

UNIT – 3

MILLING, GRINDING, AND SURFACE FINISHING

MILLING

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. Milling machine is used for machining flat surfaces, contoured surfaces, surfaces of revolution, external and internal threads, and helical surfaces of various cross-sections. The surface obtained by this machine tool is superior in quality and more accurate and precise.

Types of milling machine

The milling machines are classified according to the general design 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 type milling machine
3. Planer type milling machine
4. Special type milling machine

1 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 guide ways 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 or Horizontal 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 swivelled by 45° 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 machine drills, reamers, gears, milling cutters with a very high degree of accuracy and so it finds an important place in a workshop.

c) Omniversal milling machine

In addition to the table movements obtained in a universal milling machine, the knee can be tilted 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

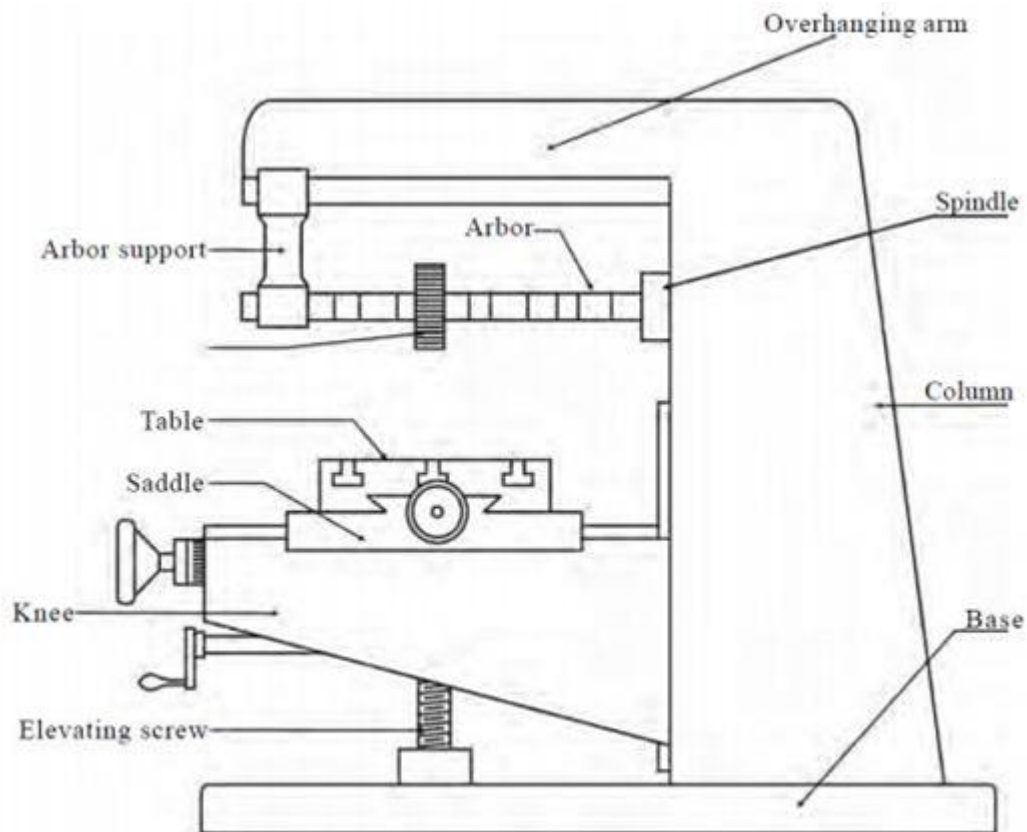
A spindle of a vertical milling machine is positioned at right angles to the table. The cutter is moved vertically or at an angle by swivelling the vertical head of the machine. The machine is adapted for machining slots and flat surfaces by moving the table. By mounting end mills and face milling cutters on the spindle, vertical milling and internal milling are performed

1. Horizontal milling machine

Main Parts of Column and knee type milling machine

Base

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 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 guide ways 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 guide ways of the column. An elevating screw mounted on the base obtains this movement. Saddle is mounted upon the knee and moves in across direction.

Saddle

It is mounted on the guide ways 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 guide ways for the table movement.

Table

The table is moved longitudinally either by power or manually on the guide ways of the saddle. The trip dogs placed on it control the movement of the table. The table of a universal milling machine can be swivelled 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.

Overhanging arm

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

Front brace

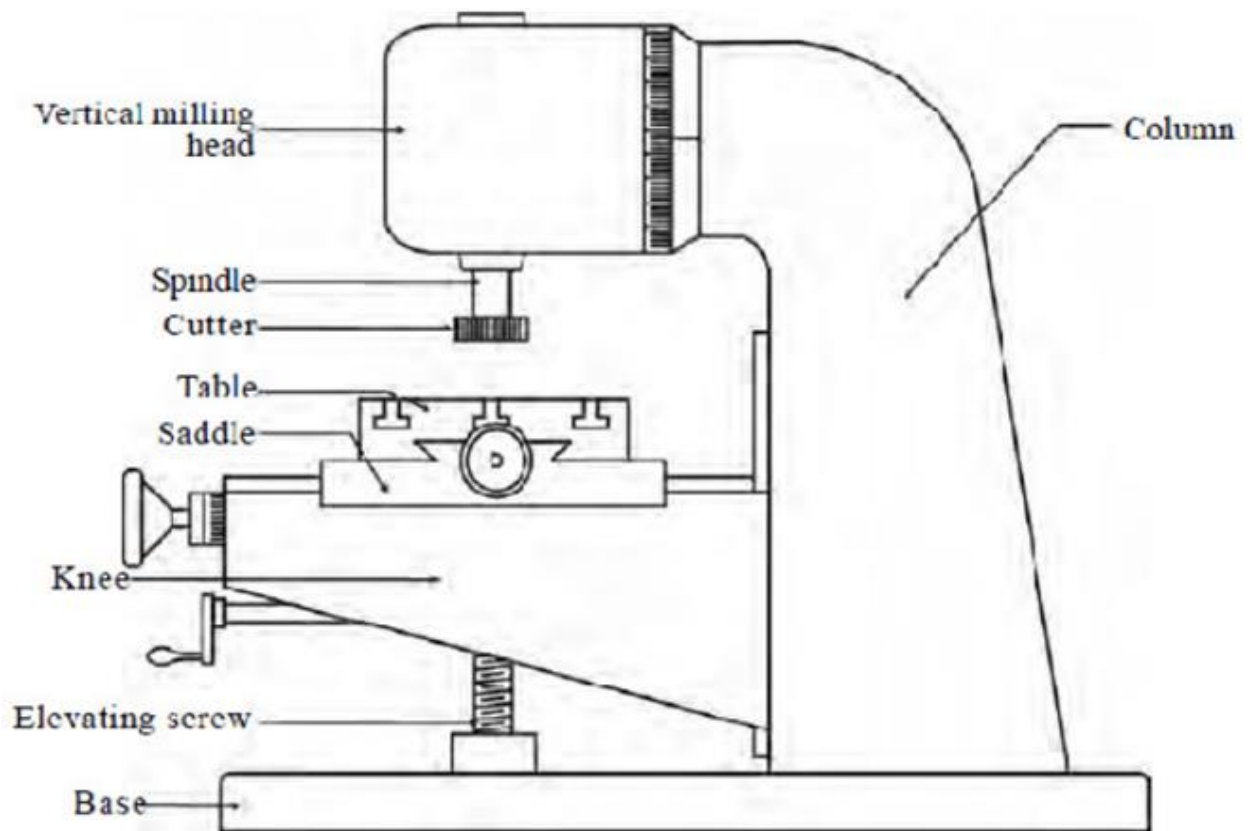
It is an extra support fitted between the knee and the overhanging arm. It is slotted to allow the knee to be adjusted vertically.

Arbor

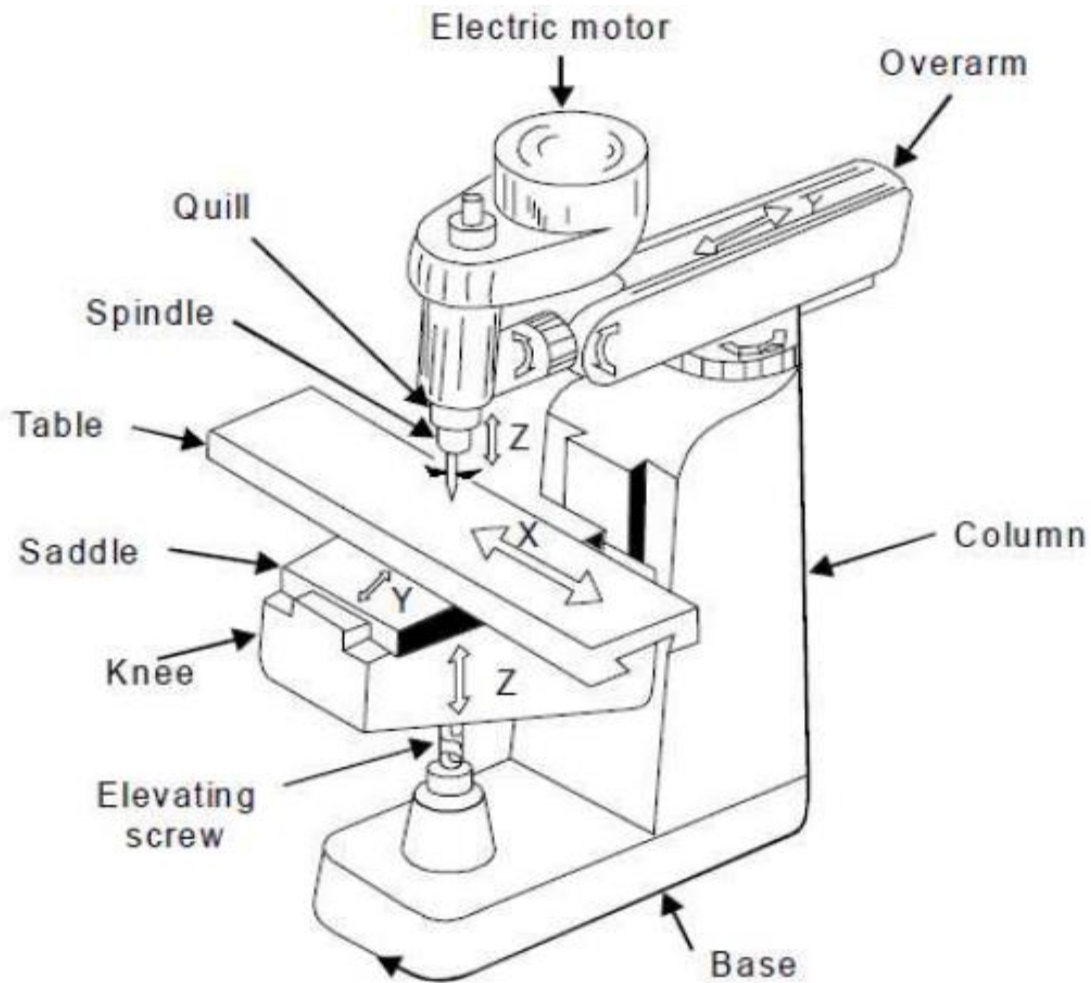
It supports the different types of cutters used in the machine. It is drawn into the taper hole of the spindle by a draw bolt. One or more cutters are mounted on the arbor by placing spacing collars between them. The arbor is supported by an arbor support. The arbor is provided with a Morse taper or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

2. 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. The spindle is rotated by the power obtained from the mechanism placed inside the column. Angular surfaces are machined by swivelling the spindle head.



