Milling Machine

Milling is the machining process in which the removal of metal takes place due to the cutting action of a rotating milling cutter.

In a **milling machine**, the cutter is rotating due to this workpiece is fed against it. This can hold more than one tool at a time. The cutter rotates at a high speed and because of the many cutting edges, it removes metal at a very fast rate.

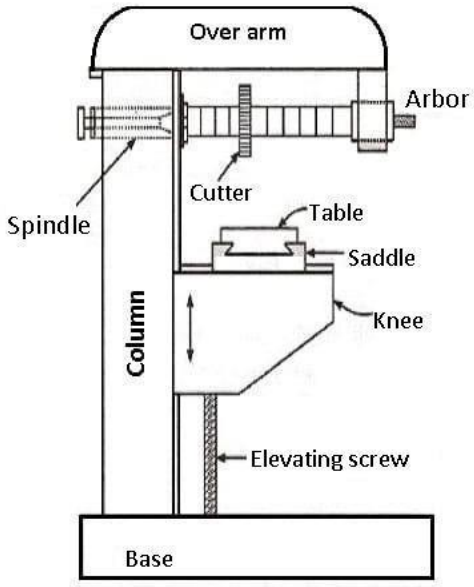
The machine can also hold one or a number of cutters at a time. Thus, **the milling machine** is one of the most important machines in the workshop. In this machine, all the operations can perform with high accuracy.

The metal removal rate is high as compared to a lathe machine, planner machine, and shaper machine. It has good accuracy and better surface finish. This is why a milling machine finds wide application in production work.

Parts of Milling Machine

Following are the **parts of milling machine:**

1. Base
2. Column
3. Saddle
4. Table
5. Overhanging arm
6. Front brace
7. Spindle
8. Arbor



Base

- The base of the machine is grey iron casting and serves as a foundation member for all other parts which rests on it.
- The base carries the column at its one end. In some other machines, the base is hollow and works as a reservoir for cutting fluid.

Column

- The column is the main supporting frame mounted on the base.
- It is box-shaped and houses all the driving mechanism for the spindle and feed table.
- The front vertical face of the column is precisely machined and is equipped with dovetail guideways for supporting the knee.
- The top of the column is finished to hold an overarm that extends beyond the front of the machine.

Knee

- The knee is a fixed grey iron casting that slides up and down on the vertical ways of the column face.
- The adjustment of height is affected by an elevating screw mounted on the base that also supports the knee.
- The knee houses the feed mechanism of the table and controls to operate it.
- The top face of the knee forms a slideway for the saddle that gives cross travel to the table.

Saddle

- On the top of the knee is placed the saddle, which slides on guideways set exactly at 90 degrees to the column face.
- A crossfeed screw near the top of the knee engages a nut on the bottom of the saddle to move it horizontally, by hand or power, to apply cross-feed.
- The top of the saddle is precisely machined to provide guideways for the table.

Table

- It rests on guideways on the saddle and travels longitudinally.
- The top of the table is finished accurately and T-slots are provided for clamping the work and other fixtures.
- A lead-screw is provided under the table that engages with a nut on the saddle, it helps to move the table horizontally by hand or power.
- The longitudinal travel of the table possibly limited by fixing trip dogs on the side of the table.
- In universal machines, the table may also be swivelled horizontally. For this purpose, the table is mounted on a circular base, which in its turn is mounted on the saddle.
- The circular base is graduated in degrees.

Overhanging arm

- Overhanging arm act as a support for the arbor.
- It is mounted on the top of the column extends outwards the column face and works as bearing support for the other end of the arbor.
- The Overhanging arm is adjustable so that the bearing support may be provided nearest to the cutter.
- More than one bearing support can be provided for the arbor.

Front brace

- It is extra support, which provides rigidly to the arbor and the knee.
- The front base is fitted between the knee and overarm.
- The front brace is slotted to allow for the adjustment of the height of the knee relative to the overarm.

Spindle

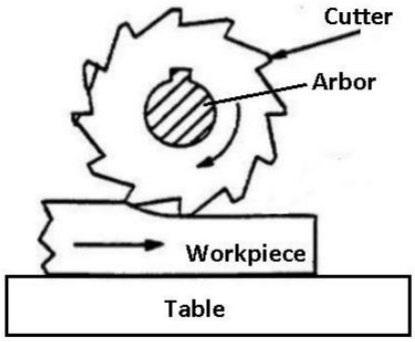
- The spindle of the machine is located in the upper part of the column and receives power from the motor through belts, gears, and clutches and transmit it to the arbor.
- The front end of the spindle just projects from the column face and is provided with a tapered hole into which various cutting tools and arbor may be inserted.
- The accuracy in metal machining by the cutter depends on the strength, accuracy and rigidity of the spindle.

Arbor

- Arbor is an extension of the machine spindle on which milling cutters are securely mounted and rotated.
- These are made with taper shanks for proper alignment with the machine spindles having taper holes at their nose.
- The taper shank of the arbor match to the Morse taper or self-release taper whose value is 7:24.
- The arbor may be supported at the farthest end from the overhanging arm or maybe of cantilever type which is called stub arbor.

Working Principle of Milling Machine

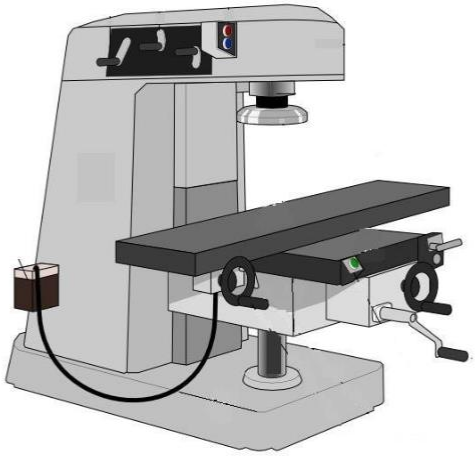
The working principle of the milling machine, applied in the metal removing operation on a milling machine. The work is rigidly clamped on the table of the machine and revolving multi teeth cutter mounted either on a spindle.



The cutter revolves at a normal speed and the work fed slowly past the cutter. The work can be fed in a longitudinal, vertical or cross direction. As the work progress further, the cutter teeth remove the metal from the work surface to produce the desired shape.

Size of Milling Machine

The size of the milling machine is determined by the dimensions of its maximum length of longitudinal, cross and vertical travel of the table and also by working surface of the machine. The below image shows the typical size of a horizontal knee type milling machine.



$$Table\ lenght \times Width = 1000 \times 310mm$$

$$Power\ traverse: longitudinal \times cross \times vertical = 650 \times 235 \times 420mm$$

In addition to the above dimensions, number of spindle speeds, number of feeds, power available, spindle nose taper, net weight and the floor space required, etc. Should also be considered in order to specify the machine fully.

