AMIRAJ
COLLEGE OF ENGINEERING & TECHNOLOGY

LABORATORY MANUAL

MANUFACUTRING PROCCESS

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MECHANICAL ENGINEERING DEPARTMENT

B.E. 4th SEMESTER

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Amiraj College of Engineering and Technology,
Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

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CERTIFICATE

This is to certify that Mr. / Ms. ____ Of class____________________ Enrolment No ___________________________has Satisfactorily completed the course in ____________________________________as by the Gujarat Technological University for ____ Year (B.E.) semester___ of Mechanical Engineering in the Academic year_______.

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Manufacturing Process

(3141308)

List of Experiments

Sr. No.	Title	Date of Performance	Date of submission	Sign	Remark
1.	Job making on Lathe machine.				
2	Job making on Drilling machine.				
3	Job making on Milling machine.				
4	Job making on Shaper Machine				
5	Job making on Grinding Machine.				

EXPERIMENT 1

Aim: Study of Lathe Machine.

1. Introduction

The history of invention, design and manufacture of a useful form of lathe dates back to eighteenth century. Still it was in a crude form. The first useful form of lathe, incorporating the essential features, was made by H. Maudslay, a Britisher, in 1800. Later developments and researches led to a number of amendments, as years passed, and the result is what we see today. Lathe was actually the first machine tool which came into being as a useful machine for metal cutting. Thus, it formed the basis of production of all the other machine tools which are the results of later developments.

2. Engine Lathe

The engine lathe derives its name from the early lathes that were driven by the power obtained from engines, and is the most widely used lathe. It differs from the speed lathe in that it is provided with additional features for controlling the spindle speed and the feed of the cutting tool. It also consists of a compound slide and can feed the cutting tool both in the cross and longitudinal directions.

Engine lathes are usually driven by a constant-speed motor mounted on a lathe. These lathes can be further sub-classified as (a) belt driven speed cone lathes, (b) motor driven lathes, and (c) geared head lathes

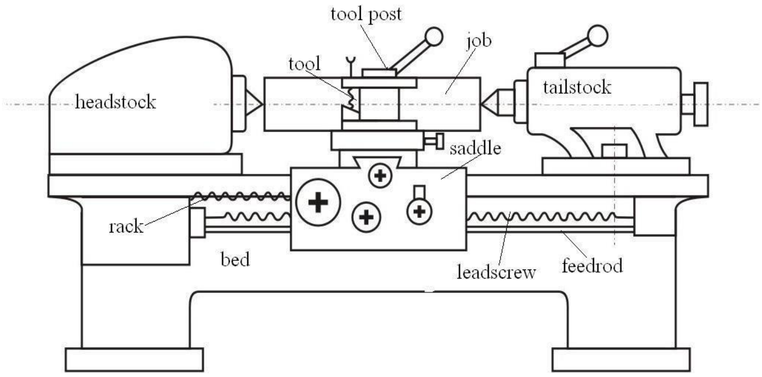


Fig. engine lathe

3. Parts of a Lathe:-

The lathe carries die following main parts, as illustrated by a block diagram Detailed mechanical features of die lathe. The main parts of a lathe are

1. Bed
2. Headstock
3. Tailstock
4. Carriage
5. Saddle
6. Cross slide
7. Compound slide
8. Apron
9. Tool post
10. Feeding mechanism
11. Centers
12. Thread cutting mechanism
13. Chucks
14. The face plate
15. Steadies
16. Mandrel

Bed

The bed of a lathe consists of two heavy parallel sides having a ways or V s over it. As shown in fig. it is held rigidly by cross girths supported by cast iron support.

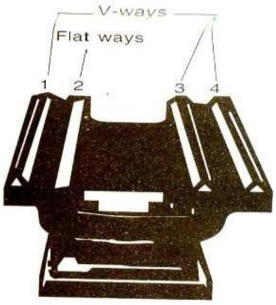


Fig.1.4lathe bed

Head Stock

It is a situated at the left end of the bed. It consists of a headstock, casing and support the spindle and driving arrangement as shown in the fig. the steel spindle is hollow show that the bar can be passed through it if necessary the spindle nose of the spindle is threaded to hold the chuck or face plate by screwing it on.

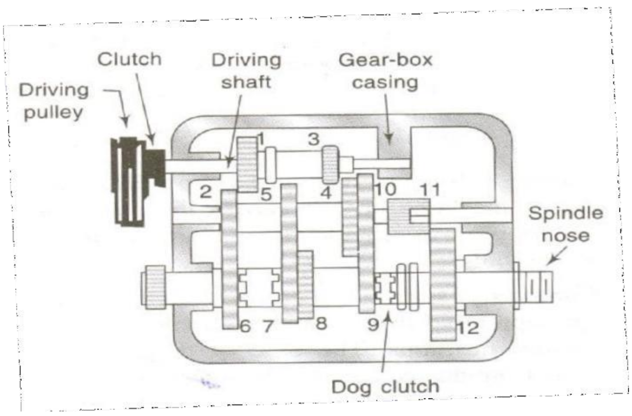


Fig. sectional view of a geared headstock

Tail Stock

This is a counter part of the head stock and is located opposite it on the ways of the bed it consists of a taper hole adjusting screw and hand wheel it is a used for supporting and feeding drills, reamers and center.

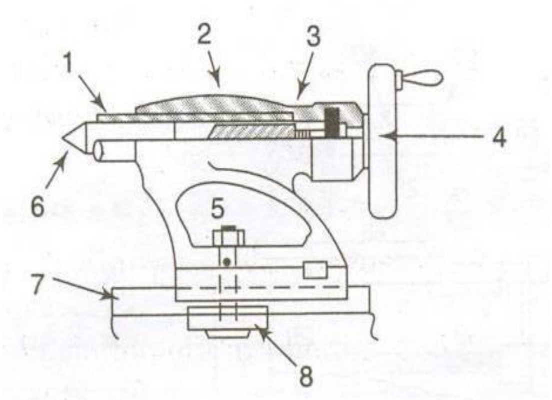


Fig. Tailstock: 1. Barrel 2. Feed screw 3. Nut 4. Hand wheel 5. Clamp nut 6. Dead centre 7 Bed 8. Clamp plate

Saddle

This is an H shaped component bridge across the lathe bed. It carries the cross slide and tool rest to provide a various kind of motion to the tools.

Cross Slide

It is mounted ob the top of the saddle and always moves hi a direction normal to the axis of the main spindle. It can either be operated by hand, by means of tbe cross-feed screw, or may be given power feed through the apron mechanism.

Compound Slide

It is used for supporting the tool post and cutting tool in various positions. The base of the compound slide is graduated and the tool post can be swiveled to various angular positions for different turning operation.

Carriage

The carriage is a moving part that slides over the ways between head stock and tail stock. It consists of saddle and apron and also carries the compound rest

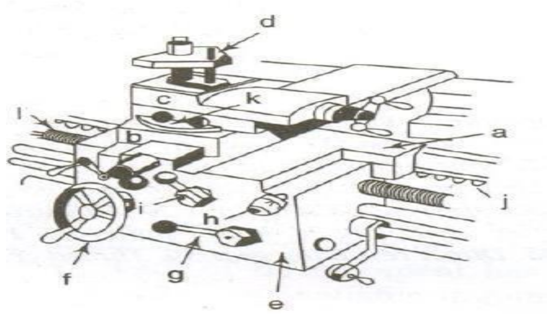


Fig. The lathe carriage: (a) Saddle (b) Cross-slide (c) Compound slide (d) Tool post *(e) Apron box (I) Carriage hand wheel (g) Power feed lever (h) Half nut (i) Feed change lever (j) Rack (k) Swivel plate and (1) Lead screw*

Apron

It is the hanging part in front of the carriage. It serves as a housing for a number of gear trains through which power feeds can be given to the carriage and the cross-slide. Also, it carries the clutch mechanism and the split half nut Out of these two, the former (clutch mechanism) is used to transmit motion from the feed rod where as the latter, in conjunction with the lead screw, moves the whole carriage in thread cutting. For efficient operation of the machine it is important to understand the apron mechanism and its working in detail. The same will now be discussed fully in the following paragraphs.

