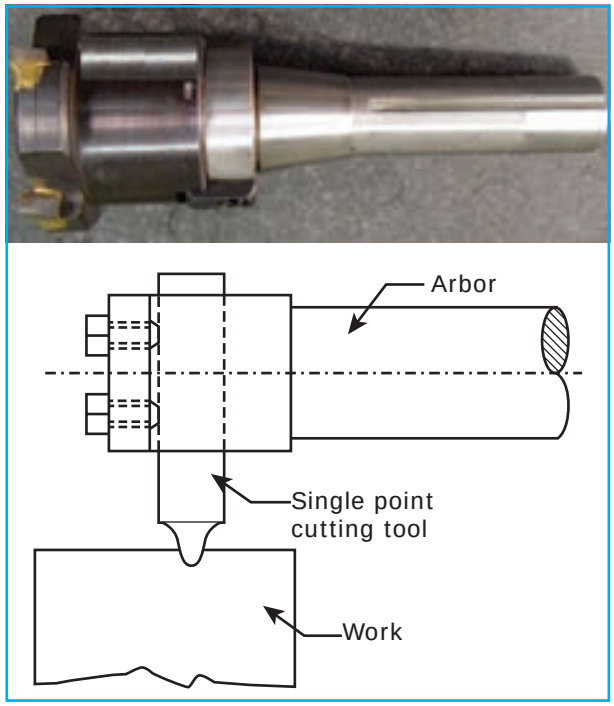


End milling cutters

Flying cutter

Flying cutter is the simplest form of cutter. It consists of a single point cutting tool attached to the end of the arbor. The cutting edge may be formed to reproduce a contoured surface. They are used when standard cutters are not

available. The work is done very slowly because of a single cutting edge. A flying cutter is shown in Figure.



Flying cutter

Form cutter

Form cutters have irregular profiles on their cutting edges to produce required outlines on the work. Concave and convex milling cutters are used to produce convex and concave surfaces respectively using gear milling cutters. Gears are machined corner round milling cutters are used for cutting a radius on the edges of the work with the help of thread milling cutter threads are milled on a specific form and size. Tap and reamer cutter are used for producing grooves or flutes in tap and reamers.

5.13 Elements of a plain milling

Cutter

The main parts and angles of a plain milling cutter as shown in Figure.

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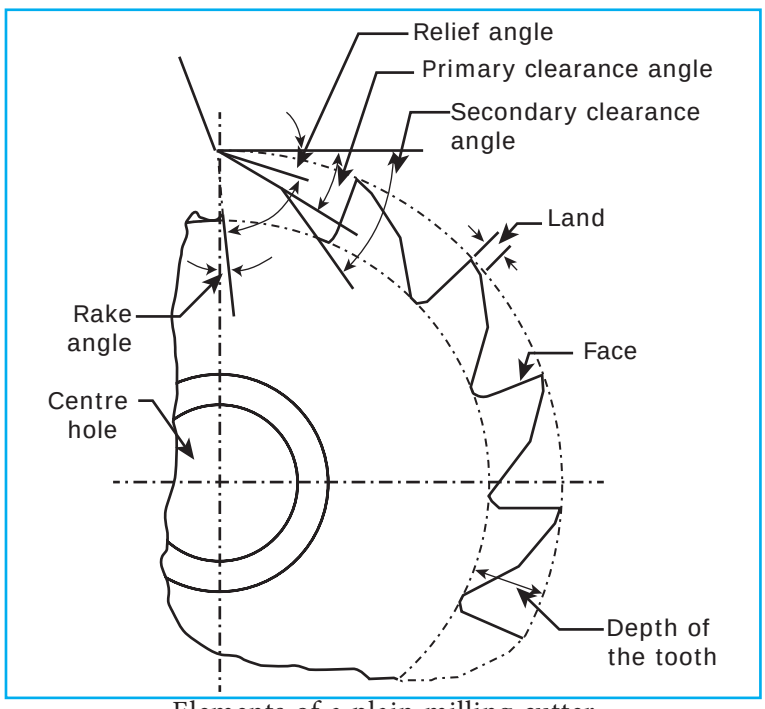
Body of cutter

It is the part of the cutter left after exclusion of the teeth.