Vertical milling machine



3. Milling Operation - 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

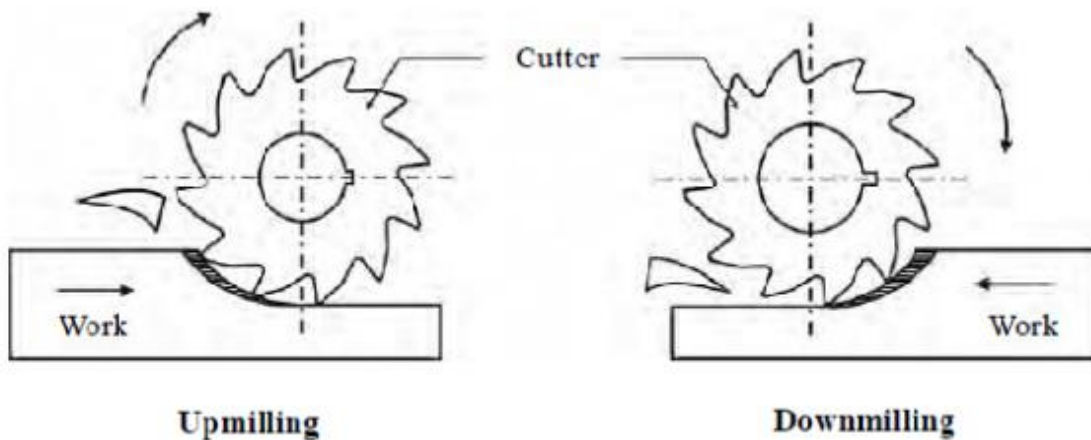
Up milling

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. As 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

reasons the quality of the surface obtained by this method 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 direction 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 setup on the workpiece.



1. Standard milling cutters or Types of milling cutters

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

1. Plain milling cutter
2. Side milling cutter
3. Metal slitting saw
4. Angle milling cutter
5. End milling cutter
6. 'T' – Slot milling cutter
7. Fly cutter
8. Formed cutter

1. 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 or cylindrical milling cutter. They have a central hole in order to be mounted on the arbor. Plain milling cutters have nicked teeth to break the chips into small pieces. Helical plain milling cutters are superior to a straight plain milling cutter. A plain milling cutter is illustrated in Fig

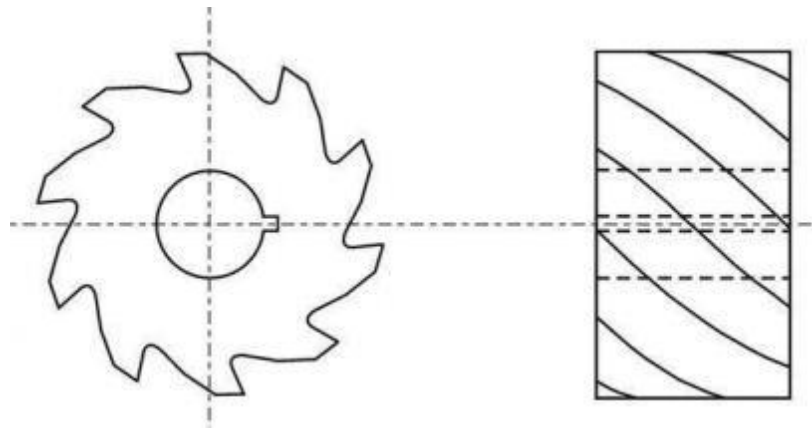


Fig 5.14 Plain milling cutter

2. 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 interlocked side milling cutter. Machining is performed by selecting a proper milling cutter. A side milling cutter is illustrated in Fig.



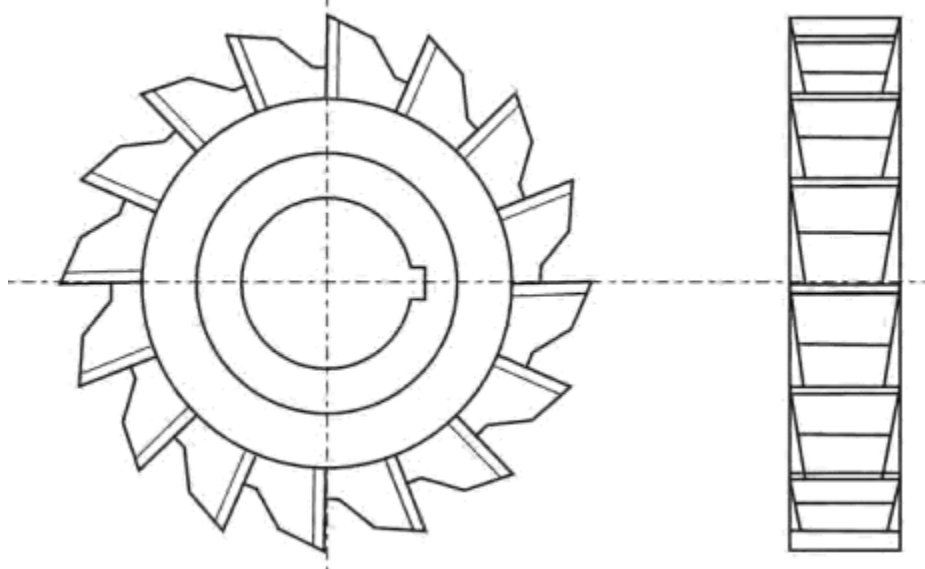


Fig Side milling cutter

3. 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 is limited. The outside diameter of the cutter will be upto 200mm and width of the cutter ranges from 0.75mm to 7mm. The side of the cutter is relieved so that the side may not rub against the work. A metal slitting saw is illustrated in Fig

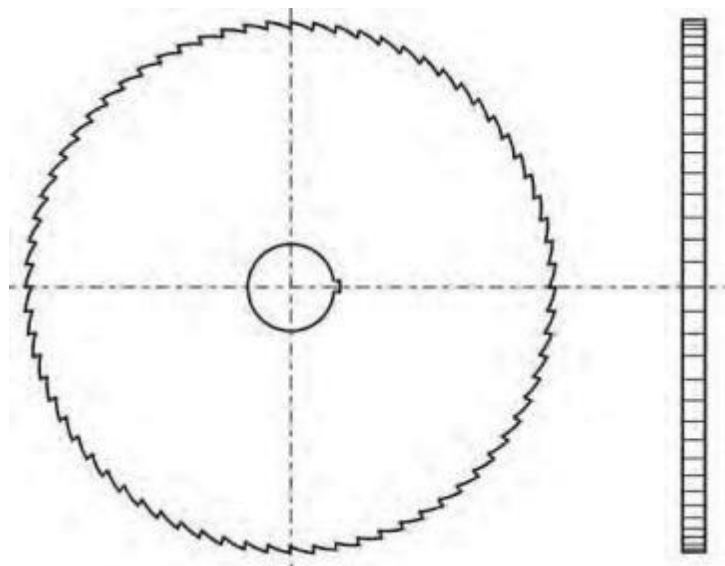


Fig 5.16 Metal slitting saw

4. Angle milling cutter

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 cutter and double angle milling cutter. Fig. shows a single angle milling cutter.

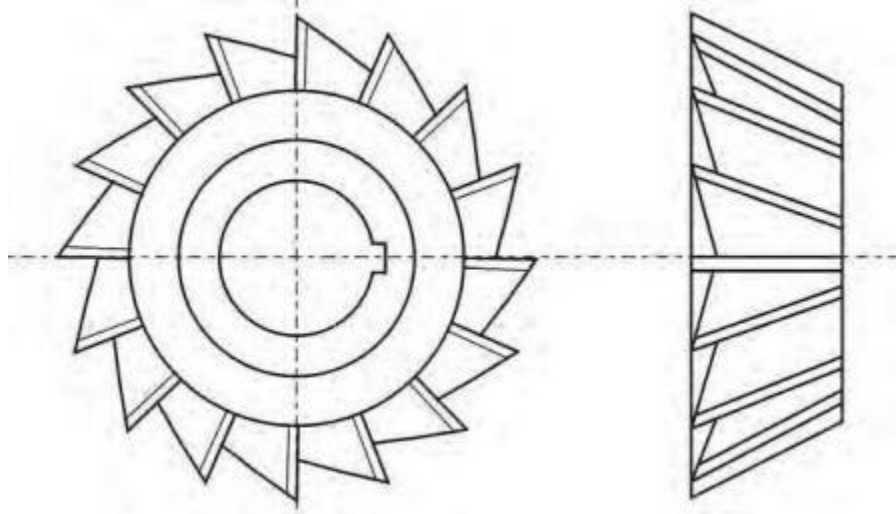


Fig. Angle milling cutter (Single)

5. '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. Fig. shows a 'T' – Slot milling cutter.