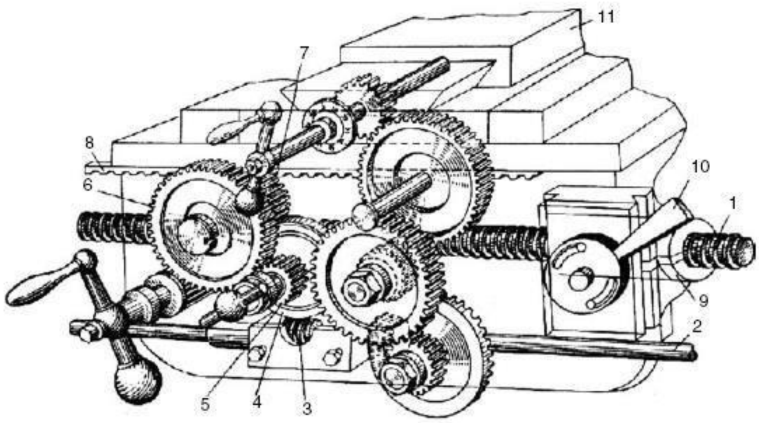
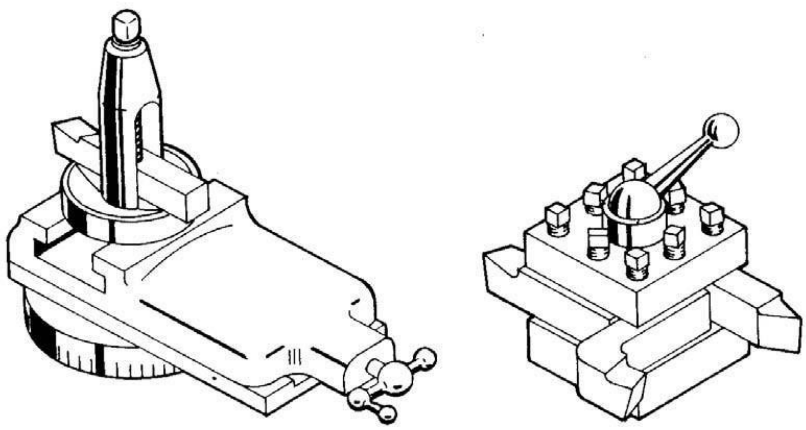


Fig. apron mechanism

Tool Post

A tool post is used to hold various tools and tool holders to create convenient working condition. It consists of a tool post screw (for tightening the tool holder), a ring at the bottom and a rectangular section with a flat top.



(a) single tool *(b) upto four tools*

Fig. Tool post &tool holder

Feeding Mechanism

The feeding mechanism of a lathe is obtained by using a train of gears (series of gears in mesh) that transmit motion from the headstock to the main spindle and the lead screw. From the feed rod, the motion is transmitted to various gears in the apron. The feed gears are controlled by friction through small knobs located in front of the apron.

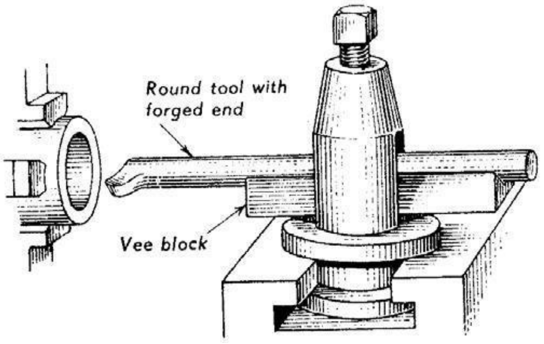


Fig. Boring tool mounted in the tool post in centre lathe.

Centers

The shanks of a centre are usually finished with standard mores taper and the tip is generally made at an angle of 60°. The accuracy of the work is influenced by alignment of the centers. The headstock centre is accommodated in the tapered hole in the headstock and the tailstock centre is accommodated in the tailstock. Different types of centers used for lathe work are shown in Fig.

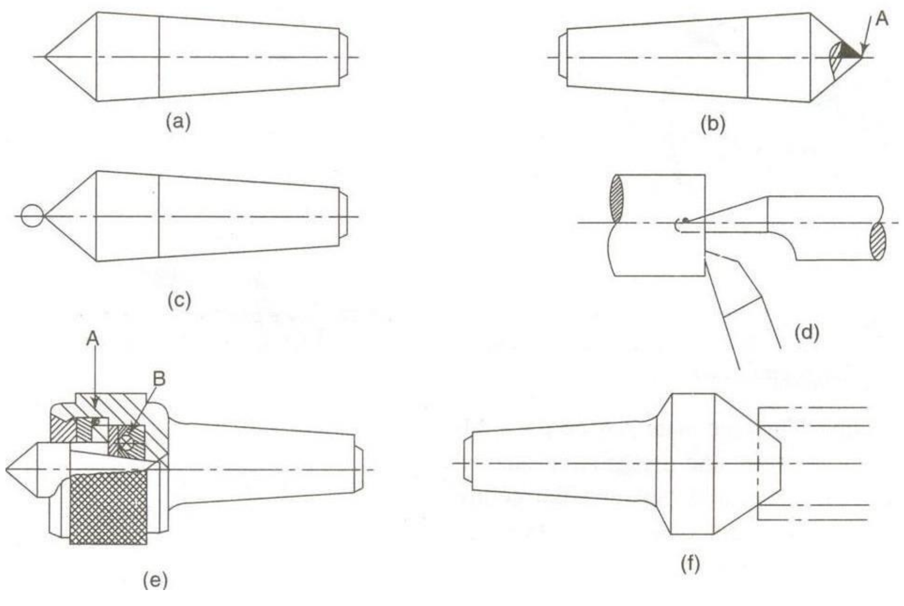


Fig. Lathe centers: (a) Ordinary centre. (b) Tipped centre, (c) Ball centre, (d) Half centre, (e) Frictionless centre(A-taper roller bearing, B-thrust bearing), (f) Pipe centre

4 Operation Performed On Lathe

Turning

Turning involves various processes of removal of material from the outer surface of a work piece to obtain finished surfaces, when the job rotates against a single point cutting tool. The surfaces may be of uniform diameter, stepped, tapered or contoured.

Facing

Facing is the process of making flat surfaces on a lathe. The job is held on a face plate or chuck and the tool is fed at right angles to the bed to obtain flat surfaces.

Drilling

This is the process of making holes in the work piece with the help of drills. The drill is held in the tailstock and the drilling operation is carried out by advancing the drill in the work piece by rotating the handle of the tailstock, as shown in Fig. On a lathe, drilling is generally done in the centre of the work piece.

Reaming

It is the process of enlarging holes to accurate sizes. Reaming is always carried out after drilling. It is similar to the drilling process the reamer is held in the tailstock to carry out the reaming operation.

Milling

On a lathe, the milling cutter is held in the headstock and the work piece is clamped in movable vice. The milling operation is carried out by a cutter revolving against the work piece. This process is used for milling small work pieces only, where a milling machine can not be used.

Grinding

On a lathe, the work piece is held between the centers and the grinding operation is carried out by mounting the tool post grinder on the compound slide. The grinding operation is carried out after rough turning, to provide an accurate finish to the work piece by removing a small amount of material.

Boring

The process of removal of stock from a hole in the work piece is called boring. Holes are bored by single point cutting tools. The cut-ting tool shaves off a thin layer of material to an accurate size. Tapered holes are bored in the same manner as in the case of taper turning. A boring tool and the boring operations carried out on a lathe are shown in Fig.

Counter Boring

The process of boring a hole to more than one diameter on the same axis is known as counter boring. Counter boring is needed for receiving the head of a socket head cap screw. This operation is also carried out with a boring tool, as discussed above.

Knurling

The process of rendering rough surface of a work piece by making a series of indentation or depression on it is known as knurling. The knurling tool which is held in the tool post is pressed against the job to carry out the operation. The indentations are generally of a criss-cross pattern and can be classified into three categories coarse, medium and fine, as shown in Fig. Another form of indentation is known as straight knurling and is not used extensively. A knurling tool and the process of knurling in a work piece are shown in Fig.

Threading

The process of cutting threads on a work piece is known as threading. External threading is the process of cutting threads on the outside surface of the work piece. Internal threading is the process of cutting threads on the inside surface or part of a hole.

Screw Cutting Attachment on the Lathe

It is evident, therefore, that this process should be very carefully understood. Before we actually take up this operation practically on the lathe it is necessary that we should be fully conversant with the different types of threads used in engineering practice, their detailed specifications and use, various terms used in relation to them, their shapes and similar other relevant details.

Types Of Lathe

Such a large variety of types and sizes of lathes is available that it is difficult to classify them into some definite categories. There is a fairly large variation hi their design, construction and use. However, according to their construction and design we can broadly classify lathes as follows:

Bench lathe :

It is a very small lathe and is mounted on a separately Prepared bench or cabinet It is used for small and precision work since it is very accurate. It is usually provided with all the attachments, which a larger lathe carries, and is capable of performing almost all the operations which a larger lathe can do.

Speed lathes :

These lathes may be of bench type or they may have the supporting legs cast and fitted to the bed. These lathes have most of the attachments which the other type of lathes carry but have no provision for power feed. They have no gear box, carriage and the lead screw. With the result, the tool is fed and actuated by hand. Usually the tool is either mounted on a tool post or supported on a T-shaped support. Such lathes are usually employed for wood turning, polishing, centering and metal spinning, etc. Thus, they can be considered as merely of a theoretical value. So on a lathe far as the modern machine shops are concerned. They are named so because of the very high speed at which their spindle rotates.

Engine lathe :

It is probably the most widely used type of lathe. The name Engine Lathe is a little confusing in modem practice as all these lathes are now made to have an individual motor drive. However, it carries a great historical significance that in the very early days of its development it was driven by a steam engine. From this, it derived its name which is popular even today.

Tool room lathe:

It is nothing but the same engine lathe but equipped with some extra attachments to make it suitable for a relatively more accurate and precision type of work carried out in a tool room.