Elements of a plain milling cutter

Face

The portion of the teeth next to the cutting edge is known as face.

Land

The relieved back portion of the tooth adjacent to the cutting edge. Its value is approxmately 1.5 mm. It is relieved to avoid interference between the surface being machined and the cutter.

Outside diameter

The diameter of the circle passing through the peripheral cutting edges.

Centre hole

It refers to hole present at the centre of cutter. A keyway is cut inside the hole.

Cutter angles

Relief angle

It is the angle between land of the tooth and the tangent to the outside diameter of the cutter at the cutting edge of the particular tooth. (Approx 7.5^0)

Primary clearance angle

It is the angle between the back of the tooth and the tangent drawn to the outside diameter of the cutter at the cutting edge (Approx 15^0).

Secondary Clearance Angle

It is the angle formed by the secondary clearance surface and the tangent to the periphery of the cutter at the cutting edge.

Rake angle

The angle measured in the diametral plane between the face of the tooth and a radial line passing through the cutting edge of the tooth. The rake angles may be positive, negative or zero. If the face and the tooth body are on the same side of the radial line and the tooth body may be on opposite sides of the radial line. Then the rake angle is negative. If the radial line and the tooth face coincide in the diameter plane the rake angle is zero.

5.14 Milling cutter material

The milling cutters are generally made of the following materials.

1. Tool steel – High Speed Steel (HSS)
   High Carbon Steel (HCS)
2. Cemented carbide
3. Stellite

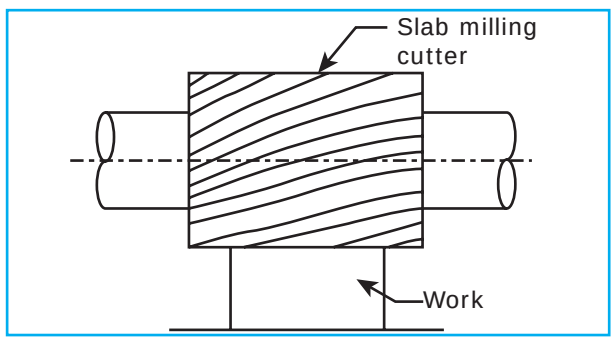
> In general shop work, the high speed steel cutters are most widely used.

5.15 Milling machine operations

The following operations are performed using suitable milling cutters

Horizontal milling

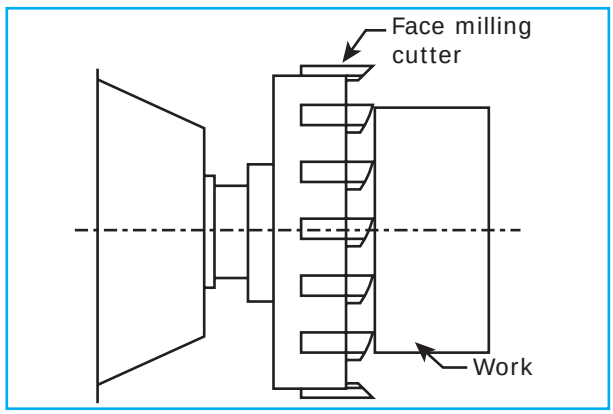
It is the operation of production of a flat surface parallel to the axis of rotation of the cutter. It is also called as slab milling, plain milling cutters and slab milling cutters are used to perform this operation.



Horizontal milling

Face milling

The face milling is the operation performed by the face milling cutter rotated about an axis at right angles to the work surface. End mills and side & face milling cutters are also used at times to perform this operation. The depth of cut is provided to the table.



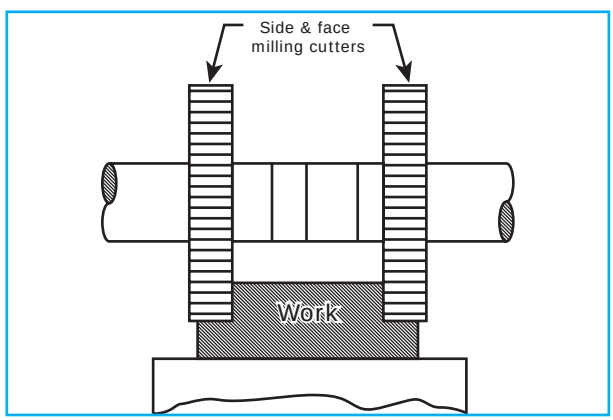
Face milling operation

Side milling

Side milling is the operation of machining a vertical surface on the side of a work piece by using a side milling cutter.