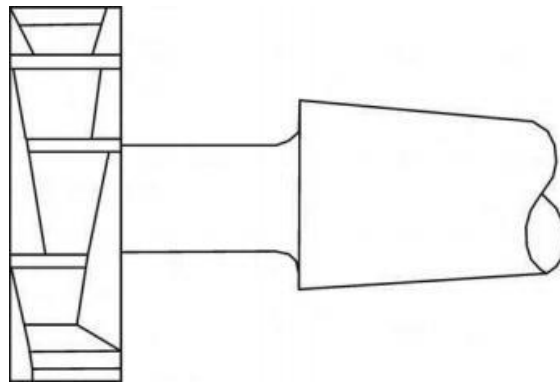


Fig. 'T' slot milling cutter

6. End mill

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 surfaces. An End mill is illustrated in Fig.

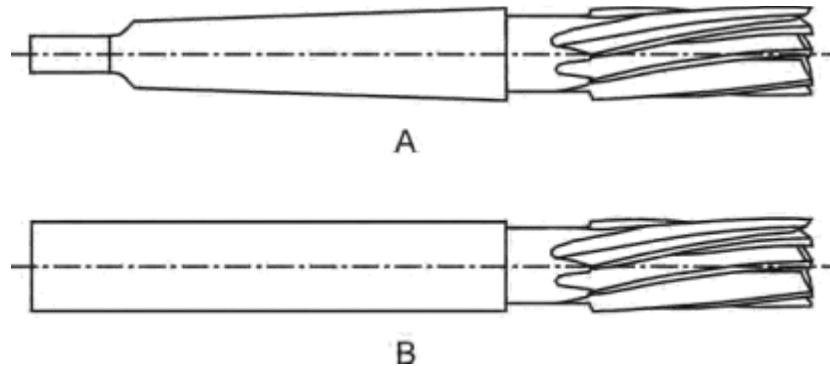
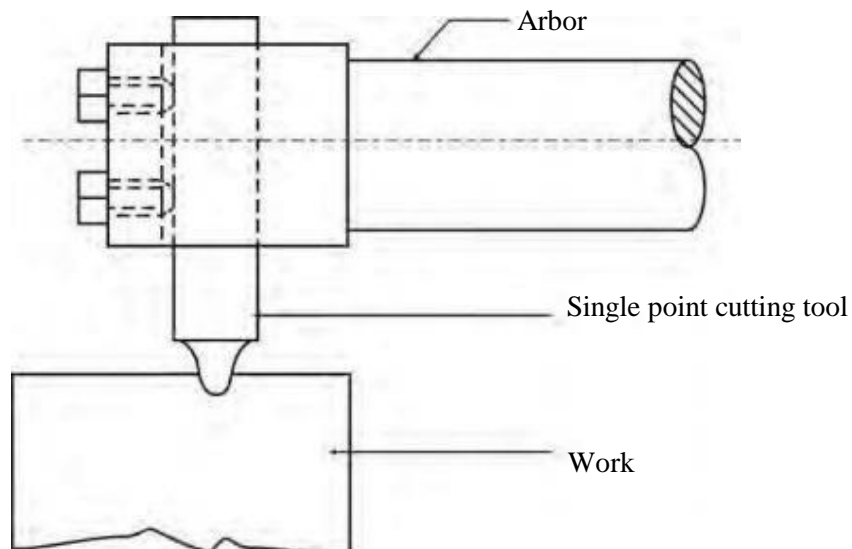


Fig. End milling cutters

A - Taper shank B - Straight shank

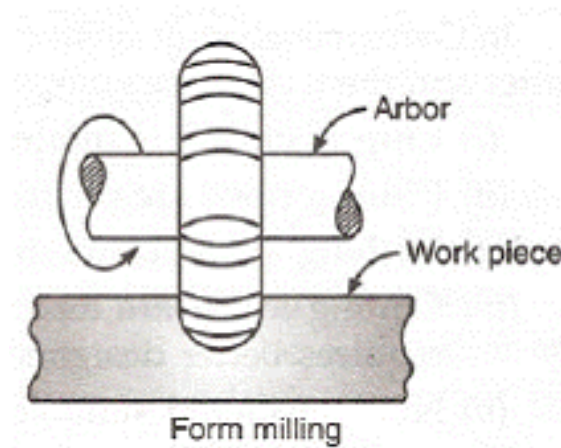
7. Fly cutter

Fly 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 fly cutter is shown in Fig.



8. Formed cutter

Formed 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 cutters threads are milled to a specific form and size. Tap and reamer cutters are used for producing grooves or flutes in taps and reamers.



Milling machine operations

The following operations are performed using suitable milling cutters.

1. Plain milling
2. Face milling
3. Side milling
4. Straddle milling
5. Angular milling
6. Gang milling
7. Form milling
8. End milling
9. Flute milling
10. Keyway milling
11. Drilling & reaming
12. Boring
13. Gear cutting
14. Thread milling
15. Cam milling

1 Plain 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. *Fig. shows plain milling operation.*

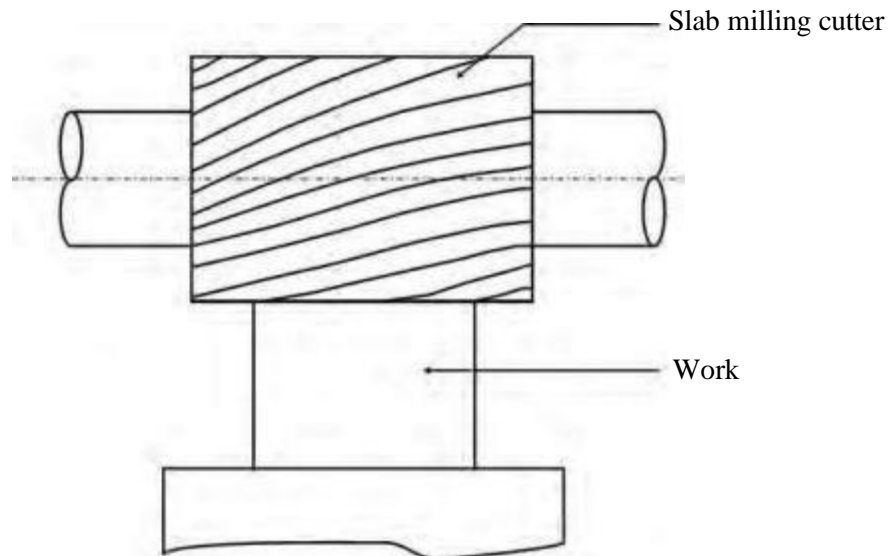
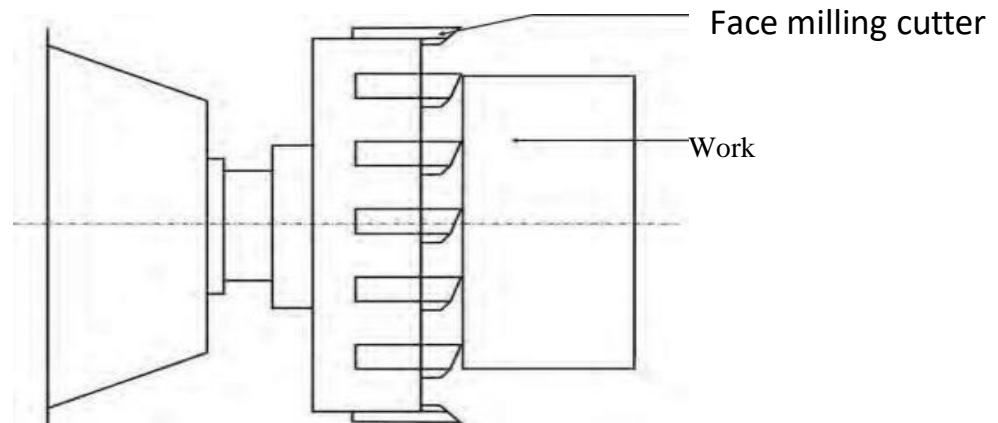


Fig Plain milling operation

2 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 cutter are also used at times to perform this operation. The depth of cut is provided to the table. Fig. shows face 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. Fig. shows angular milling operation.

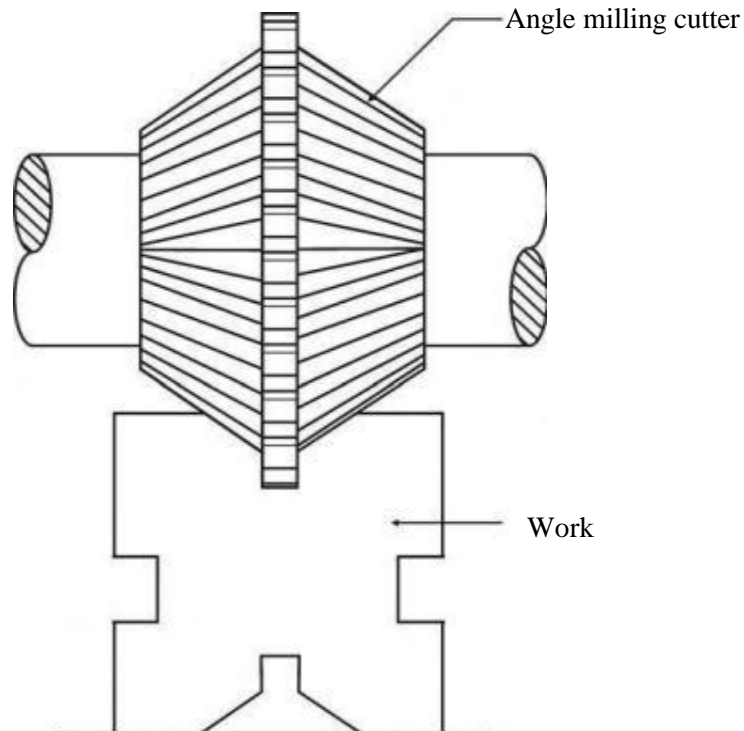


Fig Angular milling operation

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. Fig. shows gang milling operation.