Capstan and turret lathes:

These lathes form a very important and useful group and are vastly used in mass production. These machines are actually of semi-automatic type and a very wide range of operations can be performed on them. In operating these machines, a very little skill is required of the operator. Whatever skill is needed of the operator is only in the setting of tools in the turret or capstan head, and once this setting has been successfully accomplished further operation of these machines is more or less automatic. They carry special mechanisms for indexing of their tool heads.

Automatic lathes :

These lathes help a long way in enhancing the quality as well as the quantity of production. They are so designed that all the working and job handling movements of the complete manufacturing process for a job are done automatically. No participation of the operator is required during the operation. Another variety of this type of lathes includes the semi-automatic lathes, in which the mounting and removal of work is done by the operator whereas all the operations are performed by the machine automatically. Automatic lathes are available having single or multispindles. They fall in the category of heavy duty, high speed, lathes mainly employed in mass production.

Special-purpose lathes :

A large number of lathes are designed to suit a definite class of work and to perform certain specified operations only. They, obviously, prove to be more efficient and effective as compared to the common engine lathe so far as this specified class of work is concerned These are specially designed lathes used for carrying out various operations that cannot be done on ordinary lathes. The headstock, tailstock and carriage of these lathes are made according to the requirements of the special operations to be performed. Commonly used special purpose lathes are (a) the wheel lathe, (b) the gap bed lathe, (c) T-lathe, and (d) duplicating lathe.

5.cutting Speed And Feed

Speed

The cutting speed or rate is the surface speed at which the work piece passes the cutter. It is expressed in m/min. Mathematically,

$$CS=\frac{\pi}{1000}DN$$

where CS is the cutting speed in m/min

D=diameter of the work piece in mm

N=number of revolutions per minute

It is difficult to standardize the cutting speed of a material as it depends upon many factors, such as the characteristics of the material, the cutting material of the tool, the heat treatment operations performed on it, the depth of the cut and the amount of feed. On a lathe, it is rather difficult to continuously increase the cutting speed as the diameter of the work piece decreases from 120 to 25 mm.

Feed

It refers to the amount of tool advancement per revolution of the job parallel to the surface of the job to be machined. In turning it is expressed as millimeters per revolution. The feed of a tool depends upon many factors, such as the depth of cut, the surface finish required, the characteristics of the tool and work piece, and the rigidity of the machine tool.

Depth Of Cut

It refers to the advancement of the tool in the job in a direction perpendicular to the surface being machined. Depending upon the type of finish required, the depth of cut varies from 0.33 to 10 mm.

Rake Angles

A single point lathe or shaper cutting tool is designed in such a way that the cutting point of the tool enters the material first. For this purpose, rake angles are provided on the top face. The two types of rake angles provided on tools are top rake angle and side rake angle. The top rake angle is provided to help aim the cutting edge toward the work so that it shears the material with an upward thrust. It is not always ground but is often taken care of by the design of the tool holder. This is done by providing an angle of 15° to 20° in the slot of the tool The size of the angle depends upon many factors, including the characteristics of the material to be machined. The function of the side rake angle is the same as that of the top rake angle. It lies between 6° and 15°.

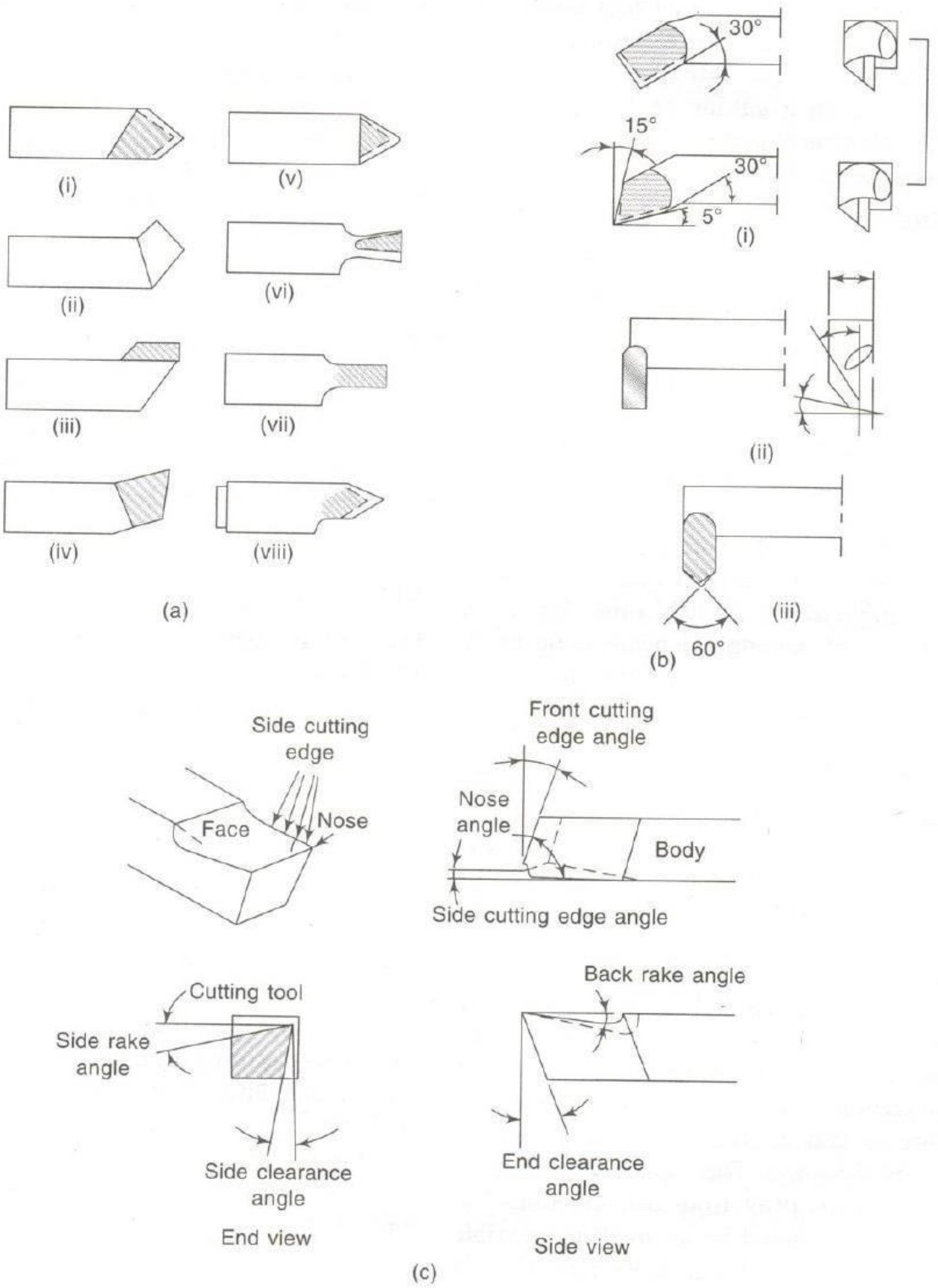


Fig. a) Tools for working on external diameters of work pieces on lathes: (i) Straight turning tool, (ii) Bent turning tool. (iii) Turning and facing tool, (iv) Facing tool, (v) Finish turning tool or V-tool. (vi) Grooving tool (vii) Parting tool (viii) Threading tool
(a) Tools for working on internal diameters of work piece: (i) Internal boring tool. (ii) internal recessing and grooving tool. (iii) Internal threading tool

(b) Cutting tool angles

Clearance angles are also known as relief angles. They are provided to keep the surface of the tool clear of the work piece. The value of the clearance angle depends upon the type of cut. During a turning operation, the tool moves parallel to the lathe bed as the work piece revolves.

If the tool moves parallel to the axis of the work piece, the clearance angle is formed at the tip of the tool. The side rake angle together with the side clearance angle give shape to the cutting edge so that cutting action occurs as the tool moves sideways. The side rake angle also moves the chips away from the operator. The clearance angle should be as small as possible to enhance tool life. Carbide tools have a brittle cutting edge and should have a small clearance angle. This is done to provide maximum support to the cutting edge.

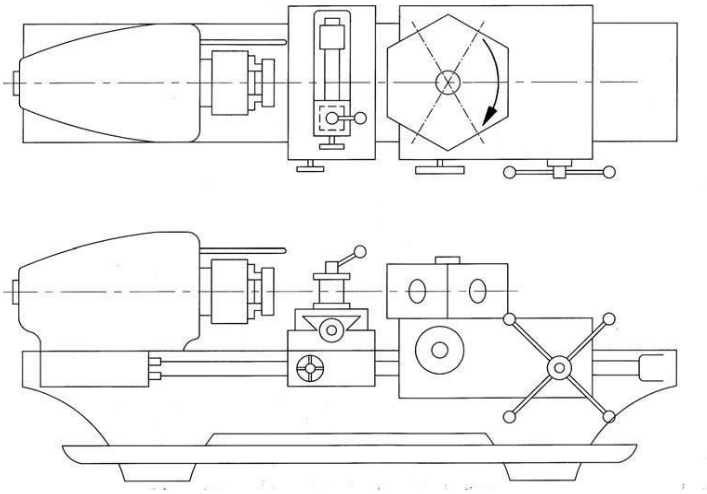


Fig Schematic configuration of capstan lathe.