Straddle milling

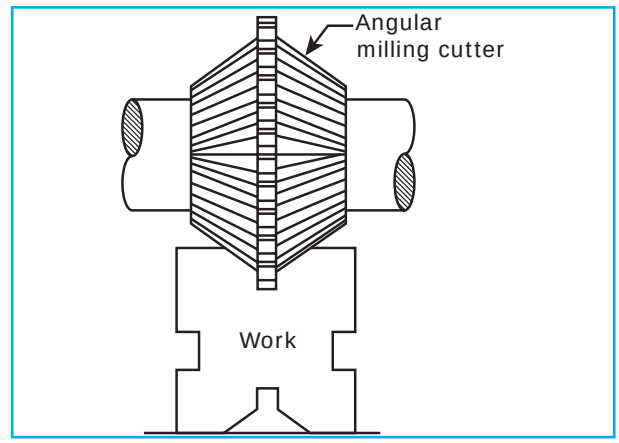
It is the operation of production of two vertical surfaces on both sides of the work by two side milling cutters mounted on the same arbor. By using suitable spacing collars, the distance between the two cutters are adjusted correctly. The straddle milling is commonly used to produce square or hexagonal surface.



Straddle milling operation

Angular milling

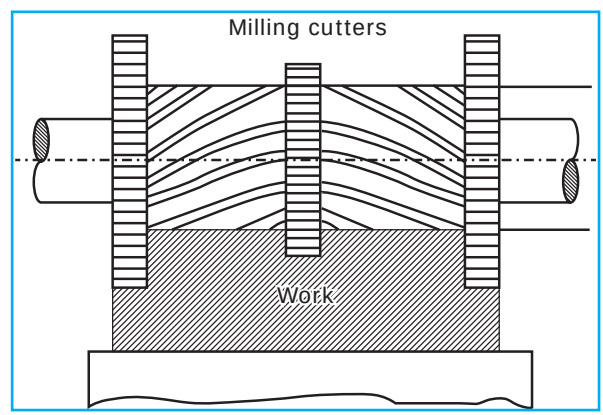
Production of an angular surface on a workpiece other than at right angles to the axis of the milling machine spindle is known as angular milling. Example of angular milling is the production of the 'V' blocks.



Angular milling operation

Gang milling

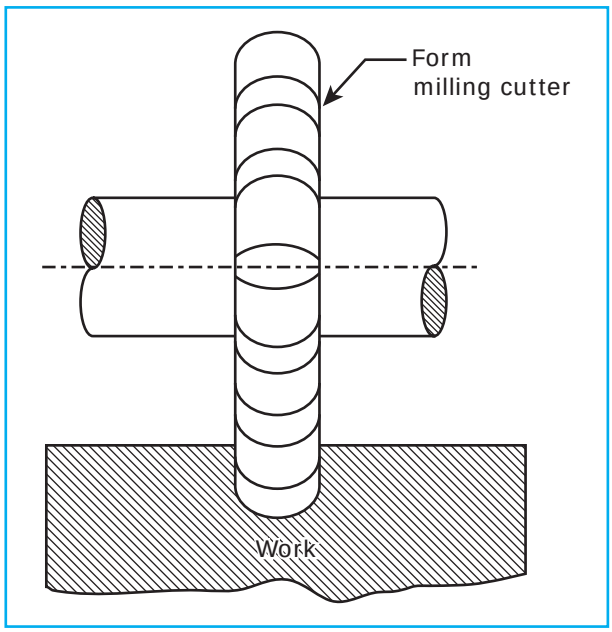
It is the operation of machining several surfaces of work simultaneously by feeding the table against a number of cutters (either of same type or of different type) mounted on the arbor of the machine. This method saves much of machining time and mostly used in production work.