Types of Milling Machines

Following are the different types of milling machines:

1. Column and knee type
    1. Hand milling machine
    2. Plain or horizontal milling machine
    3. Vertical milling machine
    4. Universal milling machine
    5. Omniversal milling machine
2. Manufacturing type or fixed bed type
    1. Simplex milling machine
    2. Duplex milling machine
    3. Triplex milling machine
3. Planer type milling machine
4. Special Type
    1. Rotary table milling machine
    2. Drum milling machine
    3. Profile milling machine
    4. Planetary milling machine
    5. Tracer controlled milling machine
    6. Pantograph milling machine
    7. NC/CNC milling machine

Column and Knee Type

For general shop work, the most used type of milling machine is the **column and knee type machine.** where the table is mounted on the knee-casting which in turn is mounted on the vertical slides of the main column.

The knee vertical adjustable on the column so that the table can be moved up and down to accommodate work of various heights.

The column and knee type milling machines are classified.

- According to the various methods of supplying power to the table.
- Different movements of the table. and
- The different axis of rotation of the main spindle.

1. Hand Milling Machine

It simplest of all types of milling machine in which table feeding is controlled by hand. The cutter is mounted on a horizontal arbour and is rotated by power.

This type of milling machine is of small in size and suitable for light and simple milling operations. For Example, machining slots, grooves, and keyway.

2. Plain Milling Machine

These are much stronger than hand millers. The table feeding is done either by hand or power. the plain milling machine having a horizontal spindle is also called as a horizontal spindle milling machine. The table may be fed in a longitudinal, cross, or vertical directions.

The feed is:

- Longitudinal - when the table is moved at right angles to the spindle.
- Cross - when the table is moved parallel to the spindle.
- Vertical - when the table is adjusted in the vertical plane.

3. Universal Milling Machine

It can be adapted to a wide range of milling operations. Here the table can be swiveled to any angle up to 45-degrees on either side of the normal position.

In addition to 3 movements as mentioned earlier in a plain milling machine, the table may have the fourth movement when it is fed at an angle to the milling cutter. Helical milling operation can also be performed. The capacity of this type of machine is increased by using special attachments such as

- Dividing head or index head.
- Vertical milling attachment.
- Rotary attachment.
- Slotting attachment.

This machine can produce spur, bevel, spiral, twist drill, reamer, milling cutter. All operations that are performed on a shaper can be done using a universal milling machine.

4. Ominversal Milling Machine

Here the table also has four movements of the universal milling machine. It can also be tilted in a vertical plane by providing a swivel arrangement at the knee.

The additional swivelling arrangement of the table helps in machining spiral grooves in reamers and bevel gears.

5. Vertical Milling Machine

Here the position of the spindle is vertical or perpendicular to the table. This type of machine is adapted for machining grooves, slots, and flat surfaces.

The machine may be of the plain or universal type and has all the movements of the table for a proper setting and feeding the work.

The spindle head is clamped to the vertical column which is swivelled at an angle. It allowing the milling cutter fixed on the spindle to work on angular surfaces. In some machines, the spindle can also be adjusted up or down relative to the work.

Manufacturing of Fixed Bed Type Milling Machine

These machines are large, heavy and rigid in construction. These machines differ from column and knee type milling machines by the construction of its table mounting.

The table is mounted directly on the ways of a fixed bed. The table movement is restricted to reciprocating at a right angle to the spindle axis with no provisions for cross or vertical adjustment.

It is classified as simplex, duplex, triplex based on a machine provided with the single, double and triple spindle heads respectively.

- Simplex - single spindle head.
- Duplex - two-spindle head.
- Triplex - three spindle head.

Planer Type Milling Machine

This types of milling machine are also called as "Plano-Miller". It is a massive machine used for heavy-duty work having spindle heads adjustable in the vertical and transverse direction.

It relates to a planer and like a planing machine. This machine has a cross rail capable of being raised or lowered carrying the cutters. It has their heads, and the saddles, all supported by rigid uprights.

This arrangement of driving multiple cutter spindles enables a number of work surfaces to be machined. Thereby it obtains the great reduction in production time.

The essential difference between a planer and a Plano-miller lies in the table movement. In a planer, the table moves to give the cutting speed. But in a Plano-milling machine, the table movement gives the feed.

Special Types of Milling Machine

Milling machines of non-conventional design have been developed to suit special purposes. This machine has a spindle for rotating the cutter and provision for moving the tool or the work in different directions. The following special types of machines of interest are described below:

1. Rotary Table Milling Machine

Here the table is circular in nature and rotates about a vertical axis. Here cutters are set at different heights. Which results in one cutter roughing the workpiece and other one cutter finishing them.

The advantage of this machine is that continuous loading and unloading of workpieces can be done by the operator, while is in progress.

2. Drum Milling Machine

It is like a rotary table milling machine. But its workpiece supporting table is called as "DRUM" and it rotates in the horizontal axis.

The face milling cutters mounted on three or four-spindle heads rotate in a horizontal axis and remove metal from workpieces supported on both the faces of the drum. The finished machined parts are removed after one complete turn of the drum, and then the new ones are clamped to it.

3. Planetary Milling Machine

Here workpiece is held stationary while the revolving cutter. The cutter moves in a travelling path to finish a cylindrical surface on the workpiece either internally or externally. This machine is also adapted for milling internal and external threads.

4. Pantograph Milling Machine

A pantograph machine can duplicate a job by using a pantograph mechanism. It allows the size of the workpiece reproduced to be smaller than, equal to or greater than the size of a template. Also used for the different model for special purposes.

A pantograph is a mechanism that is generally constructed of four bars or links which are connected in the form of a parallelogram.

Pantograph machines are available in two dimensional and three-dimensional models. The two-dimensional pantograph is used for engraving letters or other designs. Whereas three-dimensional models are employed for copying any shape and contour of the workpiece.

5. Profiling Milling Machine

A profiling machine duplicated the full size of the template attached to the machine. Here the spindle can be adjusted vertically and the cutter horizontally across the table.

A hardened guide pin regulates the movement of the cutter. The longitudinal movement of the table and the crosswise movement of the cutter head follows the movement of the guide pin on the template.

6. Tracer Controlled Milling Machine

The tracer controlled milling machine reproduces irregular or complex shapes of dies, moulds by synchronized (matched) movements of the cutter and tracing elements.

The movement of the stylus energized an oil relay system which in turn operates the main hydraulic system for the table. This arrangement is termed as a servomechanism.

Types of Milling Cutters

A milling machine is a machine tool that cuts metal as the workpiece is fed against a rotating multipoint cutter. The milling cutter rotates at a very high speed because of the multiple cutting edges, it cuts the metal at a very fast rate. This machine can also hold single or multiple cutters at the same time.