EXPERIMENT NO-2

Aim: Study of Drilling Machine

Structure

1. Introduction

Drilling is an operation of making a circular hole by removing a volume of metal from the job by cutting tool called drill. A drill is a rotary end-cutting tool with one or more cutting lips and usually one or more flutes for the passage of chips and the admission of cutting fluid. A drilling machine is a machine tool designed for drilling holes in metals. It is one of the most important and versatile machine tools in a workshop. Besides drilling round holes, many other operations can also be performed on the drilling machine such as counter- boring, countersinking, honing, reaming, lapping, sanding etc.

2. Objectives

After studying this unit we are able to understand

− Construction of Drilling Machine
− Types of Drilling Machine
− Types of Drills
− Operations Performed on Drilling Machine
− Size of a Drilling Machine

3. Construction of Drilling Machine

In drilling machine the drill is rotated and fed along its axis of rotation in the stationary workpiece. Different parts of a drilling machine are shown in Fig. 3.1 and are discussed below: (*i*) The head containing electric motor, V-pulleys and V-belt which transmit rotary motion to the drill spindle at a number of speeds. (*ii*) Spindle is made up of alloy steel. It rotates as well as moves up and down in a sleeve. A pinion engages a rack fixed onto the sleeve to provide vertical up and down motion of the spindle and hence the drill so that the same can be fed into the workpiece or withdrawn from it while drilling. Spindle speed or the drill speed is changed with the help of V-belt and V-step-pulleys. Larger drilling machines are having gear boxes for the said purpose. (*iii*) Drill chuck is held at the end of the drill spindle and in turn it holds the drill bit. (*iv*) Adjustable work piece table is supported on the column of the drilling machine. It can be moved both vertically and horizontally. Tables are generally having slots so that the vise or the workpiece can be securely held on it. (*v*) Base table is a heavy casting and it supports the drill press structure. The base supports the column, which in turn, supports the table, head etc. (*vi*) Column is a vertical round or box section which rests on the base and supports the head and the table. The round column may have rack teeth cuton it so that the table can be raised or lowered depending upon the workpiece requirements. This machine consists of following parts

1. Base
2. Pillar
3. Main drive
4. Drill spindle
5. Feed handle
6. Work table

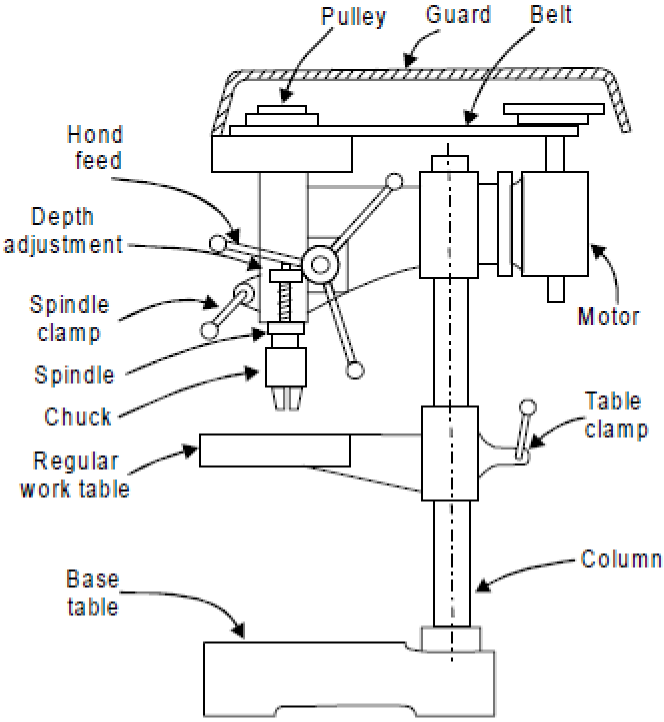


Fig. 3.1 Construction of drilling machine

4. Types of Drilling Machine

Drilling machines are classified on the basis of their constructional features, or the type of work they can handle. The various types of drilling machines are:

(1) Portable drilling machine
(2) Sensitive drilling machine
(a) Bench mounting
(b) Floor mounting
(3) Upright drilling machine
(a) Round column section
(b) Box column section machine
(4) Radial drilling machine
(a) Plain
(b) Semiuniversal
(c) Universal
(5) Gang drilling machine
(6) Multiple spindle drilling machine
(7) Automatic drilling machine
(8) Deep hole drilling machine
(a) Vertical
(b) Horizontal

Few commonly used drilling machines are described as under.

4.1 Portable Drilling Machine

A portable drilling machine is a small compact unit and used for drilling holes in worpieces in any position, which cannot be drilled in a standard drilling machine. It may be used for drilling small diameter holes in large castings or weldments at that place itself where they are lying. Portable drilling machines are fitted with small electric motors, which may be driven by both A.C. and D.C. power supply. These drilling machines operate at fairly high speeds and accommodate drills up to 12 mm in diameter.

4.2 Sensitive Drilling Machine

It is a small machine used for drilling small holes in light jobs. In this drilling machine, the workpiece is mounted on the table and drill is fed into the work by purely hand control. High rotating speed of the drill and hand feed are the major features of sensitive drilling machine. As the operator senses the drilling action in the workpiece, at any instant, it is called sensitive drilling machine. A sensitive drilling machine consists of a horizontal table, a vertical column, a head supporting the motor and driving mechanism, and a vertical spindle. Drills of diameter from 1.5 to 15.5 mm can be rotated in the spindle of sensitive drilling machine. Depending on the mounting of base of the machine, it may be classified into following types:

1. Bench mounted drilling machine and 2. Floor mounted drilling machine

4.3 Upright Drilling Machine

The upright drilling machine is larger and heavier than a sensitive drilling machine. It is designed for handling medium sized workpieces and is supplied with power feed arrangement. In this machine a large number of spindle speeds and feeds may be available for drilling different types of work. Upright drilling machines are available in various sizes and with various drilling capacities (ranging up to 75 mm diameter drills). The table of the machine also has different types of adjustments. Based on the construction, there are two general types of upright drilling machine:
(1) Round column section or pillar drilling machine.
(2) Box column section.
The round column section upright drilling machine consists of a round column whereas the upright drilling machine has box column section. The other constructional features of both are same. Box column machines possess more machine strength and rigidity as compared to those having round section column.

4.4 Radial Drilling Machine

Fig. 3.2 illustrates a radial drilling machine. The radial drilling machine consists of a heavy, round vertical column supporting a horizontal arm that carries the drill head. Arm can be raised or lowered on the column and can also be swung around to any position over the work and can be locked in any position. The drill head containing mechanism for rotating and feeding the drill is mounted on a radial arm and can be moved horizontally on the guide-ways and clamped at any desired position. These adjustments of arm and drilling head permit the operator to locate the drill quickly over any point on the work. The table of radial drilling machine may also be rotated through 360 deg. The maximum size of hole that the machine can drill is not more than 50 mm. Powerful drive motors are geared directly into the head of the machine and a wide range of power feeds are available as well as sensitive and geared manual feeds. The radial drilling machine is used primarily for drilling medium to large and heavy workpieces. Depending on the different movements of horizontal arm, table and drill head, the upright drilling machine may be classified into following types-
1. Plain radial drilling machine
2. Semi universal drilling machine, and
3. Universal drilling machine.

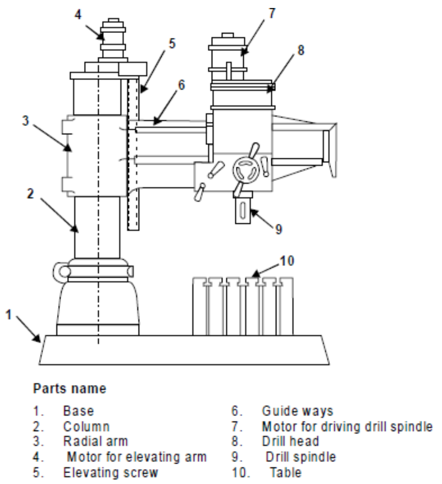


Fig. 3.2 Radial drilling machine

In a plain radial drilling machine, provisions are made for following three movements -
1. Vertical movement of the arm on the column,
2. Horizontal movement of the drill head along the arm, and
3. Circular movement of the arm in horizontal plane about the vertical column.

In a semi universal drilling machine, in addition to the above three movements, the drill head can be swung about a horizontal axis perpendicular to the arm. In universal machine, an additional rotatory movement of the arm holding the drill head on a horizontal axis is also provided for enabling it to drill on a job at any angle.

4.5 Gang Drilling Machine

In gang drilling machine, a number of single spindle drilling machine columns are placed side by side on a common base and have a common worktable. A series of operation may be performed on the job by shifting the work from one position to the other on the worktable. This type of machine is mainly used for production work.