Gang milling operation

Form Milling

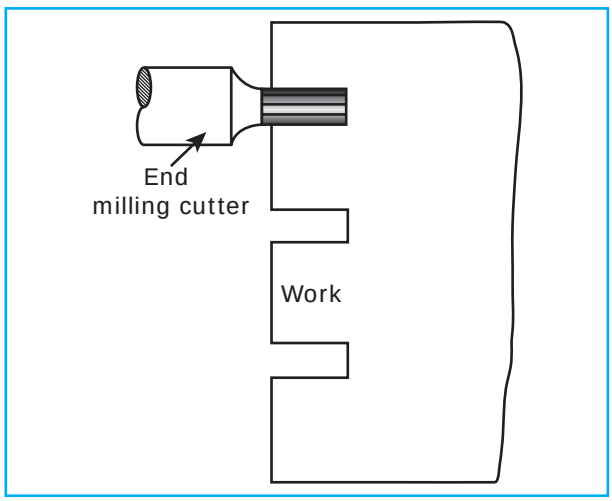
The form milling is the operation of production of irregular contours by using from cutters. Machining convex and concave surfaces and gear cutting are some examples of form milling.



Form milling operation.

End milling

It is the operation of producing a flat surface which may be vertical, horizontal or at an angle to the table surface. The end milling is performed by a cutter known as an end mill. End milling is mostly performed in a vertical machine.



End milling operation

Keyway milling

The operation of production of keyways, grooves and slots of different shapes and sizes can be performed in a milling machine by using a plain milling cutter, a metal slitting saw, an end mill or by a side milling cutter.

Gear cutting

Gear cutting operation is performed in a milling machine by using a form cutter. The work is held between centers on a universal dividing head. A proper gear cutter is selected and the teeth are cut by DP, module method.

Cam milling

Cam milling is the operation of producing cams in a milling machine with the use of a universal dividing head and a vertical milling attachment. It is performed by end mills on the cam blank.

5.16 Cutting speed, feed and depth of cut

Cutting speed

It is the distance travelled by a point on the cutting edge of the milling cutters to remove metal in time duration of one minute. It is expressed in meters per minute.

$$\text{Cutting speed} = \frac{\pi dn}{1000} \text{ meter/minute}$$

$$\pi = \frac{22}{7} \text{ (or) } 3.14,$$

Where, D = The diameter of the milling cutter in mm

N = Spindle speed in rpm.

The cutting speed depends upon the material to be machined, the cutter

material, depth of cut, feed, type of operation and the coolant used.

Example

Calculate the cutting speed to perform milling with a cutter of diameter 60 mm and spindle speed of 250 rpm.

Solution

Given Diameter of cutter (D) = 60 mm

Spindle speed (N) = 250 rpm

$$\text{Cutting speed} = \frac{\pi dn}{1000} \text{ meter/minute}$$

$$\pi = \frac{22}{7} \text{ (or) } 3.14,$$

$$= \frac{22}{7} \quad \frac{60 \quad 250}{1000}$$

$$= 47.14 \text{ metre/minute}$$

Feed

The feed in a milling machine is defined as the distance the workpiece advance under the cutter. Feed can be expressed in three different methods.

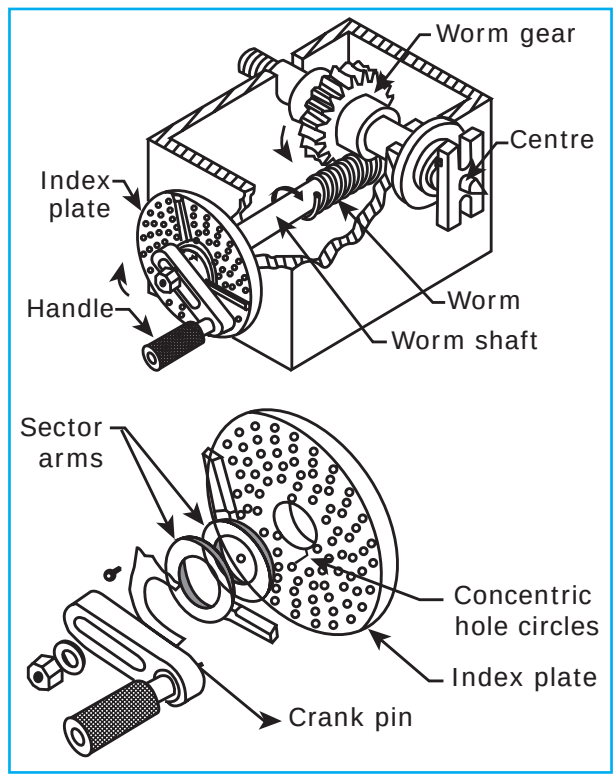
1. **Feed per teeth:** It is the distance the work advances in time between engagements by the two successive teeth. It is expressed.
2. **Feed per cutter revolution:** It is the distance the work advance in the time when the cutter turns through one complete revolution. It is expressed in mm per revolution of the cutter.
3. **Feed per minute:** It is the distance the work advances in one minute. It is expressed in mm per minute. The feed in a milling machine depends on the material to be machined, cutter material, depth of cut, cutting speed, type of operation and the rigidity of the machine.