Following are the different types of milling cutters:

1. Solid milling cutter
2. Tipped solid milling cutter
3. Inserted teeth milling cutter
4. Profile relieved milling cutter
5. Form relieved milling cutter
6. Arbor type milling cutter
7. Facing type milling cutter
8. Shank type milling cutter

9. Right-hand rotational cutter
10. Left-hand rotational cutter
11. Parallel or straight teeth cutter
12. Right-hand helical cutter
13. Left-hand helical cutter
14. Alternate helical teeth cutter
15. Standard milling cutter
16. Special milling cutter

1. According To The Constructional Feature of The Cutter

Solid Cutter

A solid cutter has teeth with the cutter body. The cutters are of smaller diameter and made of one piece material usually of (HSS) high-speed steel.

Tipped Solid Cutter

A tipped solid cutter is similar to a solid cutter, except that the cutter teeth are made of cemented carbide or stellite tips which are brazed on the tool shanks of an ordinary tool steel cutter body to lower the cost of the cutter.

Inserted Teeth Cutter

In large milling cutters, the teeth or blades are inserted or secured in a body of less expensive materials. The blades are held in the cutter body by mechanical means. This arrangement reduces the cost of the cutter and enables economy in maintenance, as a single tooth if broken can be readily replaced.

2. According To The Relief Characteristics of The Cutter Teeth

Profile Relieved Cutter

In this category of milling cutters, a relief to the cutting edges is provided by grinding a narrow land at the back of the cutting edges. The profile relieved cutters generate flat, curved or irregular surfaces.

Form Relieved Cutter

Form relived cutter also known as surface milling. These cutters have curved relief provided at the backside of the cutting edges. These cutters are sharpened by grinding the faces of the teeth. The form relieved cutters are used for generating formed or contoured surfaces.

3. According To The Methods of Mounting The Cutter

Arbor Type Cutter

The arbor type cutters are provided with a central hole having a keyway for mounting them directly on the milling machine arbor. Milling cutters having tapered or threaded holes are also available. They are mounted on arbors of different designs.

Shank Type Cutter

The shank type cutters are provided with straight or tapered shank integral with cutter body. The straight or tapered shanks are inserted into the spindle nose and are fixed to it by a draw bolt.

Facing Type Cutter

The facing type cutters are either bolted or attached directly to the spindle nose, or secured on the face of a short arbor called stub arbor. The facing type cutters are mainly used to produce flat surfaces.

4. According To The direction of Rotation of The Cutter Teeth

Right Hand Cutter

A milling cutter is designated as a right-hand cutter which rotates in an anticlockwise direction when viewed from the end of the spindle.

Left Hand Cutter

A milling cutter is designated as a left-hand cutter which rotates in a clockwise direction when viewed from the end of the spindle.

5. According To The Direction of The Helix of The Cutter Teeth

Parallel or Straight Teeth Cutter

The parallel or straight teeth cutters have their straight or parallel to the axis of rotation of the cutter. The helix angle of parallel teeth cutters is equal to zero.

Right Hand Helical Teeth Cutter

These cutters have their teeth cut at an angle to the axis of rotation of the cutter. The cutters may be distinguished by viewing it from one of its end faces when the helical groove or flute will be found to lead from left to right-hand direction of the cutter body.

Left Hand Helical Teeth Cutter

These cutters have their teeth cut at an angle to the axis of rotation of the cutter. The cutter may be distinguished by viewing it from one of its end faces when the helical groove or flute will be found to lead from right to left-hand direction of the cutter body.

Alternate Helical Teeth Cutter

In some cutters, the alternate teeth are provided with right and left and helical angles.

6. According To The Purpose or Use of The Cutter

Standard Helical Teeth Cutter

These cutters are a conventional type of milling cutters whose dimensions such as cutter diameter and width, the diameter of the centre hole, width and depth of keyways, etc. are standardized.

Special Milling Cutter

Special milling cutters are designed to perform special operations which may be the combination of several standard operations. The cutters may have standard or non-standard dimensions.

Types of Standard Milling Cutter

Following are the different types of standard milling cutters:

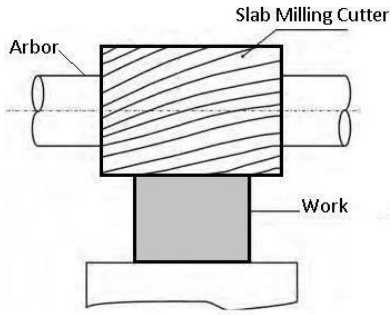
1. Plain milling cutter.
    1. Light duty plain milling cutter.
    2. Heavy-duty plain milling cutter.
    3. Helical plain milling cutter.
2. Side milling cutter
    1. Plain side milling cutter.
    2. Staggered teeth side milling cutter.
    3. Half side milling cutter.
    4. Interlocking side milling cutter.
3. Metal slitting saw
    1. Plain metal slitting saw
    2. Staggered teeth metal slitting saw
4. Angle milling cutter
    1. Single angle milling cutter
    2. Double angle milling cutter
5. Endmill
    1. Taper shank end mill
    2. A straight shank end mill
    3. Shell end mill
6. T-slot milling cutter
7. Woodruff key slot milling cutter
8. Fly cutter
9. Formed cutter
    1. Convex cutter
    2. Concave milling cutter

3. Corner rounding milling cutter
4. Gear cutter
5. Thread milling cutter

10. Tap and reamer cutter

1. Plain Milling Cutter

This types of milling cutters are circular in shape and have teeth on the circumferential surface only. The cutters are intended for the production of the flat surface parallel to the axis of rotation of the spindle. The plain milling cutter teeth may be helical or straight according to the size of the cutter**.**



Plain Milling Operation

The figure shows a straight teeth plain milling cutter. Very wide plain milling cutters are termed as the slabbing cutter. These cutters have nicked teeth. The nicks are uniformly distributed on the entire periphery of the cutter.

The object of the nicks is to break up the chips and enable the cutter to take coarse feed. The plain milling cutters are available in diameters from 16 to 160 mm and the width of the cutters range from 20 to 160mm Fig. a helical plain milling cutter. the different varieties of plain milling cutters are described below.

Light Duty Plain Milling Cutter

The light-duty plain milling cutters have a face width less than 20 mm and are made with straight teeth parallel to the axis. The wider cutters are made with helical teeth, with a helix angle of fewer than 25 degrees. These are relatively fine-tooth cutters.

Heavy Duty Milling Cutter

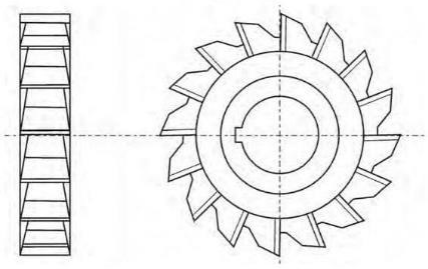
The helical duty plain milling cutters are wider cutters and are used for heavy-duty work. The helical angle of the teeth ranges from 25 to 45 degree. The cutters have fewer teeth on the periphery that increases chip space allowing them to take deeper cuts. They are also known as coarse tooth milling cutters.