4.6 Multiple-Spindle Drilling Machine

The multiple-spindle drilling machine is used to drill a number of holes in a job simultaneously and to reproduce the same pattern of holes in a number of identical pieces in a mass production work. This machine has several spindles and all the spindles holding drills are fed into the work simultaneously. Feeding motion is usually obtained by raising the worktable.

5. Types of Drills

A drill is a multi point cutting tool used to produce or enlarge a hole in the workpiece. It usually consists of two cutting edges set an angle with the axis. Broadly there are three types of drills:
1. Flat drill,
2. Straight-fluted drill, and
3. Twist drill

Flat drill is usually made from a piece of round steel which is forged to shape and ground to size, then hardened and tempered. The cutting angle is usually 90 deg. and the relief or clearance at the cutting edge is 3 to 8 deg. The disadvantage of this type of drill is that each time the drill is ground the diameter is reduced. Twist drill is the most common type of drill in use today. The various types of twist drills (parallel shank type and Morse taper shank type) are shown in Fig. 3.3

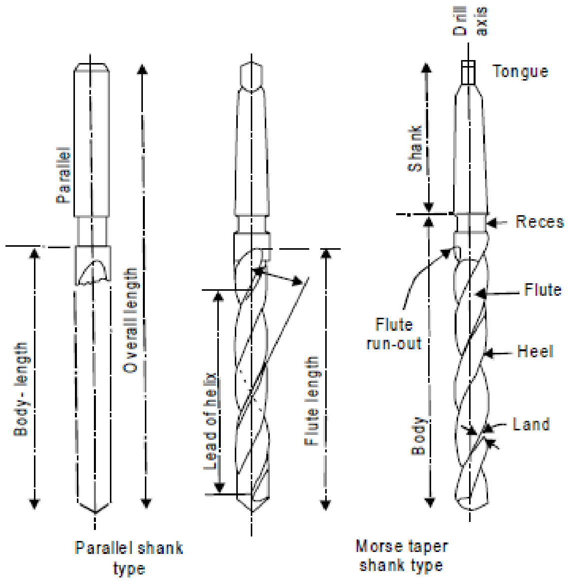


Fig. 3.3 Types of twist drill

EXPERIMENT NO-3

Aim: Study of milling machine.

1. Introduction

The milling machine, invented by Eli Whitney in 1818, carries out cutting operation on a work piece with a revolving cutter as the work piece is fed against it. A milling cutter has a series of cutting edge on its circumference. Each acts as an individual cutter during the cycle of rotation. Depending upon the type of milling operation, the cutters used on a milling machine have different shapes and sizes. These cutters are held on the arbor or attached directly to the spindle to carry out the operation. The milling machine is the most versatile machine for machining flat or formed surfaces with excellent finish and accuracy. The various operations that can be performed on it are cutting angles on work pieces, slots, gear teeth, boring and surface machining.

2. Classification of Milling Machines

Milling machines are classified in a variety of ways.

According to the drive, milling machines are classified as

(i) cone-pulley belt drive

(ii) individual motor drive.

According to design, milling machines are classified as:

(i) Column and knee-type milling machine

(ii) Planer milling machine

(iii) Fixed bed-type milling machine

(iv) Special milling machines, such as rotary table, duplicating and profiling.

According to the position of the spindle, milling machines are classified as:

(i) Horizontal spindle milling machines

(ii) Vertical spindle milling machines

The spindle of the horizontal milling machine is horizontal to the worktable, while the spindle of the vertical milling machine is at right angles to the worktable. In a vertical milling machine, the cutter can be raised or lowered by an adjustment of the spindle head. In all milling machines, the worktable can be moved to any position to carry out the operations.

3. The Principal Parts of A Milling Machine

A description of the principal parts of a milling machine follows.

Column

The main casting of a milling machine is known as the column. It encloses and supports all the parts of a milling machine.

Knee

It is a unit attached in front of the column. It moves up and down on the slide ways and encloses the feed change gearing mechanism.

Table

It is an attachment provided at the top of the knee. It is used for holding work pieces for machining and can be moved in a longitudinal as well as a crosswise direction.

Spindle

It is a large shaft located at the top of the column having a tapered hole in front of it. The tapered hole is used for holding arbors and cutting tools.

Over arm

The portion at the top of the column above the spindle is called the over arm. It is used for supporting arbors and can be moved forward and backward.

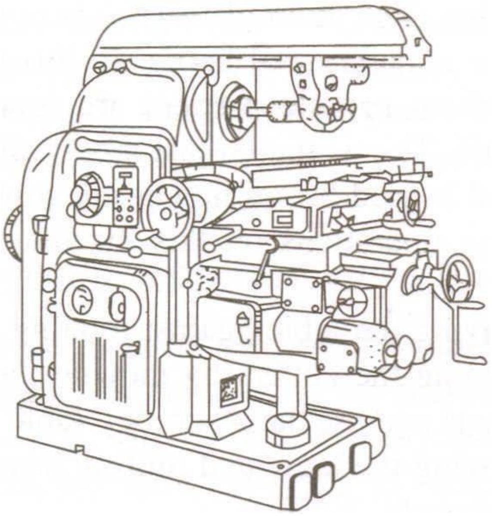
4. Types Of Milling Machines

Horizontal Milling Machine

A horizontal milling machine consists of a horizontally mounted milling spindle, as shown in Fig. The spindle, the main feed drive, the knee and the milling table are supported by the column. The main spindle is supported on sturdy anti-friction bearings for smooth operation. The spindle head is provided with inside and outside tapers for mounting the milling cutters.

Rotary motion to the main spindle is provided by the main drive either through a stepped cone-pulley drive or a gear drive. Modern machines are provided with gear drives which enable them to get a large variation of speeds by simple lever control.

The feed to the work piece is provided by the milling table fitted on the knee. The knee (and thus the table) can be moved up-and-down, to and-fro and left-and-right by various levers and cross-slides mounted on the machines. Screw spindles with hand wheels are used for manual control. The milling table can also be moved by a feed drive either from the main drive or by a separate feed motor. The machines have a draw key or shifting gear transmission mechanism for various feeds. They are suitable for general milling work, such as surface finishing, gear cutting, keyway cutting and slotting.



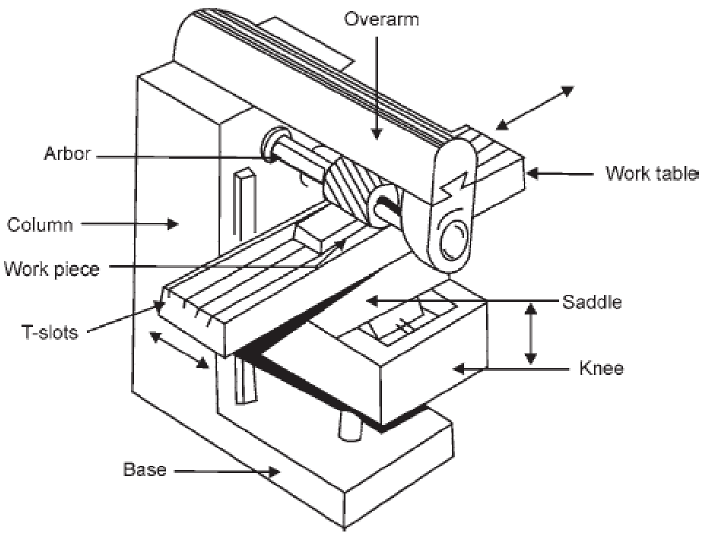
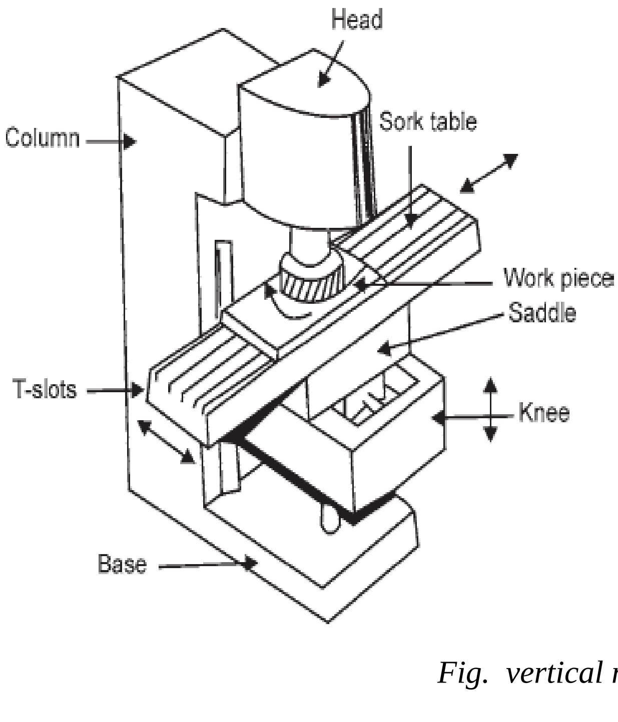