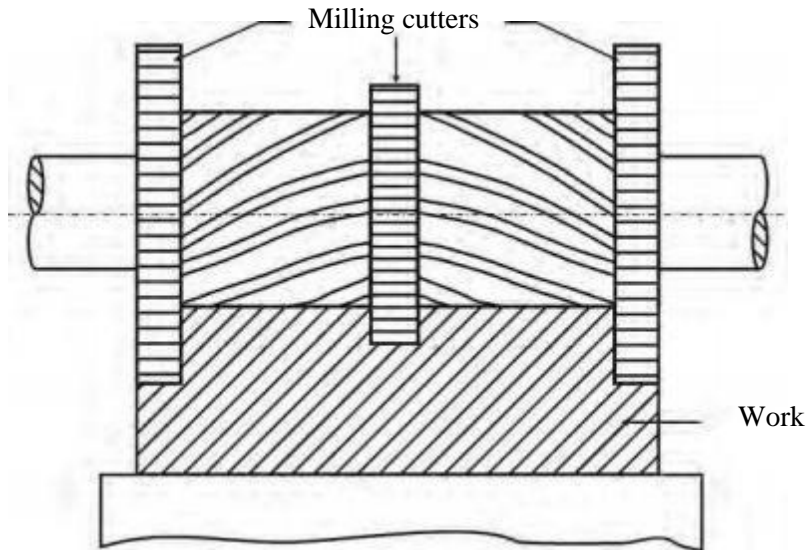


Fig Gang milling operation

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 milling machine. Fig. shows end milling operation.

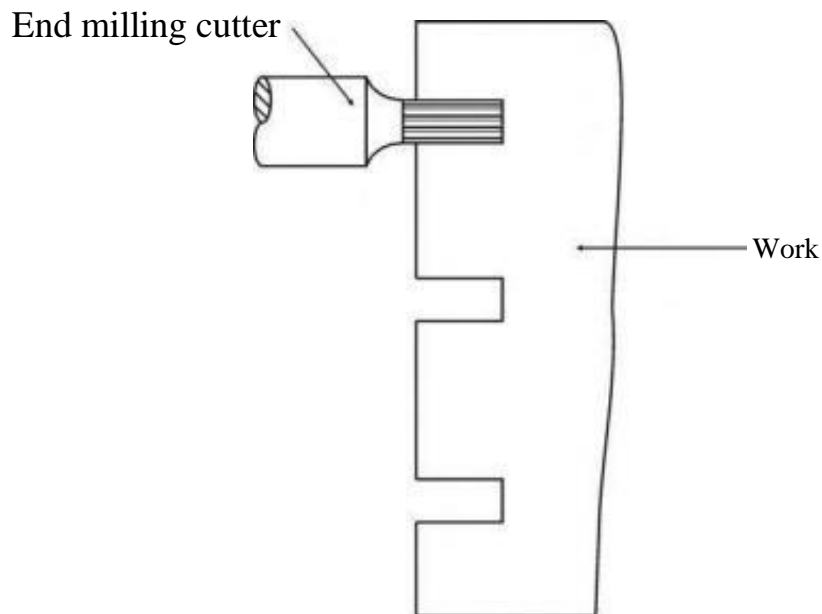


Fig End milling operation

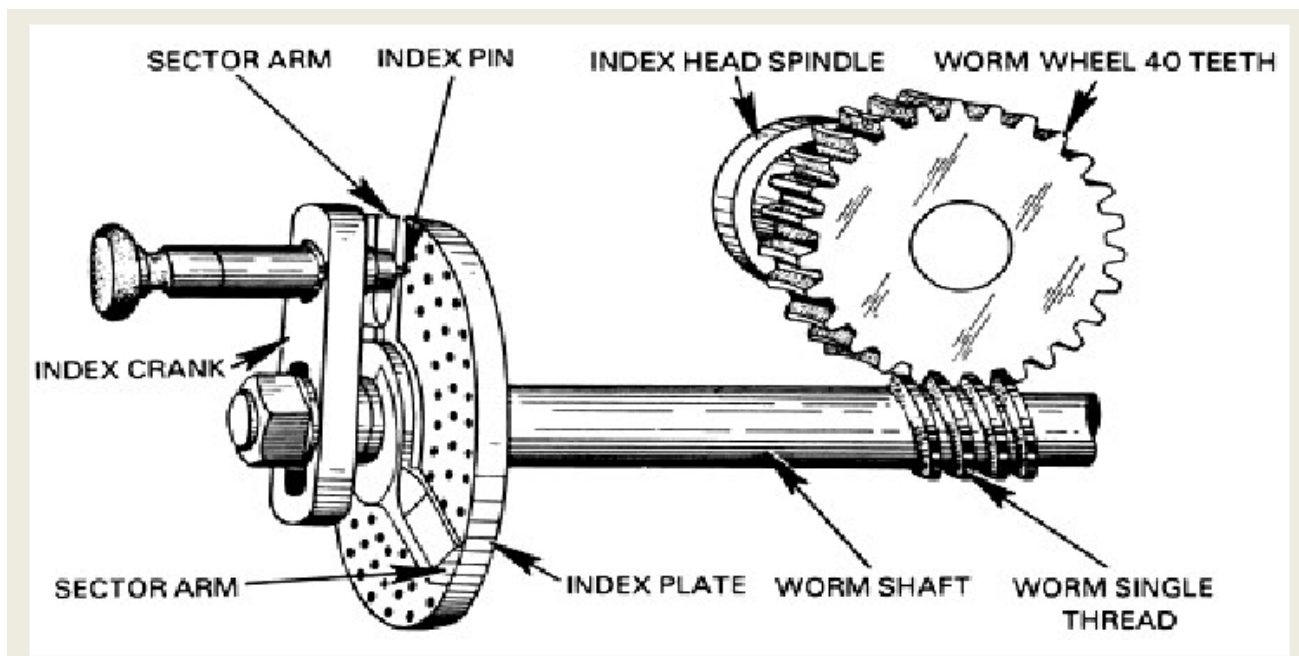
Indexing of Milling Machine

Indexing is the process of evenly dividing circumference of a circular work piece equally spaced division. It is used in cutting gear teeth, cutting splines, milling grooves in reamers and tap and spacing holes on a circle.

Indexing or Dividing head

The indexing head of the indexing fixture contains an indexing mechanism which is used to control the rotation of the index head spindle to space or divide a work piece accurately. A simple indexing mechanism consists of 40 teeth worm wheel fastened to the index head spindle, a single-cut worm, a crank for turning the worm shaft, an index plate and a sector.

Since there are 40 teeth in worm wheel, one turn of the index crane causes the worm wheel, and the index head spindle to make $1/40$ of a turn. So, 40 turns of the index crane revolve the spindle one full turn.



Index Plate

The indexing plate is a round plate with a series of six or more circles of equally spaced holes. The index pin on the crank can be inserted in any hole in any circle. With the interchangeable plates regularly furnished with most index heads, the spacing necessary for most gears, bolt heads, milling cutters, splines can be obtained.

Three indexing plates are used. These plates have concentric circles of holes with their different numbers as described below:

Plate No. 1: 15,16,17,18,19,20

Plate No. 2: 21,23,27,29,31,33

Plate No. 3: 37,39,41,43,47,49

Index Methods

In simple indexing, an index plate selected for the particular application, is fitted on the worm shaft and locked through a locking pin. To index the work through any required angle, the index crank pin is withdrawn from the hole of the index plate than the work is indexed through the required angle by turning the index crank through a calculated no of whole revolution and holes on one of the hole circles, after which the index pin is relocated in the required hole.

If the number of turns that the crank must be rotated for each indexing can be found from the formula $N = 40/Z$

Where,

Z = No of division or indexing needed on the work

40 = No of teeth on the worm wheel attached to the indexing plate,

since 40 turns of the index crank will turn the spindle to one full turn.

For example, if it is desired to index for 16 divisions, 16 divided into 40 equals $2 \frac{8}{16}$ turns i.e. for each indexing we need two complete rotation of crank plus 8 more holes on the 16-hole circle of plate1 (Plate1 – 15,16,17,18,19,20 holes)

The Gear Cutting Process

The process of cutting a gear on a milling machine generally involves the following steps:

Gear Blank Preparation:

The gear blank, usually a cylindrical piece of material, is machined to the correct outside diameter, bore size, and face width according to the gear specifications.

Setup on the Milling Machine:

- The indexing head is mounted and aligned on the milling machine table.
- The gear blank is securely mounted on an arbor or mandrel, which is then placed between the centres of the indexing head and tailstock (if used for support).
- The appropriate gear cutter is selected based on the gear's pitch and number of teeth and mounted on the milling machine's arbor (for horizontal mills) or in the spindle (for vertical mills).
- The cutter is carefully aligned with the centre of the gear blank.

Calculating Indexing:

The required indexing movement for each tooth is calculated based on the number of teeth to be cut and the capabilities of the indexing head. This determines how much the indexing head crank needs to be turned for each tooth space.

Cutting the First Tooth Space:

- The gear blank is moved upwards (or the cutter downwards, depending on the machine type) to the correct depth of the tooth space. This depth is typically calculated based on the gear's pitch.
- The milling machine table is then fed horizontally to cut the first tooth space along the face width of the gear blank.

Indexing to the Next Tooth:

Once the first tooth space is cut, the cutter is retracted, and the indexing head is rotated precisely according to the calculated indexing movement to position the blank for the next tooth space.

Repeat Cutting and Indexing:

Steps 4 and 5 are repeated for each tooth until all the tooth spaces are cut around the entire circumference of the gear blank. It is often recommended to take multiple passes, gradually increasing the depth of cut, to reduce cutter load and improve accuracy and surface finish.

Deburring and Finishing:

After all the teeth are cut, any burrs or sharp edges are removed from the gear teeth. Depending on the application and required precision, further finishing processes like filing or grinding may be performed.

GRINDING

Introduction

Grinding is a metal cutting operation like any other process of machining removing metal in comparatively smaller volume. The cutting tool used is an abrasive wheel having many numbers of cutting edges. The machine on which grinding the operation is performed is called a grinding machine.