Helical Plain Milling Cutter

The helical plain milling cutters have further coarse pitch and the helix angle of the teeth ranges from 45 to 60 degree. The cutter is useful in profile milling work due to its smooth cutting action and is adapted for taking light cuts on soft steel or brass and where wide surfaces are to be machined.

2. Side Milling Cutter

The side milling cutter has teeth on its periphery and also on one or both of its sides. This types of milling cutters are intended for removing metals from the side of a work a side milling cutter.



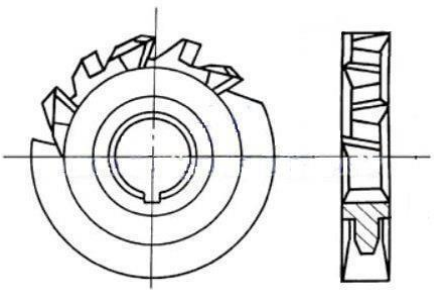
SIDE MILLING CUTTER

The side milling cutter. The side milling cutters are available from 50 to 200 mm in diameter and the width of the cutter ranges from 5 to 32 mm. The different types of side milling cutters are described below.

Plain Side Milling Cutter

The plain side milling cutter has straight circumferential teeth and has side teeth on both of its sides. Two or more such cutters may be mounted on the arbour and different faces of the workpiece may be machined simultaneously.

Staggered Teeth Side Milling Cutter



These cutters have an alternate tooth with opposite helix angle and are made of high-speed steel for long lasting durability. This design of the cutter teeth maximizes the chip space to a great extent. The cutter is suitable for milling deep, narrow slots or keyways on workpieces. staggered teeth side milling cutter.

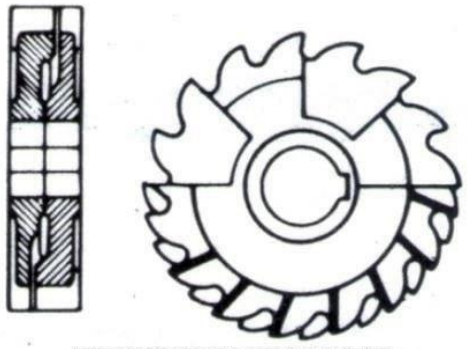
Half Side Milling Cutter

The half side milling cutter has straight or helical teeth on its circumferential surface and on one of its sides only. The periphery teeth do the actual cutting, whereas the side teeth size and finish the work.

While straddle milling, when two half side milling cutters are mounted on the arbor at a fixed distance apart to mill the two end faces of the work simultaneously, the cutters are chosen with one having right-hand helical teeth and the other having left-hand helix to counter-balance the end thrust on the arbor.

Interlocking Side Milling Cutter

The interlocking side milling cutters are formed out of two half side milling cutters or two staggered which are made to interlock to form one unit. The teeth of the two cutters may be plain or of paths of the teeth overlap when the cutters are assembled.



INTERLOCKING SIDE MILLING CUTTER

The cutters are used for milling cutters wider slots of accurate width. The width of the cutter may be varied by inserting spacers of suitable thickness between the two halves of the cutters. This feature the cutter to maintain an accurate width even after repeated sharpening. The width of the cutter ranges from 10 mm to 32 mm with a possible adjustment to the maximum of 4 mm. The cutters are available in diameters ranging from 50 to 200mm. an interlocking side milling cutter.

3. Metal Slitting Saw

The metal slitting saws resemble a plain milling cutter or a side milling cutter in appearance but they are of very small width. These cutters are used for slotting or for parting-off operation. A metal slitting saw. The different types of metal slitting saws are described below.

Plain Metal Slitting Saw

The plain metal slitting saws are thinner in construction and the width of the cutters is limited to 5mm. The sides of the cutter are relieved in order that the side faces may not rub against the work.

Staggered Teeth Metal Slitting Saws

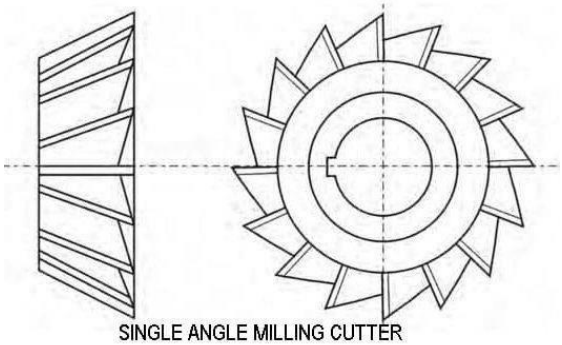
The staggered teeth metal slitting saws resemble a staggered teeth side milling cutter, but the width of the cutter is limited to 6.5 to 7 mm. The cutter is employed for heavy sawing in steel.

4. Angle Milling Cutter

These types of milling cutters are made as single or double angle cutters and are used to machine angles other than 90 degrees. The cutting edges are formed at the conical surface around the circumferential surface of the cutter. The different types of angle milling cutters are described below.

Single Angle Milling Cutter

The single angle milling cutters illustrated in fig, have teeth on the conical or angular face of the cutter and also on the large flat side. The angle of the cutter is identified by the combined angle between the conical face and the large flat face of the cutter.

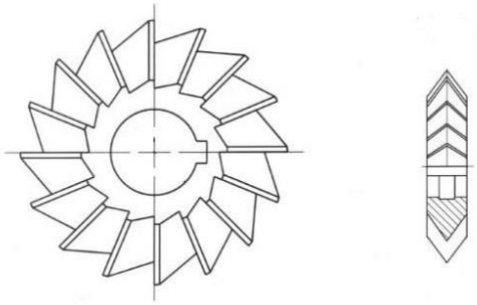


SINGLE ANGLE MILLING CUTTER

The cutters having different included angles of 30°, 45°, 60°, 65°, 70°, 75°, 80°, and 85° are available with a diameter of 50mm and width of 12mm. There are another set of cutters having the same range of included angle, but the diameter of the cutters is 63mm and width 28mm. There is a third set of cutters having included angle of 78°, 75° and 80° degrees, all having 63mm in diameter and 28mm in width.

Double Angle Milling Cutter

The double angle milling cutters illustrated in fig. have V-shaped teeth with both conical surfaces at an angle to their end faces. The angles of teeth may not be symmetrical with respect to a plane at right angles to the cutter axis.

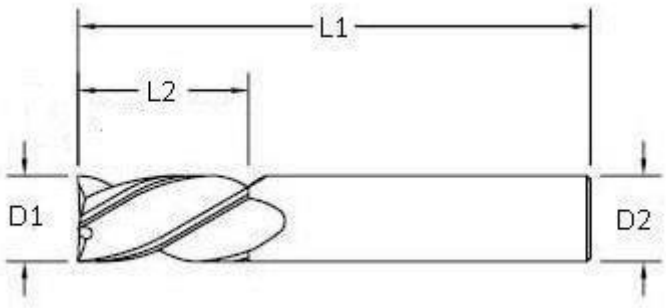


DOUBLE ANGLE MILLING CUTTER

The unsymmetrical double angle cutters are available in diameters of 50, 63, 80 and 100 mm and their width varies from 12 to 36 mm. The cutters are available in different included angles of 55°, 60°, 65°, 70°, 75°, 80°, 90° and 100° degrees. The equal angles cutters are available in diameters from 56 to 100 mm having a width ranging from 10 to 18 mm. The included angle of the cutter may be 45°, 60° or 90°. The double angle milling cutters are mainly used for cutting spiral grooves on a piece of the blank.