Fig. Horizontal milling machine

Vertical Milling Machine

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



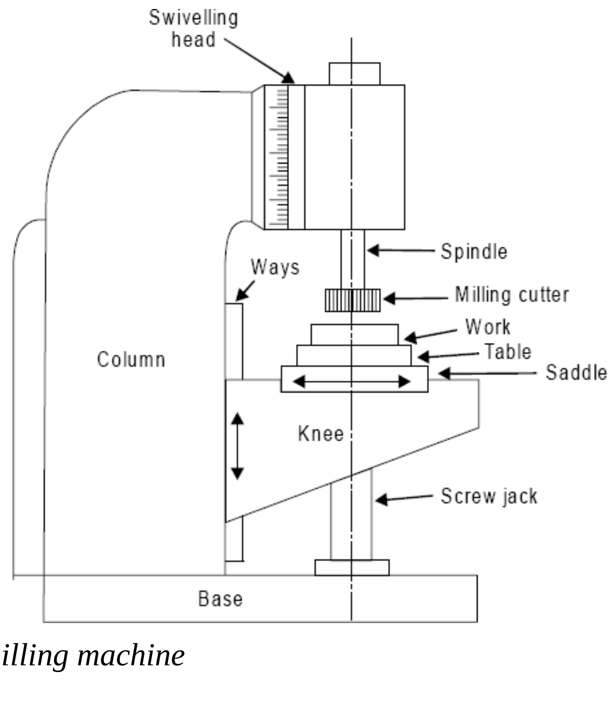


Fig. vertical milling machine

Universal Milling Machine

In appearance, a universal milling machine is similar to a horizontal milling machine. The worktable of this machine is provided with another extra swivel movement with an index or dividing head located at the end of the table. The swivelling attachments provided on these machines help in cutting spirals, gears and cams in addition to normal milling operations. These machines are very accurate and are used mainly for toolroom work

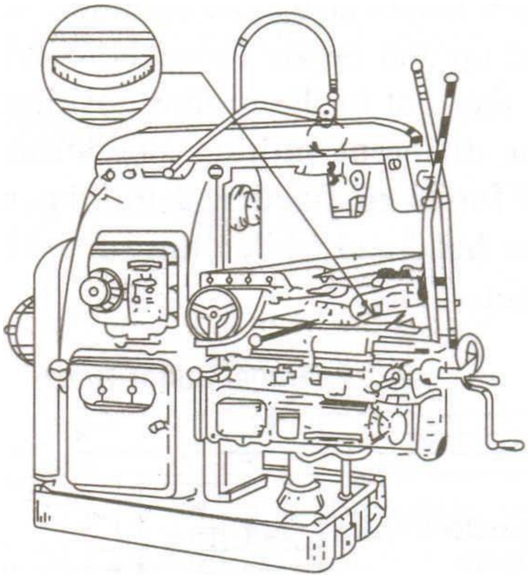


Fig. Universal milling machine

Omniversal Milling Machine

This may be said as a modified form of a plain (horizontal) milling machine. It consists of two spindles, one of which is in the horizontal plane while the other is carried by a universal swivelling head. The latter can be set in a vertical position and swiveled up to 45° on both sides. The knee of this machine can also be swiveled in the horizontal plane, thus enabling it to carry out a large number of operations.

Fixed Bed Plain Milling Machine

In a fixed bed plain milling machine, the table is mounted on a fixed bed instead of a saddle and knee, as in the case of plain milling machine. Since the bed is fixed, it cannot move up, down or crosswise. The machine consists of an adjustable spindle head spindle carrier fixed rigidly to the column with parallel vertical ways. The spindle head carries the spindles, which can be moved up and down along the column ways to adjust the tool in the proper position for carrying out different milling operations. Other modified forms of fixed bed milling machines are duplex head and triplex head fixed bed milling machines.

Planer-Type Milling Machine

It is called planer-type milling machine since it resembles a double housing planing machine in appearance, construction and to some extent in its working. The main difference between these machines is in the tool heads. In this machine, motor-driven spindle carriers are mounted on cross-rails. This is the largest sized milling machine and is used for milling heavy components.

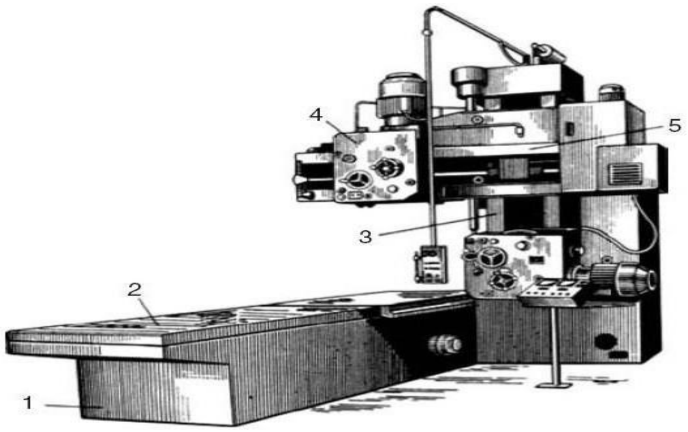
Milling operations on this machine are carried out by

(a) moving the table against rotating cutters

(b) feeding the cutters by moving the milling heads against the stationary table

(c) moving the table and milling heads simultaneously.

These machines are suitable for machining flat surfaces of very heavy work pieces.



1. Bed 2.Table 3.Column 4.Spindle heads 5.Cross-arm

Fig. Planer-type general-purpose milling machine.

Rotory Table Milling Machine

This is also known as a continuous milling machine. It consists of a heavy and robust structure and is mainly used for large-scale production. It is called a continuous milling machine since no idle time is needed in locating the component on its bed

5. Milling Machine Mechanism

The mechanism of a milling machine can be divided into (a) a spindle drive mechanism and (b) a table feed mechanism.

In modern milling machines, the spindle drive mechanism is housed in a column. The spindle receives power from an electric motor through a combination of gear and gear trains fitted inside the column, by altering the gear ratio

The table feed mechanism is contained within the knee of the machine and provides motion in the longitudinal, cross and vertical directions. The power is transmitted from the feed gear box consisting of change gears.

Dividing Head Attachment

A dividing head is also called an indexing head. It is mainly employed on milling machines for setting the work piece and rotating it through predetermined angles and dividing circles into the required number of parts. The work is mounted either on a chuck fitted on the dividing head or supported between live and dead centres.

The three types of dividing heads commonly used are plain, universal and helical. The spindle of a plain dividing head rotates on the horizontal axis. The main parts of a plain dividing head are shown in Fig. (a) and (b). A universal dividing head is a modified form of plain dividing head whose spindle can be swivelled in a vertical plane. A helical dividing head is similar to a plain dividing head in design but its spindle can be connected to a table lead screw through intermediary gears. In this way two types of motions can be imparted to a job-rotary and translatory. This arrangement is suitable for cutting helical gears along the line AB, as shown in Fig.

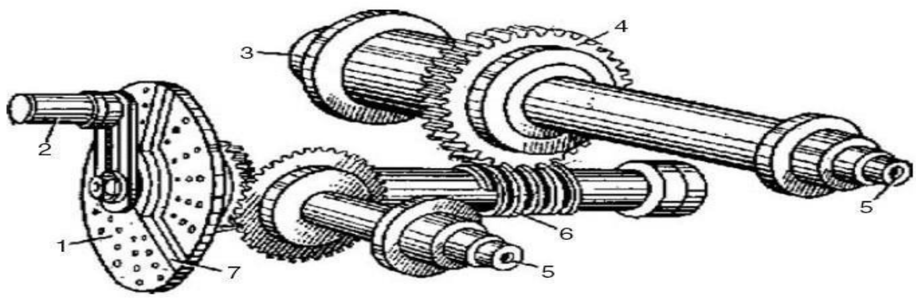


Fig. Universal dividing head

Index Plates

Indexing plates are used on dividing heads for dividing the periphery of a component into equal! required degrees. These plates have equally spaced holes arranged in circular rows. Each plate has six concentric circular rows. With these plates the division of a circle is possible in a range from 2 to 20,000 parts. An index plate mounted on a dividing head is shown in Fig.

6. Milling Cutter

These are multi tooth rotary cutting tools generally made of high-speed steel or sintered carbides

A milling cutter is specified by

(a) type of the cutter

(b) outer diameter of the cutter

(c) width of the cutter

(d) shank size of the cutter.

8.