Types of grinding machines

According to the accuracy of the work to be done on a grinding machine, they are classified as

- Rough grinding machines
- Precision grinding machines

Rough grinding machines

The rough grinding machines are used to remove stock with no reference to the accuracy of results. Excess metal present on the cast parts and welded joints are removed by rough grinders. The main types of rough grinders are

1. Hand grinding machine
2. Bench grinding machine
3. Floor stand grinding machine
4. Flexible shaft grinding machine
5. Swing frame grinding machine
6. Abrasive belt grinding machine

Precision grinding machines

Precision grinders are used to finish parts to very accurate dimensions. The main types of precision grinders are:

1. Cylindrical grinding machines
2. Internal grinding machines
3. Surface grinding machines
4. Tool and cutter grinding machines
5. Special grinding machines

Cylindrical grinding machine

Cylindrical grinders are generally used to grind external surfaces like cylinders, taper cylinders, faces and shoulders of work. There are two types of cylindrical grinding machines and they are

External cylindrical grinding machines

Internal cylindrical grinding machines

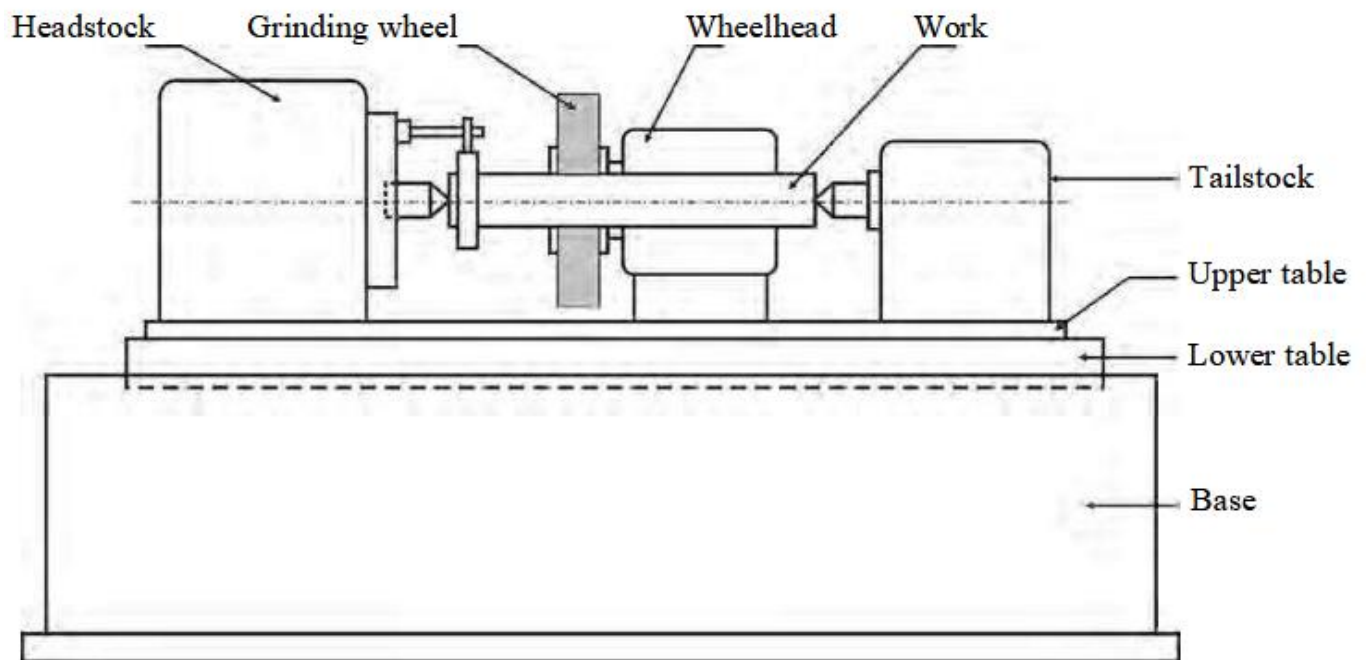


Fig. Cylindrical grinding machine

Base

The base is made of cast iron and rests on the floor. It supports the parts mounted on it. The top of the base is accurately machined and provides guideways for the table to slide on. The base contains the table driving mechanisms.

Tables

The tables are mounted on top of the base. There are two tables namely lower table and upper table. The lower table slides on the guideways on the bed. It can be moved by hand or by power within required limits.

The upper table can be swiveled upto $\pm 10^\circ$ and clamped in position. Adjustable dogs are clamped in longitudinal slots at the side of the lower table. They are set up to reverse the table at the end of the stroke.

Headstock

The headstock is situated at the left side of upper table. It supports the workpiece by means of a centre and drives it by means of a dog. It may hold and drive the workpiece in a chuck. It houses the mechanism meant for driving the work. The headstock of a universal grinding machine can be swiveled to any required angle.

Tailstock

The tailstock is situated at the right side of the table. It can be adjusted and clamped in various positions to accommodate different lengths of workpieces.

Wheelhead

The wheel head may be moved at right angles to the table ways. It is operated by hand or by power to feed the wheel to the work. The wheelhead carries a grinding wheel. Its driving motor is mounted on a slide at the top and rear of the base. The grinding wheel rotates at about 1500 to 2000 r.p.m.

Surface grinding machines

Surface grinding machines are employed to finish plain or flat surfaces horizontally, vertically or at any angle.

There are four different types of surface grinders. They are

- Horizontal spindle and reciprocating table type
- Horizontal spindle and rotary table type
- Vertical spindle and reciprocating table type
- Vertical spindle and rotary table type

Horizontal spindle surface grinding machine

The majority of surface grinders are of horizontal spindle type. In the horizontal type of the machine, grinding is performed by the abrasives on the periphery of the wheel. Though the area of contact between the wheel and the work is small, the speed is uniform over the grinding surface and the surface finish is good. The grinding wheel is mounted on a horizontal spindle and the table is reciprocated to perform grinding operation.

Base

The base is made of cast iron. It is a box like casting which houses all the table drive mechanisms. The column is mounted at the back of the base which has guideways for the vertical adjustment of the wheelhead.

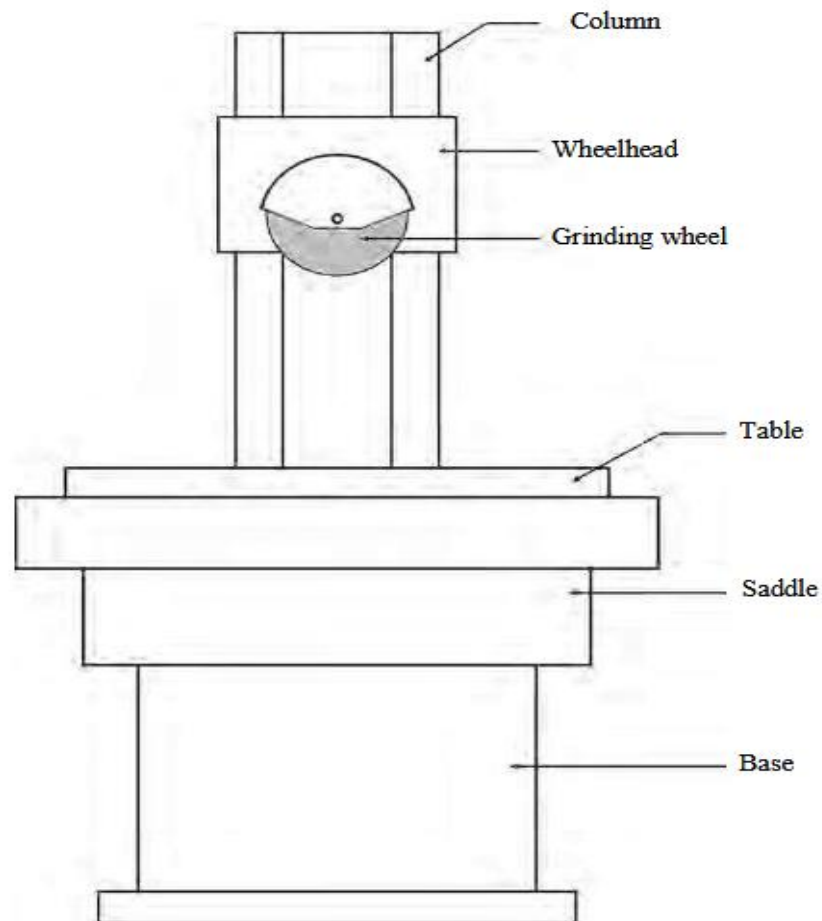


Fig. Horizontal spindle surface grinder

Saddle

Saddle is mounted on the guideways provided on the top of the base. It can be moved at cross towards or away from the column.

Table

The table is fitted to the carefully machined guideways of the saddle. It reciprocates along the guideways to provide the longitudinal feed. The table is provided with 'T'- slots for clamping workpieces directly on the table or for clamping grinding fixtures or magnetic chuck.

Wheelhead

An electric motor is fitted on the wheelhead to drive the grinding wheel. The wheelhead is mounted on the guideways of the column, which is secured to the base. It can be raised or lowered with the grinding wheel to accommodate workpieces of different heights and to set the wheel for depth of cut.

Vertical spindle surface grinding machine

The face or sides of the wheel are used for grinding in the vertical type surface grinders. The area of contact is large and stock can be removed quickly. But a criss-cross pattern of grinding scratches is left on the work surface. Considering the quality of surface finish obtained, the horizontal spindle type machines are widely used.

The grinding wheel is mounted on the vertical spindle of the machine. The work is held on the table and grinding is done. The base of the machine is a box like casting. The base is very similar to the one of the horizontal spindle type. It houses all the table drive mechanisms.

The table is mounted on the base on top of which a magnetic chuck is mounted. A grinding wheel is mounted on the wheelhead which slides vertically on the column. The table is made to reciprocate or rotate to bring the work surface below the grinding wheel to perform grinding.