5. End Mill

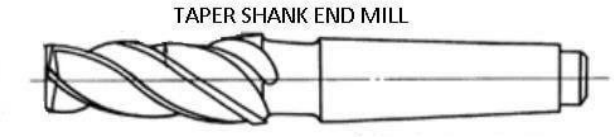
The end mills have cutting teeth on the end as well as on the periphery of the cutter.
The peripheral teeth may be straight or helical and helix may be right hand or left hand.



The end mills are used for small milling operations like cutting slots, producing narrow flat surfaces, machining accurate holes and for profile milling operations. The different type of end mills is described below.

Taper Shank End Mill

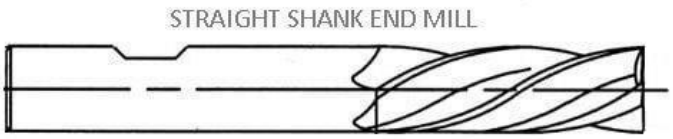
This cutter has a tapered shank or extension on one end for mounting and driving the cutters. The cutters may be double fluted or multiple flutes.



TAPER SHANK END MILL

The teeth are provided on the periphery as well as on both sides of the cutter. The taper shank end mills are available from 10 to 63 mm in diameter and may have a tanged end or tapped end for mounting on the arbor. The taper shanks conform to the Morse taper No. 1 to No. 5.

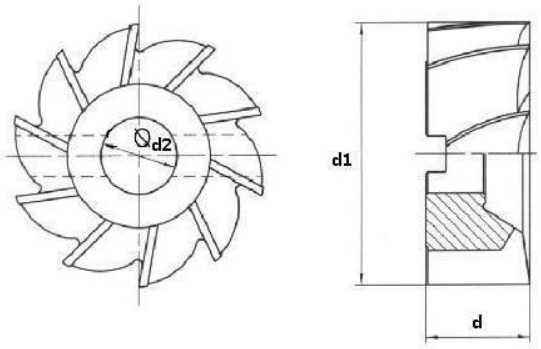
Straight Shank End Mill



This cutter has a round shank for mounting and driving the cutters. The cutters teeth may be straight or helical. The diameter of the cutter ranges from 2 mm to 63 mm.

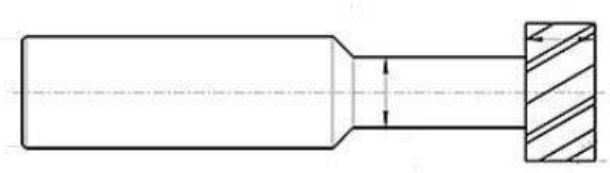
Shell End Mill

The shell end mills are larger and heavier and mills provided with a central hole for mounting the cutter on a short arbor. This design of the cutter gives economy in tool material as the cutters having different diameter may be interchanged on a single shank.

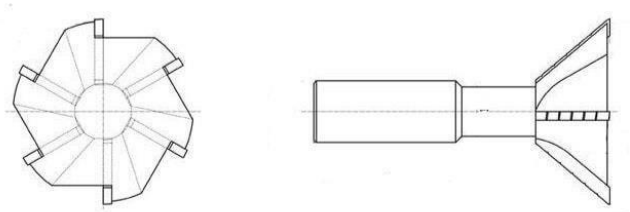


The cutting edges are provided at the end and round the periphery of the cutter. The teeth may be straight or helical and may be left or right handed. The diameter of cutters ranges from 40 to 160 mm and width from 32 to 63 mm. The bore diameter of cutters ranges from 16 to 50 mm.

6. T-Slot Milling Cutter



The T-slot milling cutters are a special form of end mills for producing T-slots. Fig illustrated a T-slot and dovetail slot milling cutter.



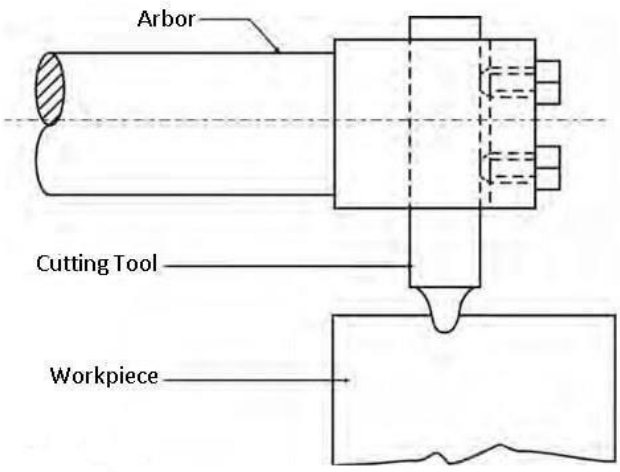
DOVETAIL SLOT MILLING CUTTER

The teeth are provided on the periphery as well as on both sides of the cutter.

7. Woodruff Key Slot Milling Cutter

These cutters are small in size and similar in construction to a thin, small diameter plain milling cutter, employed for the production of Woodruff key slots. The cutter is provided with a shank and has staggered or straight teeth.

8. Fly Cutter



FLY CUTTER

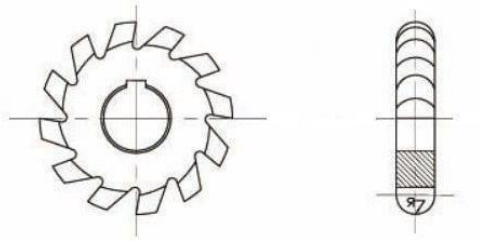
The fly cutters are simple in form and are mainly used in tool room works. The fly cutter consists of a single point cutting tool mounted to the end of an arbor. The cutting edge formed to reproduce the contoured surface. This cutter considered as an emergency tool when the standard cutters are not available.

9. Formed Cutter

The formed cutters have irregular profiles on the cutting edges in order to generate an irregular outline of the work. The different types of standard formed cutters are described below.

Convex Milling Cutter

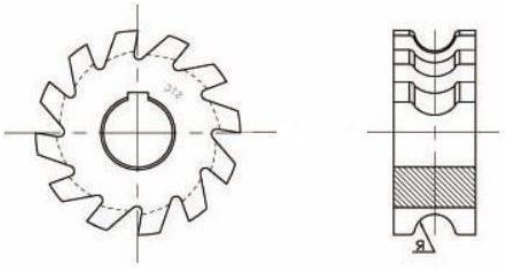
The convex milling cutters have teeth curved outwards on the circumferential surface to form the contour of a semicircle.