Depth of cut

The depth of cut is the thickness of the material removed in one pass of the work below the cutter. It is expressed in mm.

5.17 Indexing head

Indexing is the method of dividing the periphery of a piece of work into any number of equal parts. The attachment used for performing indexing is known as indexing head.



Indexing head

Uses of indexing

The indexing operation can be adapted for cutting gears, ratchet wheels. Keyways, fluted drills taps and reamers. The indexing head serves as an attachment for holding and indexing the work in during the above tasks. There are three different types of indexing heads namely

1. Plain or simple dividing head
2. Universal dividing head
3. Optical dividing head

5.18 Construction of indexing head

The construction of a universal dividing head as shown in figure and explained below.

Base

The base of the indexing head is fitted in the 'T' – slots of the milling machine table. It supports all the other parts of dividing head.

Spindle

The spindle is situated at the centre of the dividing head. It has a taper hole to receive a live center. The spindle is supported on a swiveling block, which makes the spindle to be tilted through any angle from 5^0 below horizontal to 10^0 beyond vertical. A worm wheel is mounted on the spindle. While doing direct or rapid indexing the index plate is directly fitted on the front end of the spindle nose.

Worm shaft

It is situated at right angles to the main spindle of the dividing head. A single threaded worm is mounted on the worm shaft which meshes with the worm wheel.

An indexing plate is fitted on the front end of the worm shaft and with the help of a handle, the worm shaft can be rotated to a pre determined amount.

Indexing Plate

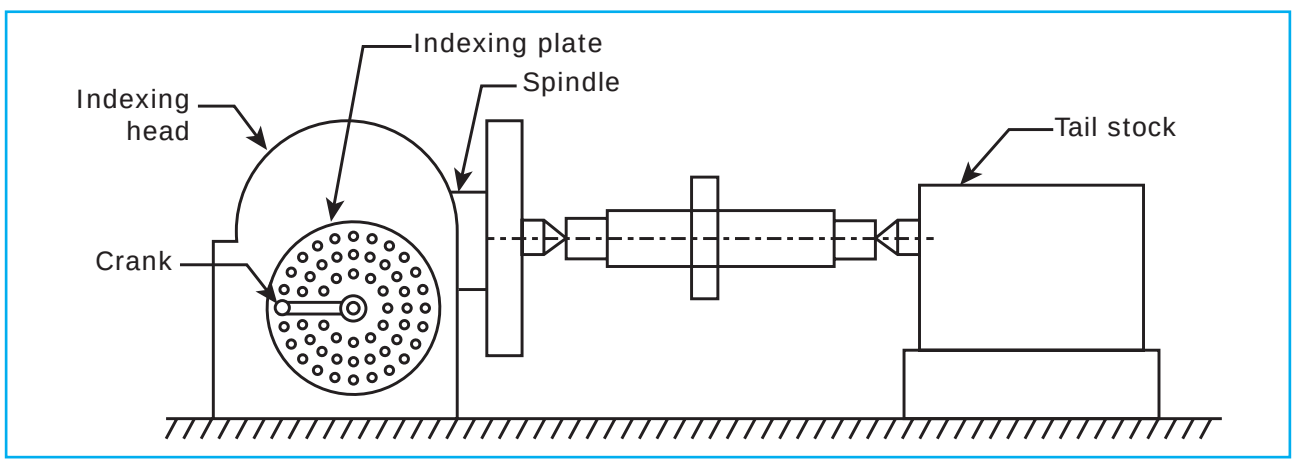
It is mounted on the front end of the worm shaft. It is circular disk having different numbers of equally spaced holes arranged in concentric circles. The crank is positioned in the required hole circle and rotated through a calculated amount while indexing. The sector arm is used to eliminate the necessity of counting the holes on the index plate each time the index crank is moved.