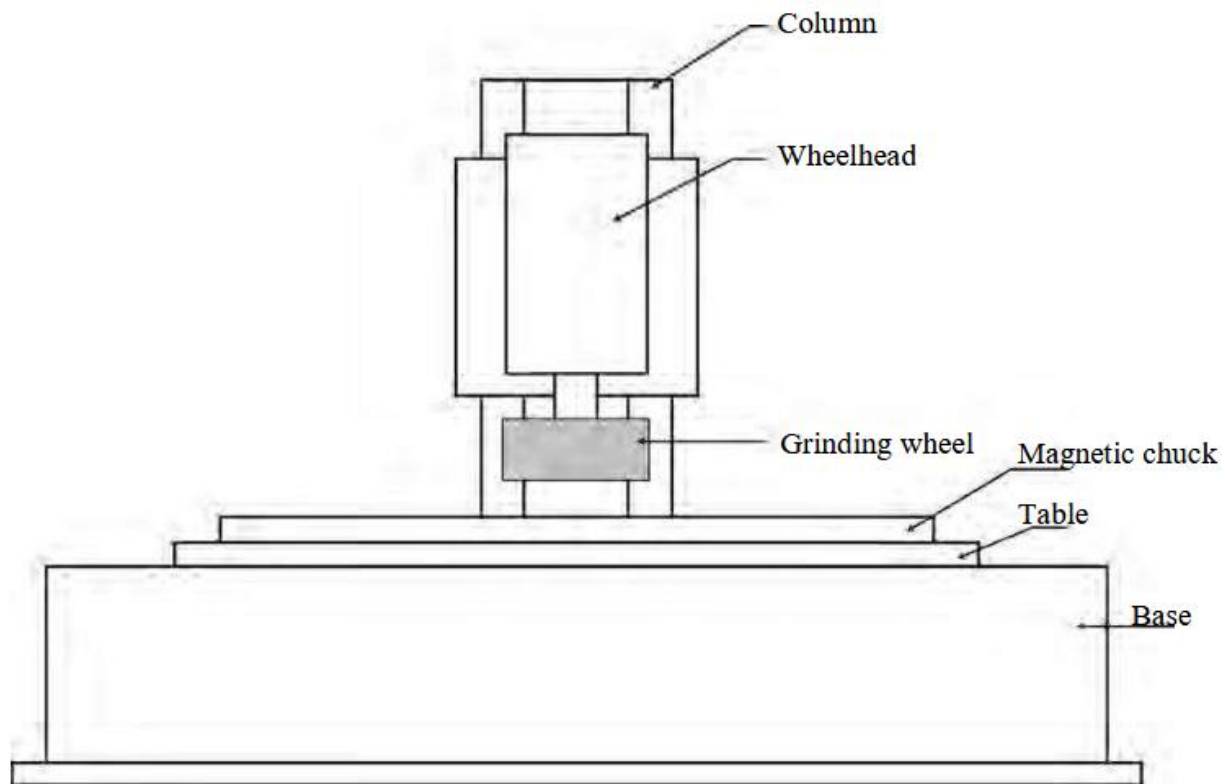


Fig. Vertical spindle surface grinder

Abrasives

Abrasives are used for grinding and polishing operations. It should have uniform physical properties of hardness, toughness and resistance to fracture. Abrasive may be classified into two principal groups.

Natural abrasives

Artificial abrasives

Natural abrasives

The natural abrasives are obtained from the Earth's crust. They include sandstone, emery, corundum and diamond.

Sandstone is used as abrasive to grind softer materials only.

Emery is natural alumina. It contains aluminium oxide and iron oxide. Corundum is also a natural aluminium oxide. It contains greater percentage of

aluminium oxide than emery. Both emery and corundum have a greater hardness and abrasive action than sandstone.

Diamond is the hardest available natural abrasive. It is used in making grinding wheels to grind cemented carbide tools.

Artificial abrasives

Artificial abrasives are of two types.

Silicon carbide abrasives

Aluminium oxide abrasives

Silicon carbide

Silicon carbide is manufactured from 56 parts of silica, 34 parts of powdered coke, 2 parts of salt and 12 parts of sawdust in a long rectangular electric furnace of the resistance type that is built of loose brick work. There are two types of silicon carbide abrasives – green grit and black grit.

Silicon carbide is next to diamond in the order of hardness. But it is not tough enough as aluminium oxide. It is used for grinding materials of low tensile strength such as cemented carbides, ceramic materials, grey brass, bronze, copper, aluminium, vulcanized rubber etc. This is manufactured under trade names of carborundum. It is denoted by the letter ‘S’.

Aluminium oxide

Aluminium oxide is manufactured by heating mineral bauxite, silica, iron oxide, titanium oxide, etc., mixed with ground coke and iron borings in arc type electric furnace.

Aluminium oxide is tough and not easily fractured, so it is better adapted to grinding materials of high tensile strength such as most steels, carbon steels, high speed steels, and tough bronzes. This is denoted by the letter ‘A’

Types of bonds

A bond is an adhesive substance that is employed to hold abrasive grains together in the form of grinding wheels. There are several types of bonds. Different grinding wheels are manufactured by mixing hard abrasives with suitable bonds. The table containing the types of wheels manufactured using different types of bonds and their symbols is given below

Type of bond	Symbol	Grinding wheel
1. Vitrified	V	Vitrified wheel
2. Silicate	S	Silicate wheel
3. Shellac	E	Elastic wheel
4. Resinoid	B	Resinoid wheel
5. Rubber	R	Vulcanised wheel
6. Oxychloride	O	Oxychloride wheel

Grain size, Grade and Structure (or) Grit

Grit (or) Grain Size:

The grinding wheel is made up of thousands of abrasive grains. The grain size or grit number indicates the size of the abrasive grains used in making a wheel, or the size of the cutting teeth. Grain size is denoted by a number indicating the number of meshes per linear inch of the screen through which the grains pass when they are graded. There are four different groups of the grain size namely coarse, medium, fine and very fine. If the grit number is large, the size of the abrasive is fine and a small grit number indicates a large grain of abrasive.

Coarse : 10, 12, 14, 16, 20, 24

Medium : 30, 36, 46, 54, 60

Fine : 80, 100, 120, 150, 180

Very fine : 220, 240, 280, 320, 400, 500, 600

Grade

The grade of a grinding wheel refers to the hardness with which the wheel holds the abrasive grains in place. It does not refer to the hardness of the abrasive grains. The grade is indicated by a letter of the English alphabet. The term 'soft' or 'hard' refers to the resistance a bond offers to disruption of the abrasives. A wheel from which the abrasive grains can easily be dislodged is called soft whereas the one, which holds the grains more securely, is called hard. The grade of the bond can be classified in three categories

Soft	:	A	B	C	D	E	F	G	H		
Medium	:	I	J	K	L	M	N	O	P		
Hard	:	Q	R	S	T	U	V	W	X	Y	Z

Structure:

The relative spacing occupied by the abrasives and the bond is referred to as structure. It is denoted by the number and size of void spaces between grains. It may be 'dense' or 'open'. Open structured wheels are used to grind soft and ductile materials. Dense wheels are useful in grinding brittle materials.

Dense	:	1	2	3	4	5	6	7	8	
Open	:	9	10	11	12	13	14	15 or higher		

Standard marking system of grinding wheels

The Indian standard marking system for grinding wheels has been prepared with a view of establishing a uniform system of marking of grinding wheels to designate their various characteristics.

Prefix	Manufacturer's abrasive type symbol
First element (letter)	Type of abrasive
Second element (number)	Size of abrasive
Third element (letter)	Grade of bond
Fourth element (number)	Structure of the grinding wheel
Fifth element (letter)	Type of bond
Suffix	Manufacturer's symbol

The meaning of the given marking on a grinding wheel

w A 54 M 7 V 20

w -	Manufacturer's abrasive type symbol	
A -	Type of abrasive	- Aluminium oxide
54 -	Size of abrasive	- Medium
M -	Grade of bond	- Medium
7 -	Structure of the grinding wheel	- Dense
V -	Type of bond	- Vitrified
20 -	Manufacturer's symbol	

Dressing and truing of grinding wheels

Dressing

If the grinding wheels are loaded or gone out of shape, they can be corrected by dressing or truing of the wheels. Dressing is the process of breaking away the glazed surface so that sharp particles are again presented to the work. The common types of wheel dressers known as “Star” -dressers or diamond tool dressers are used for this purpose.

A star dresser consists of a number of hardened steel wheels on its periphery. The dresser is held against the face of the revolving wheel and moved across the face to dress the wheel surface. This type of dresser is used particularly for coarse and rough grinding wheels.

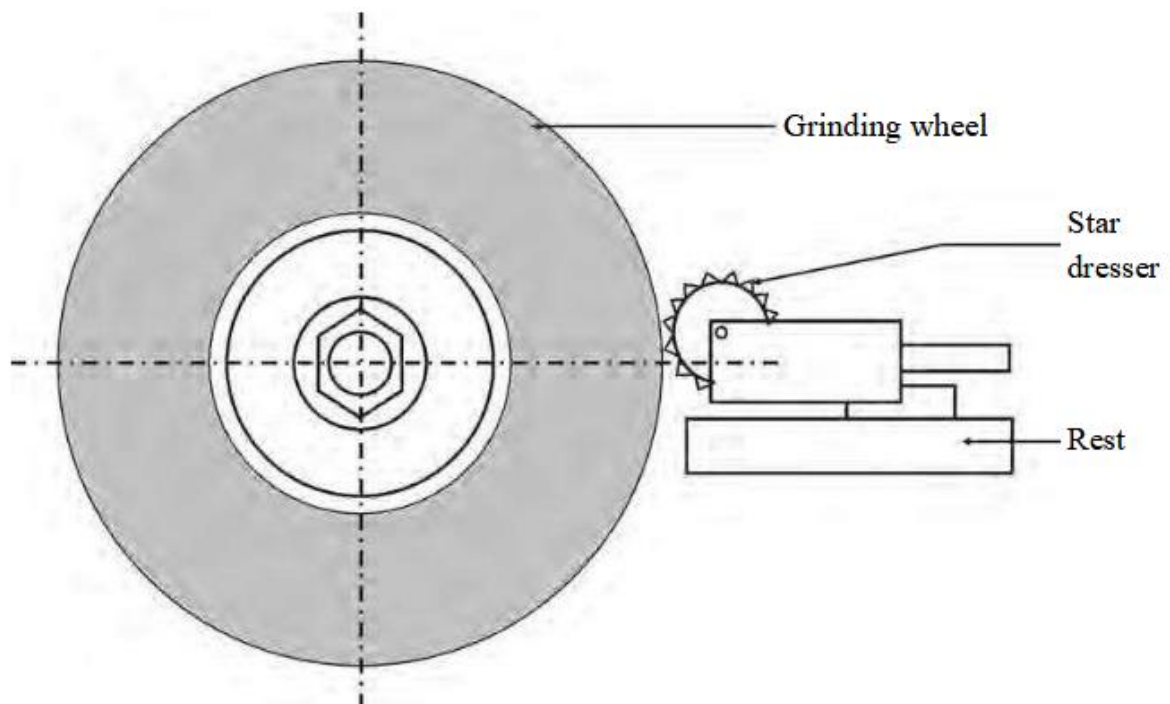


Fig. Dressing of a grinding wheel (Star wheel method)

For precision and high finish grinding, small industrial diamonds known as ‘bort’ are used. The diamonds are mounted in a holder. The diamond should be kept pointed down at an angle of 15° and a good amount of coolant is applied while dressing. Very light cuts only may be taken with diamond tools.