The cutter produces a concave semicircle surface on a workpiece. The diameter of the cutter ranges from 50 mm to 125mm. And the radius of the semicircle varies from 1.6 to 20mm.

Concave Milling Cutter

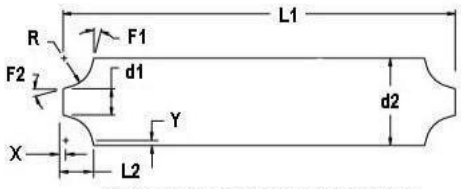
The concave milling cutters have teeth curved inwards on the circumferential surface to form the contour of a semicircle.



The concave milling cutters produce a convex semicircle surface on a work piece. The diameter of the cutter ranges from 56 to 110 mm and the radius of the semicircle varies from 1.5 to 20 mm.

Corner Rounding Milling Cutter

The corner rounding milling cutters have teeth curved inward on the circumferential surface to form the contour of a quarter circle.

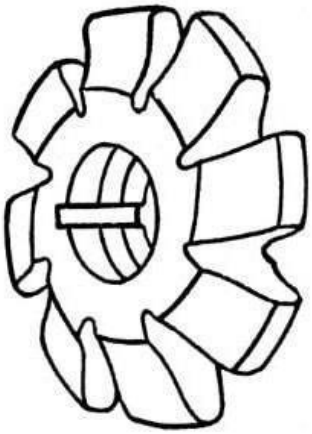


CORNER ROUNDING MILLING CUTTER

The cutter produces a convex surface having a contour of a quarter circle. The cutter is used for cutting a radius on the corners or edges of the work. The diameter of the cutter ranges from 56 to 110mm and the radius of the quarter circle varies from 1-5 to 20 mm.

Gear Cutter

The gear cutter has formed cutting edges which reproduce the shape of the cutter teeth on the gear blank. The shape of the cutter teeth may be involute or cycloidal according to the gear tooth profile.

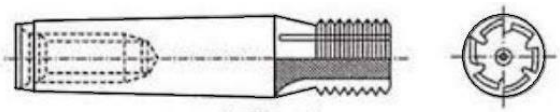


GEAR CUTTER

The cutter tooth profile should be differently shaped for each pitch of the gear and also for each change in a number of teeth on the gear which it is going to cut. But in practice, a compromise is effected by using one cutter to cover a range of gear sizes. Thus for cutting gear teeth of the involute profile, 8 numbers of cutters are required to cut from a pinion of 12 teeth to a rack and for cutting different numbers of gear teeth. A list of cutters with the number of teeth they are intended to cut is given in the table.

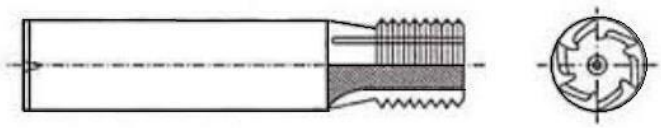
Thread Milling Cutter

The thread milling cutters are designed to mill thread of specific form and size on a workpiece. Usually, worms and acme threads are produced by thread milling cutters.



TAPER SHANK THREAD MILLING CUTTER

The cutters may have parallel or taper shanks. The parallel shank thread milling cutters are available in diameters ranging from 8 to 20 mm and the length of the threaded portion varies from 8 to 33 mm.



PARALLEL SHANK THREAD MILLING CUTTER

The pitch of the thread corresponds to the diameter of the cutter. The taper shank thread milling cutters are available in diameters ranging from 16 to 25 mm and the length of threaded portion varies from 16 to 40 mm.

10. Tap and Reamer Cutter

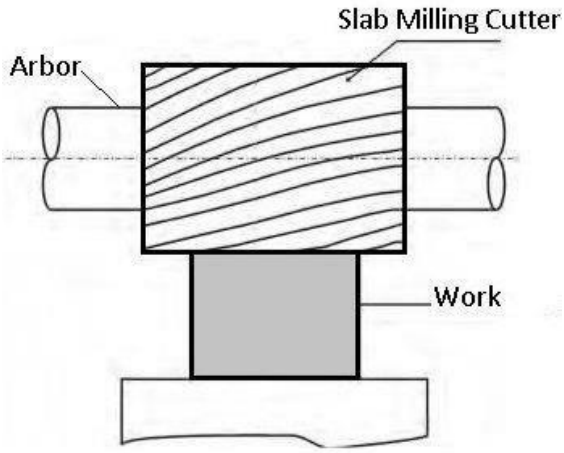
The tap and reamer cutters are special type double angle cutters intended for producing grooves of flutes in tap or reamers. The pointed end of the tooth is rounded and the tooth profile corresponds to the type of groove that it is going to make.

Milling Machine Operations

Following are the different types of operations performed on milling machine:

1. Plain Milling Operation
2. Face Milling Operation
3. Side Milling Operation
4. Straddle Milling Operation
5. Angular Milling Operation
6. Gang Milling Operation
7. Form Milling Operation
8. Profile Milling Operation
9. End Milling Operation
10. Saw Milling Operation
11. Milling Keyways, Grooves, and Slot
12. Gear Milling
13. Helical Milling
14. Cam Milling
15. Thread Milling

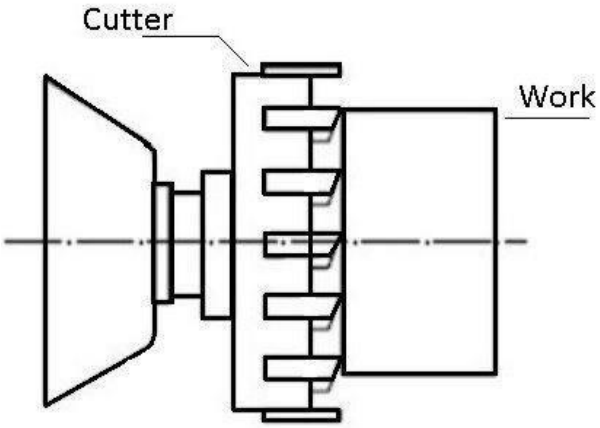
1. Plain Milling



Plain Milling Operation

- The plain milling is the most common types of milling machine operations.
- Plain milling is performed to produce a plain, flat, horizontal surface parallel to the axis of rotation of a plain milling cutter.
- The operation is also known as slab milling.
- To perform the operation, the work and the cutter are secured properly on the machine.
- The depth of cut is set by rotating the vertical feed screw of the table. And the machine is started after selecting the right speed and feed.