Tail Stock

The work is held between the center of the spindle and the tailstock. It can be made slide and positioned at the required location.

Working principle of dividing head

When the crank is rotated with help of a handle through the required number of holes in the index plate. The work is rotated to required amount. This is possible because of the worm and worm wheel mechanism.



Construction of an indexing head

A gear train is arranged between the main spindle and the driven shaft when indexing is done by differential indexing method. The work is rotated as usual when the handle is rotated. At the same time, the index plate is also made to rotate a small amount through the gear train when indexing is by this differential indexing method, the index plate is released from the lock pin.

5.19 Indexing methods

There are several methods of indexing and they are

1. Direct or rapid indexing
2. Plain or simple indexing
3. Compound indexing
4. Differential indexing
5. Angular indexing

5.20 Safety precautions

Before operating the milling machine, the operator should know how to operate various controls of the machine. It should be ensured that the workpiece is held rigidly on the milling machine table. The cutter should not be in contact with the work even before the machining is commenced.

The spindle speed of machine should not be altered when the machine is in operation. When the power of the machine table is on the arbor should not be removed or tightened. The operator should keep his body away from the rotating cutter. No steps should be taken to measure the workpiece while the cutter is cutting or revolving near the workpiece when the machine is in operation, safety guards should be placed in their position to prevent coolant and metal chips from spilling out.

The metal chips should be removed with suitable brushes and with bare hands. The operation should seek assistance from others while handing special attachments and heavy workpieces. The operator should always be present in person at the machine tool when the machine is in operation.

The machine tool should always be started and stopped by the operator himself. Danger's can be averted by handling the cutters with sharp cutting edges with great care. The machine tool should be kept clean. Milling cutters and measuring instruments should not be placed on the machine. The attention of the operation should always be focused on the task only. When troubles happen in the machine, they should be corrected with assistance of proper technicians in general safety should be ensured to the operator, the workpiece and the cutting tool.

ACTIVITIES

1. To arrange the students visit nearby industry and demonstrate the milling machine construction details and various kinds of operations.
2. To explain the different types of indexing methods with practical examples.

Questions

Part I.

Choose the correct option 1 Mark

1. Milling machine was developed by
   a. Henry Maudslay
   b. Eli Whitney
   c. James Nasmith
   d. Michael Faraday
2. In a milling machine, cutters are mounted on
   a. Column
   b. Spindle
   c. Over hanging arm
   d. Arbor
3. The distance of table-travel is controlled by
   a. Saddle
   b. Trip dogs
   c. Cross-slide
   d. Elevating Screw

4. The distance travelled by a point on a milling cutter in one minute is known as,
   a. Cutting speed
   b. Depth of cut
   c. Spindle speed
   d. Feed

Part II.

Answer the following questions in one or two sentences 3 Marks

5. What is milling?
6. What are the types of milling machine?
7. How is the size of a milling machine specified?
8. Name the fundamental milling process?
9. What are the types of peripheral milling?
10. Name four work holding devices in a milling machine?
11. What is indexing?
12. What are the uses of indexing head?
13. What are the types of indexing head?
14. What are the methods of indexing?

Part III.

Answer the following questions in about a page 5 Marks

15. What are the differences between a plain milling machine and a universal milling machine?
16. List out various milling machine special attachments.
17. List out various types of milling cutters.
18. Mention the different types of milling machine operations.

Part IV.

Answer the following Questions in detail. 10 Marks

19. Draw a neat diagram of a milling machine and explain its construction.
20. Explain – up milling and down milling.
21. Explain any four cutter holding devices with diagram.
22. Draw a neat diagram of a plain milling cutter and explain its nomenclature.