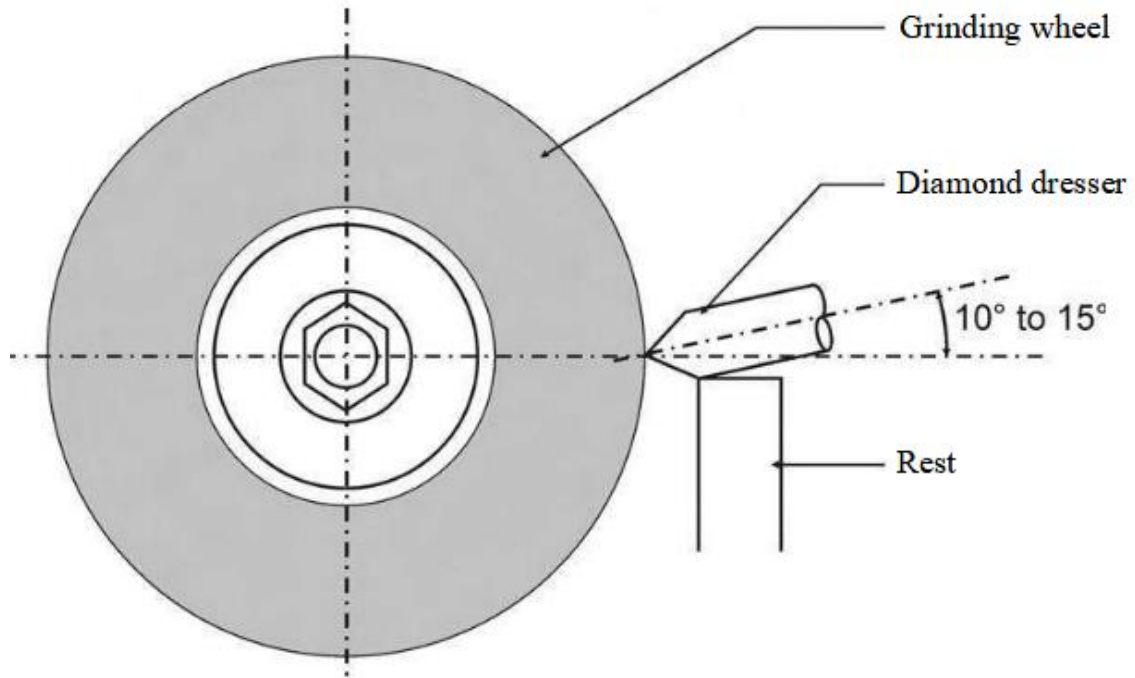


Fig. Dressing of a grinding wheel (Diamond dresser method)

Truing

The grinding wheel becomes worn from its original shape because of breaking away of the abrasive and bond. Sometimes the shape of the wheel is required to be changed for form grinding. For these purposes the shape of the wheel is corrected by means of diamond tool dressers. This is done to make the wheel true and concentric with the bore or to change the face contour of the wheel. This is known as truing of grinding wheels. Diamond tool dressers are set on the wheels at 15° and moved across with a feed rate of less than 0.02mm . A good amount of coolant is applied during truing.

Surface finishing processes

In a workshop, metal parts are manufactured by performing different operations in lathe, shaping machine, milling machine, drilling machine or grinding machine. In order to enhance the quality of surfaces of these parts, several surface finishing processes are performed on them. If better finish is desired for looks, for accuracy, for wearing qualities or for better fits, one of the following processes is employed.

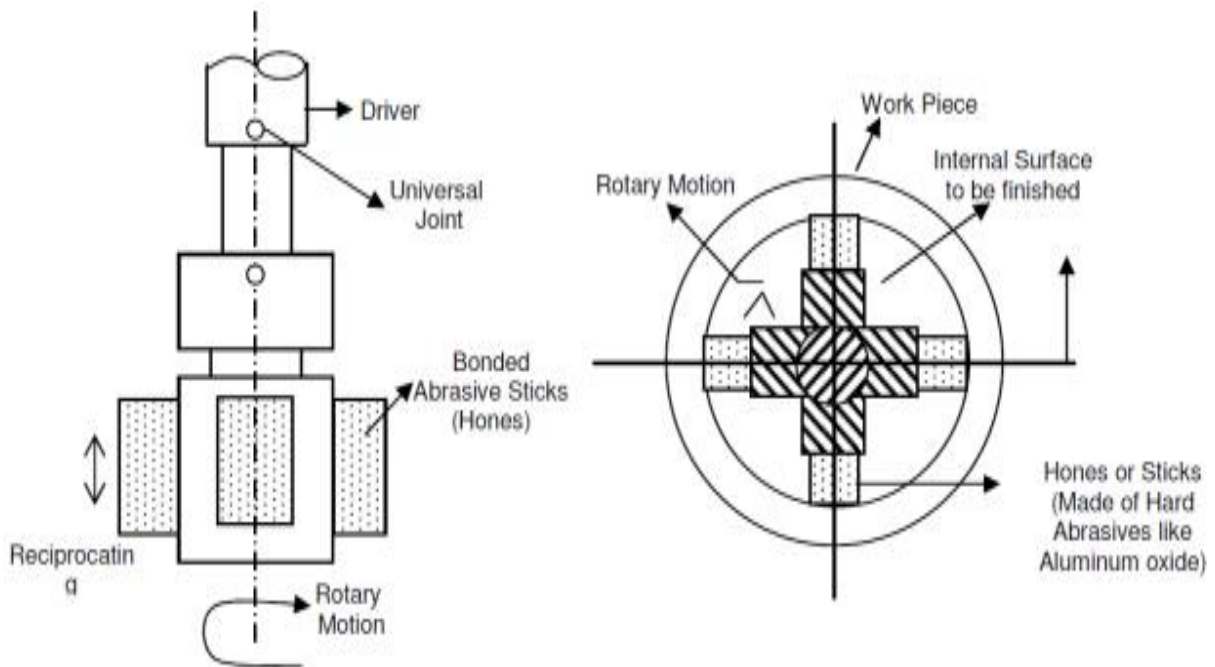
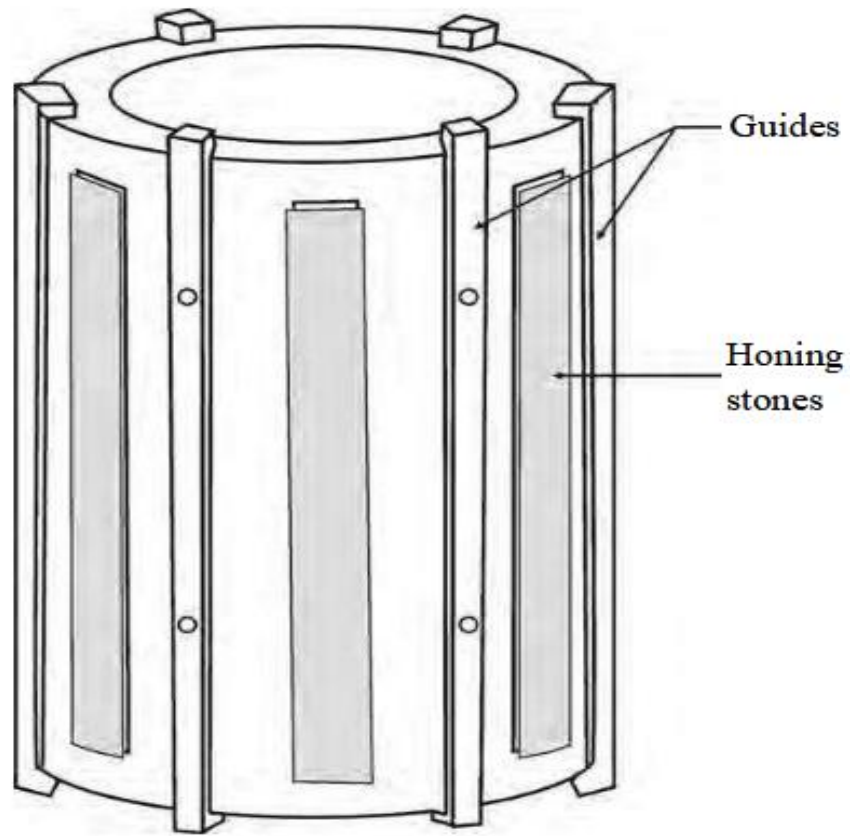
1. Lapping
2. Honing
3. Superfinishing
4. Polishing
5. Buffing
6. Scraping
7. Electroplating

HONING

Honing is a surface finishing operation based on abrasive action performed by a set of bonded abrasive sticks. It is generally used to finish bores of cylinders of IC engine, hydraulic cylinders, gas barrels, bearings, etc. It can reduce the level of surface roughness below $32\mu\text{m}$. It produces a characteristic surface pattern as cross hatched which is a fit case to retain lubrication layer to facilitate motion to moving parts, their best example is IC engine.