2. Face Milling



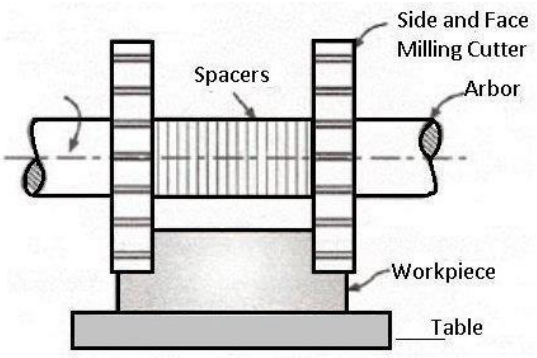
Face Milling Operation

- The face milling is the simplest milling machine operations.
- This operation is performed by a face milling cutter rotated about an axis perpendicular to the work surface.
- The operation is carried in plain milling, and the cutter is mounted on a stub arbor to design a flat surface.
- The depth of cut is adjusted by rotating the crossfeed screw of the table.

3. Side Milling

- The side milling is the operation of producing a flat vertical surface on the side of a workpiece by using a side milling cutter.
- The depth of cut is set by rotating the vertical feed screw of the table.

4. Straddle Milling

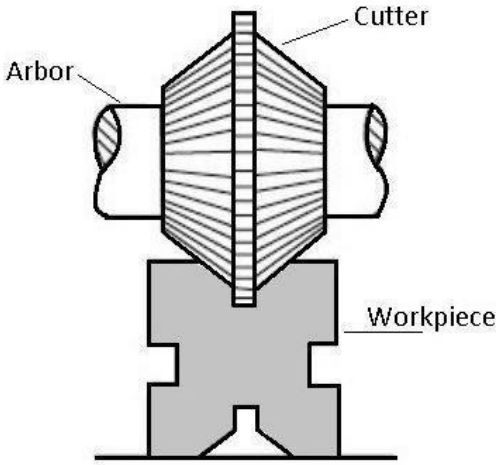


Straddle Milling Operation

- The straddle milling is the operation of producing a flat vertical surface on both sides of a workpiece by using two side milling cutters mounted on the same arbor.
- Distance between the two cutters is adjusted by using suitable spacing collars.

- The straddle milling is commonly used to design a square or hexagonal surfaces.

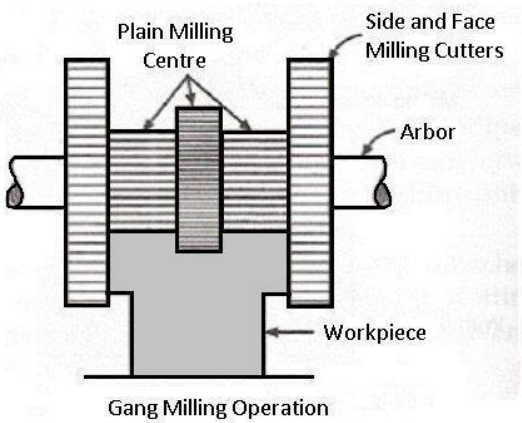
5. Angular Milling



Angular Milling

- The angular milling is the operation of producing an angular surface on a workpiece other than at right angles of the axis of the milling machine spindle.
- The angular groove may be single or double angle and may be of varying included angle according to the type and contour of the angular cutter used.
- One simple example of angular milling is the production of V-blocks.

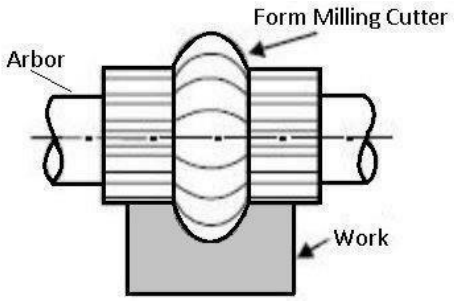
6. Gang Milling



Gang Milling Operation

- The gang milling is the operation of machining several surfaces of a workpiece simultaneously by feeding the table against a number of cutters having the same or different diameters mounted on the arbor of the machine.
- The method saves much of machining time and is widely used in repetitive work.
- Cutting speed of a gang of cutters is calculated from the cutter of the largest diameter.

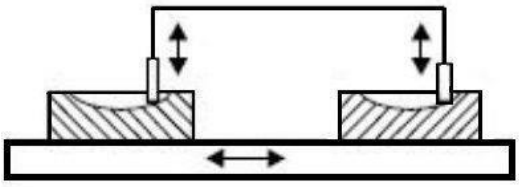
7. Form Milling



Form Milling Operation

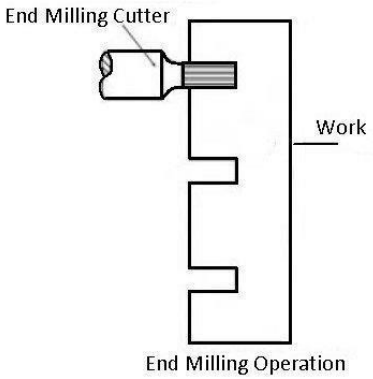
- The form milling is the operation of producing the irregular contour by using form cutters.
- The irregular shape may be convex, concave, or of any other shape. After machining, the formed surface is inspected by a template gauge.
- Cutting rate for form milling is 20% to 30% less than that of the plain milling.

8. Profile Milling


Profile Milling Operation

- The profile milling is the operation of reproduction an outline of a template or complex shape of a master dies on a workpiece.
- Different cutters are used for profile milling. An end mill is one of the widely used milling cutters in profile milling work.

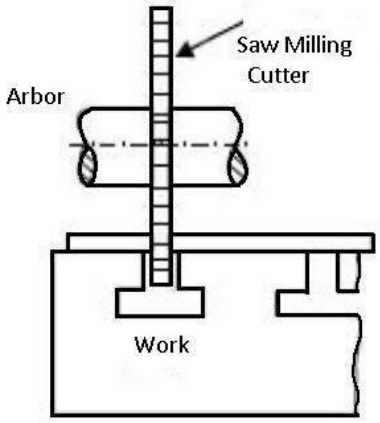
9. End Milling



End Milling Operation

- The end milling is the operation of producing a flat surface which may be vertical, horizontal or at an angle in reference to the table surface.
- The cutter used is an end mill. The end milling cutters are also used for the production of slots, grooves or keyways.
- A vertical milling machine is more suitable for end milling operation.

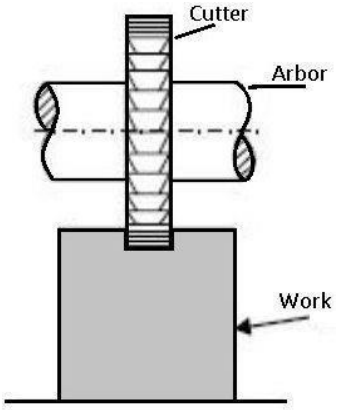
10. Saw Milling



Saw Milling Opeartion

- Saw-milling is the operation of producing narrow slots or grooves on a workpiece by using a saw-milling cutter.
- The saw-milling also performed for complete parting-off operation.
- The cutter and the workpiece are set in a manner so that the cutter is directly placed over one of the T-slots of the table.