The honing tool used to finish internal surface is shown in Figure. The honing tool consists of a set of bonded abrasive sticks. The number of sticks mounted on a tool depends on its circumferential area. Number of sticks may be more than a dozen.

The motion of a honing tool is a combination of rotation and reciprocation (linear). The motion is managed in such a way that a given point on the abrasive stick does not trace the same path repeatedly. The honing speed may be kept up to 10 cm/sec. Lower speeds are recommended for better surface finish.



Honing Tool and its Operation

Manufacturing defects like slight eccentricity a way surface, light taper, less of circulating can also be corrected by honing process. The process of honing is always supported by flow of coolants. It flashes away the small chips and maintains a low and uniform temperature of tool and work.

Honing Machines

Honing machines resembles with vertical drilling machines in their construction. Reciprocating motion of spindle is obtained by hydraulic means. The rotary motion may be by hydraulic motor or by a gear train. Depending upon the movement of spindle or hones a machine may be vertical honing machine or horizontal honing machine. Generally honing vertical honing machines are used. Horizontal honing machines are recommended for finishing internal of long gun barrels.

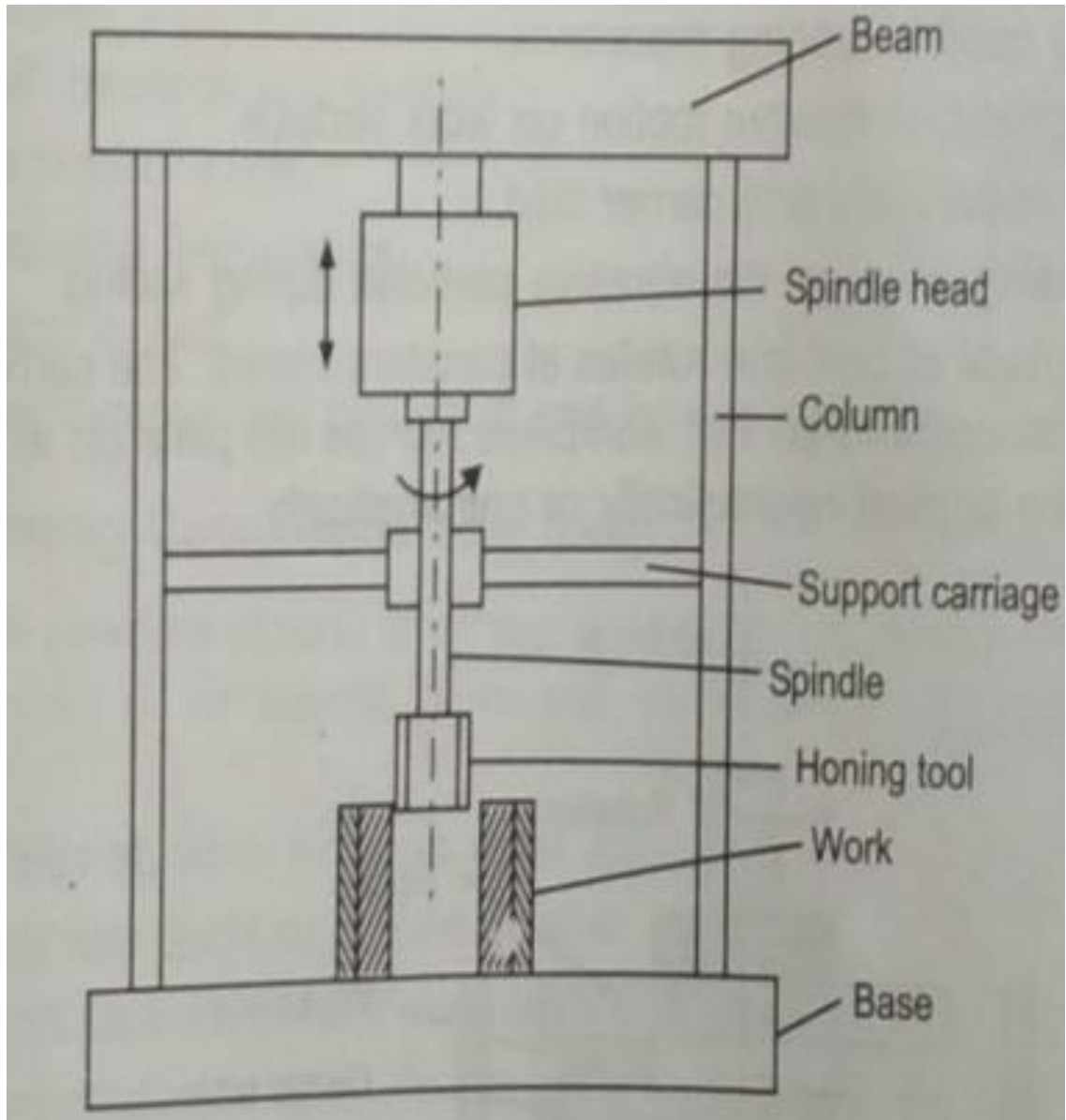
The honing machine may be general purpose, portable modes and special purpose machine.

The general purpose machine may be classified as follows.

1. Vertical Honing Machine

The honing tool rotates as well as reciprocate along a vertical axis. These machine may have single spindle or multiple spindles. It is suitable to horn short jobs. The machine has following main parts :

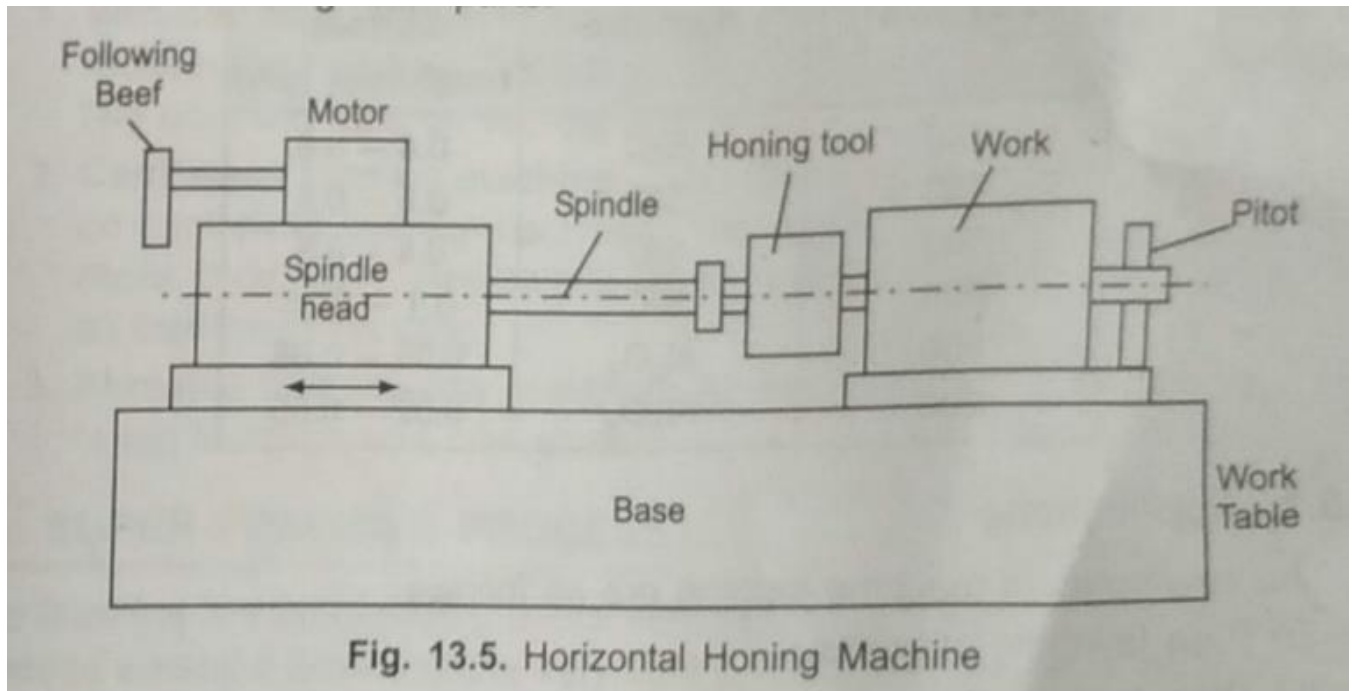
1. Base to support the job.
2. Column to support a beam which supports a spindle head.
3. Spindle head can be given reciprocating motor by hydraulic system.
4. The honing tool is rotated by a spindle attached to spindle head.
5. Support carriage for the spindle.



Horizontal Honing Machine:

These machines are used for long works. The work and the honing tool are held in horizontal direction. The machine has following main parts.

1. Base to support the spindle head and work table.
2. Work table to support the work and a pilot to guide the spindle.
3. Spindle head to given rotary and reciprocating motion to honing tool.
4. Spindle carries the honing tool.



Lapping

Lapping is the abrading process that is used to produce geometrically true surfaces, correct minor surface imperfections, improve dimensional accuracy to provide a very close fit between two surfaces in contact. Very thin layers of metal (0.005 to 0.01 mm) are removed in lapping. Machining can be done to the accuracy of less than 1micron.

To perform lapping operation, lapping shoes and lapping mixture are needed. Laps may be made of almost any material soft enough to receive and retain the abrasive grains. They are made of soft cast iron, brass, copper or lead. It is made in different shapes. Abrasive powders such as emery, corundum, iron oxide and chromium oxide are mixed with oil or grease to make lapping mixture.

The face of the lap becomes charged with abrasive particles. Laps may be operated by hands or by machine. Cylindrical work may be lapped by rotating the work in a lathe and reciprocating the lap over the work. Flat surfaces may be lapped by holding the work against a rotating disc. Special lapping machines like vertical

lapping machine, centreless lapping machine and abrasive belt lapping machines are also widely used.