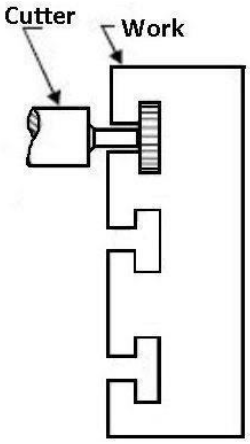
11. Milling Keyways, Grooves and Slots



Keyway Milling Operation

- The operation of producing of keyways, grooves and slots of varying shapes and sizes can be performed in a milling machine.

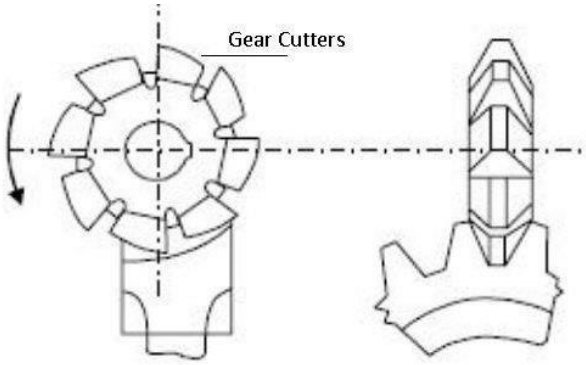
- It is done by using a plain milling cutter, a metal slitting saw, an end mill or by a side milling cutter.
- The open slots can be cut by a plain milling cutter, a metal slitting saw, or by a side milling cutter. The closed slots are produced by using endmills.



T-Slot Milling Operation

- A dovetail slot or T-slot is manufactured by using special types of cutters designed to give the required shape on the workpiece.
- The second slot is cut at right angles to the first slot by feeding the work past the cutter.
- A woodruff key is designed by using a woodruff key slot cutter.
- Standard keyways are cut on the shaft by using side milling cutters or end mills.
- The cutter is set exactly at the centre line of the workpiece and then the cut is taken.

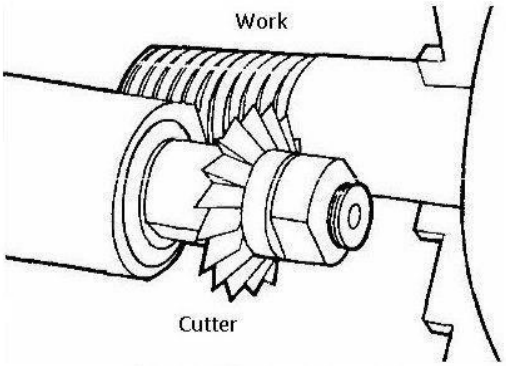
12. Gear Cutting



Gear Cutting Milling Operation

- The gear cutting operation is performed in a milling machine by using a form-relieved cutter. The cutter may be a cylindrical type or end mill type.
- The cutter profile fits exactly with the tooth space of the gear.
- Equally spaced gear teeth are cut on a gear blank by holding the work on a universal diving head and then indexing it.

13. Helical Milling



Helical Milling Operation

- The helical milling is the operation of producing helical flutes or grooves around the periphery of a cylindrical or conical workpiece.
- The operation is performed by rotating the table to the required helix angle. And then by rotating and feeding the workpiece against rotary cutting edges of a milling cutter.
- Production of the helical milling cutter, helical gears, cutting helical grooves or flutes on a drill blank or a reamer.

14. Cam Milling

The cam milling is the operation of producing cams in a milling machine by the use of universal dividing head and a vertical milling attachment. The cam blank is mounted at the end of the dividing head spindle and an end mill is held in the vertical milling attachment.

The axis of the cam blank and the end mill spindle should always remain parallel to each other when setting for cam milling. The dividing head is geared to the table feed screw so that the cam is rotated about its axis while it is fed against the end mill. The axis of the cam can be set from 0 to 90° in reference to the surface of the table for obtaining a different rise of the cam.

15. Thread Milling

The thread milling machine operations are used to produce threads by using a single or multiple thread milling cutter. Thread milling operation is performed in special thread milling machines to produce accurate threads in small or large quantities.

The operation requires three driving motions in the machine. One for the cutter, one for the work and the third for the longitudinal movement of the cutter.

When the operation is performed by a single thread milling cutter, the cutter head is swivelled to the exact helix angle of the thread. The cutter is rotated on the spindle and the workpiece is revolved slowly about its axis. The thread is completed in one cut by setting the cutter to the full depth of the thread and then feeding it along the entire length of the workpiece.

When the thread is cut by multiple thread milling cutter, the cutter axis and the work spindle are set parallel to each other after adjusting the depth of cut equal to the full depth of the thread. The thread is completed by simply feeding the revolving cutter longitudinal through a distance equal to the pitch length of the thread while the work is rotated through one complete revolution.

Fundamentals of Milling Machine

The milling process performed may be grouped under two separate headings

1. Peripheral milling
2. Face milling
3. End milling

Peripheral Milling

It is the operation performed by milling cutter to produce a machined surface parallel to the axis of rotation of the cutter.

Peripheral milling is classified under 2 types.

1. Up milling
2. Down milling

Face Milling

It is the operation performed by a milling cutter to produce a flat-machined surface perpendicular to the axis of rotation of the cutter.

The peripheral cutting edges of the cutter do the actual cutting, whereas the face cutting edges finish up the work surface by removing a very small amount of the metal.

End Milling

End milling is the combination of peripheral and face milling.

Conclusion:

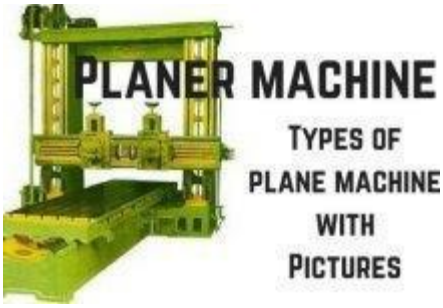
The milling machine is a widely used machine in many industries because of the high metal removal rate, good accuracy, and better surface finish. This is why a milling machine finds a wide application in production work.

From this guide, I hope that you have understood everything about the milling machine. We have explained parts, types, operations, milling cutter, and etc. but if you still have any doubts you can ask in the comment I'll respond to you.

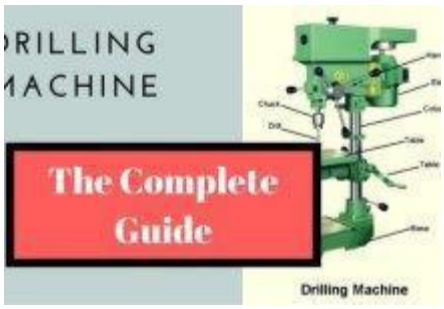
Also if you like the article on the "**Milling machine**" then please share it with your friends. If you have questions or suggestions let us know in the comments.

Read Next:

[Click here to Read]



[Click here to read]



[Click Here to Read]

[Click here to read]