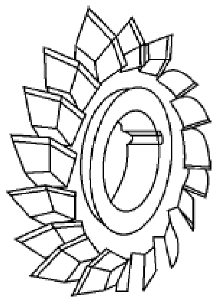


Fig. Plain mill cutter

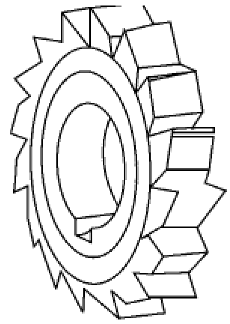


Fig. Plain side mill cutter

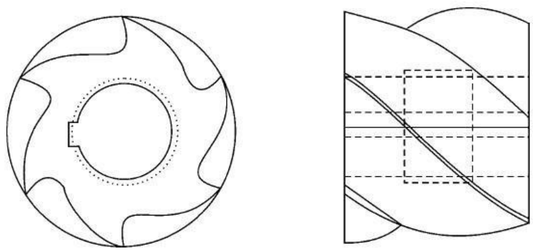


Fig. Helical Plain Milling Cutter

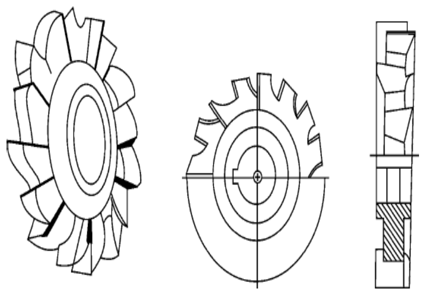


Fig. Staggered Teeth Side Milling Cutter

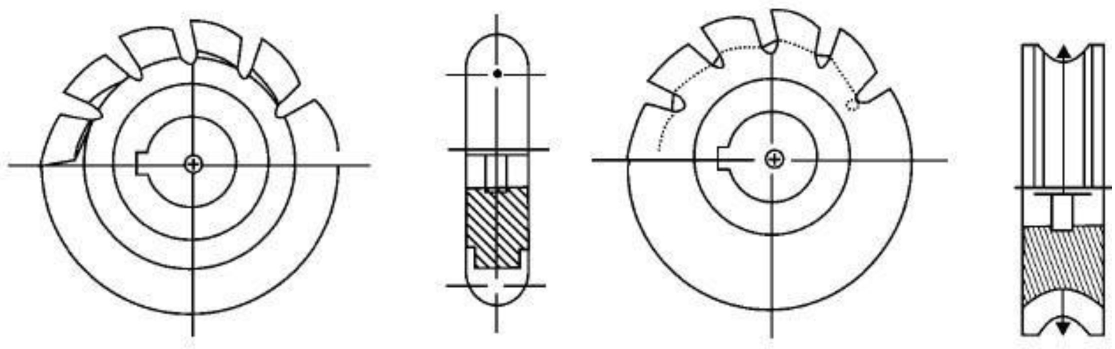


Fig. Convex and concave Milling End Cutter

7.

8.

9.

10. Cutting Speed And Feed

The cutting speed of a milling cutter is the speed with which the cutting tip passes the work, mea- sured in m/min or ft/min.

Suppose the diameter of the cutter is D (in mm) and it is moving at N rpm. Then the distance travelled by the cutting edge in one revolution

$= \pi D/1000$ m

Distance covered in N revolutions

$= \pi DN/1000$ m/min

The above expression shows that the cutting speed is directly proportional to the diameter of the cutter. Table shows the cutting speeds of different materials.

Table : cutting speeds (in m/min)

Material	High speed steel		Carbide tip tools	
	Rough milling	Finish milling	Rough milling	Finish milling
Cast iron	15-18	25-32	60-70	115-135
Malleable iron	25-35	35-50	90-110	140-165
Steels	20-30	25-35	100-110	100-120
High-carbon steel	15-25	20-30	90-100	100-110
Alloy steel	18-25	20-30	85-100	100-110
Copper and its alloy	35-65	50-80	200-220	300-320
Aluminium and its alloy	120-140	220-250	250-290	350-370
Magnesium and its alloy	130-150	240-270	270-300	380-400
Stainless steel	25-30	30-40	80-100	100-120

The cutting feed of a material is the distance advanced by the cutter in one complete revolution. It is generally expressed in mm/min. The normal practice is to give as much feed as the machine can withstand.

11. Indexing

The process of dividing a circular or straight part into equal spaces by means of a dividing head is known as indexing. The indexing head is also known as dividing head.

The indexing head is an attachment that forms a part of milling machines, by means of which the circumference of a cylindrical part can be divided into any number of equal spaces. It is also used

for imparting a rotary motion to the work. For example, if some circular part requires 24 equally spaced grooves, the dividing head is used to rotate the work 1/24 after cutting each groove.
The three systems of indexing used on a milling machine are (a) simple indexing, (b) compound indexing and (c) differential indexing.

Simple indexing

Simple indexing on a milling machine is carried out by using either a plain indexing head or a universal dividing head. This method of indexing involves the use of crank, worm, worm wheel, and index head. The worm wheel generally carries 40 teeth and the worm is single threaded. With this arrangement, when a crank completes one revolution, the work wheel rotates through 1/40th of a revolution. Similarly, a worm wheel rotates through 2/40 (1/20)th of a revolution, and so on. Thus, for one revolution of the work piece, a crank needs to hake 40 revolutions. The holes in the index plate further help in subdividing the rotation of the work piece.

Suppose the work is to be divided into a number of parts. The corresponding crank movement will be as follows.

For dividing- the work in two equal parts, a crank will make

40/2 = 20 revolutions for each division.

For 5 divisions, 40/5 = 8 revolutions

For 8 division, 40/8 = 5 revolutions

For 29 division, 40/29 = 1.37 revolutions

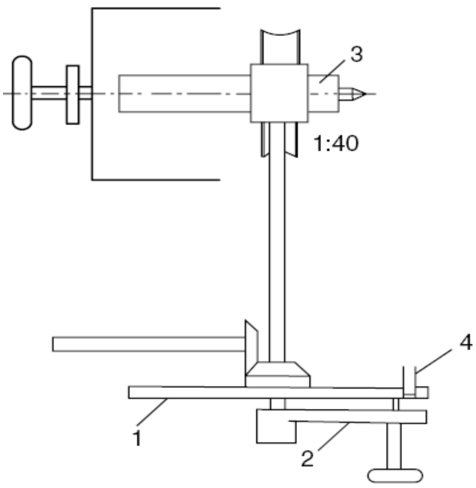


Plate 2: 21, 23, 27, 29, 31, and 33

Plate 3: 35, 37, 39, 41, 43, 47, and 49

Parkinson

Plate 1: 24, 25, 28, 30, 34, 37, 38, 39, 41, 42, and 43

Plate 2: 46, 47, 49, 51, 53, 54, 57, 58, 59, 62, and 66

In the last example above, 40/29 is not a whole number. This indicates that the crank moves by 1 rotation and 11/29 parts of the second revolution. In the fractional system, the numerator shows the number of holes to be moved and the denominator shows the number of holes on the index plate to be used. Thus, in this indexing system, for each division on the job, the crank will move through one revolution and 11 holes on the 29 holes index circle on the index plate.

12. Milling Operation

Milling operations or methods refer to the processes that are carried out on a milling machine. For proper and accurate milling of a component, the following factors need consideration:

1. Select the proper milling cutter. It should be of the right size and type, which helps in the successful performance of the operation in minimum time.
2. Mount the cutter on the milling machine as near to the spindle as possible.
3. Mount the work piece rigidly on the milling table.

Milling Flat Surfaces

This process is also known as plain or slab milling and is used for machining flat surfaces. Before carrying out the operation, select a proper cutter and fix it rigidly on the spindle or arbor of the milling machine. Clear the table, vice, etc. and fix the job at the proper position. Adjust the saddle and bring the work in the centre of the cutter. Set the graduated dial and take the cut. Take another cut if necessary. Perform the finishing operation by setting the cut from a graduated dial.

Squaring Stock by Milling

Squaring stock by milling means the milling of flat surfaces at right angles to horizontal surfaces. Two commonly used processes for squaring stock are using end mill cutters and two milling cutters. The process of squaring stock by two milling cutters is called straddle milling.

Face Milling

This is the process of milling flat surfaces using a milling cutter such that the surfaces generated is at right angles to the axis of the cutter, as shown in Fig. 7.20(b). It is generally used for milling castings or components having large surfaces.

Angular Milling

The process of milling surfaces at an angle other than right angles is called angular milling. The various processes used for angular milling are:

1. By tilting the work piece
2. By tilting the cutter at the required angle
3. By using a cutter of the required angle

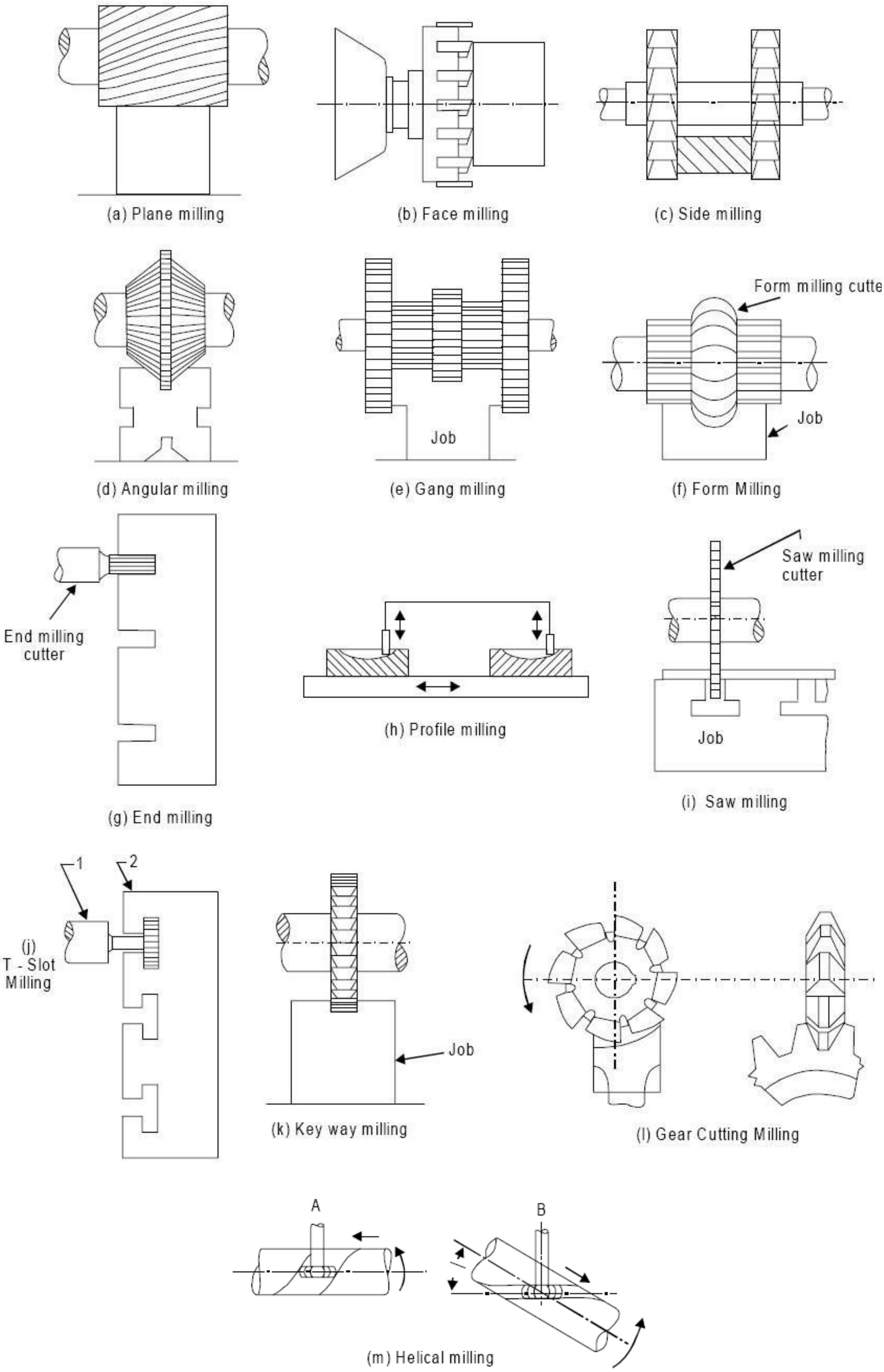


Fig. Various types of milling operations

Gang Milling

Milling with a combination of several milling cutters with different diameters is called gang milling. The operation performed by gang milling cutters is called gang milling. By gang milling, profile of different shapes can be milled in one operation (Fig. 7.25).

Negative rake milling

Cutters having a negative rake are known as negative rake cutters and are a recent development in milling practice. The development of tungsten carbide tools has greatly enhanced the rate of machining. These tools are capable of machining 2Y2 to 3 times faster than high-speed steel cutters. It is also possible to machine materials having high tensile strength and hardness by this process.

The main drawback of tungsten carbide tools is that they are brittle and cannot be used as it is on a milling machine. In order to overcome this drawback, tungsten carbide cutter teeth are inserted on a mild steel cutter body, as shown in Fig. 7.26. A positive rake maintains the tip under compression due to the action of cutting forces. Carbide tools are preferred over high-speed steels due to the following reasons:

1. At greater speeds, the power required for machining is lesser than that for high-speed steels.
2. The chances of a crater in carbide tip tools are less.
3. Carbide tools have greater resistance to abrasion.
4. The surface finish of components is better.
5. No coolant is needed in negative rake milling.

Tungsten carbide tools contain 94% tungsten and 6% carbon by weight. A recent development is the process of applying 0.005 mm coating of tin, which further increases tool life.

Upmilling and Downmilling

Upmilling and downmilling are also known as conventional milling and climb milling, respectively. In upmilling, the cutter rotates in a direction opposite to that in which the work is fed. The chip thickness varies from nil at the tooth entrance to a maximum at the tooth exit. This gradual increase of thrust on the cutter tooth may be considered an advantage, but it is so only if the cutter tooth is really sharp. Generally, this is not so and the cutting operation does not start from zero chip thickness. This produces friction between the cutter tooth and the work piece and further increases the wear of the tooth. The cutting forces in upmilling are generally directed upwards, as shown in Fig. and this tends to lift the work piece from the table.

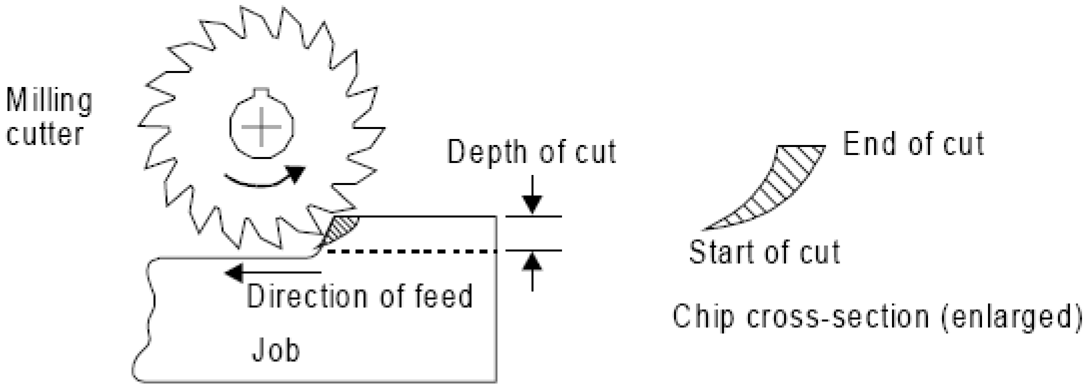


Fig.4.20 Principal of up-milling

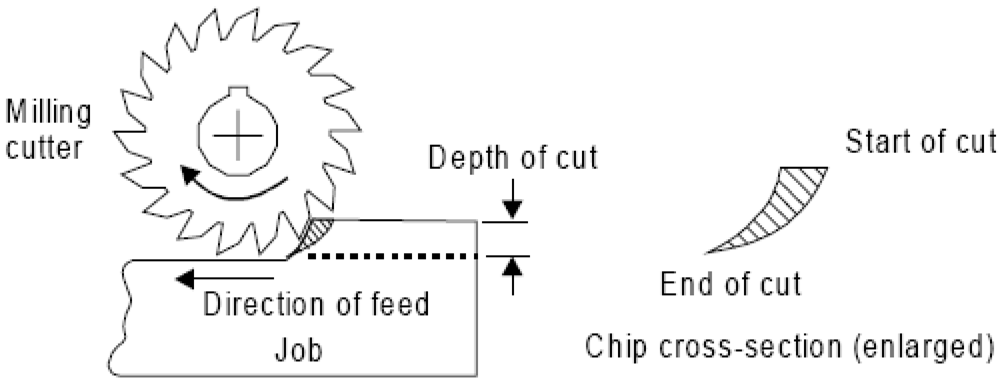


Fig. Principal of down-milling

In downmilling, the direction of rotation of the cutter coincides with the direction of motion of the work piece. In this system, the cutting tooth is subjected to a maximum load from the very beginning. This type of load is suitable for working. with carbide tools. In both uprnilling and down milling, the shape of the tooth is the same, but in upmilling as the cutter advances, the chip thickness increases gradually. In other words, the chip thickness in conventional milling is zero at the start of the cut and maximum at the end.

The selection of a particular method of milling depends mainly upon the nature of work. Upmilling is mainly used for the milling of castings and forgings. Downmilling is useful for finishing operations such as slotting, grooving, sawing, keyway cutting, etc. as it produces a good surface finish

EXPERIMENT NO-4

Aim : Study of Shaper Machine.

1. Introduction

A shaping machine (usually called shaper) is mainly used for producing flat surfaces, which may be horizontal, vertical or inclined. Sometimes irregular or curved surfaces are also produced by shapers. In shaping, a tool is given a reciprocation motion with the help of mechanism provided on the machine that changes circular motion in to the reciprocating motion. The commonly used mechanism consists of a ram, eccentric rocker arm and crank pin since the length of a job various provision is made on shaper to change the stroke to the desired length.

The length of stroke of a shaper is generally 2 cm longer than the cut to be taken. Shaper size is given by the max. length of the ram stroke. The shipping machine is indispensable in tool rooms due to its great flexibility, easy of work holding, quick adjustment and used of tools of relatively simple shape and size. It is a also very useful in die making shops, maintenance shops and production shops.

2. Working Principle

In a shaping machine the job is held in a suitable device (generally vice) clamped rigidly on the machine table. The cutting tool is held in the tool post mounted on the ram of the shaper. The arm reciprocates to-and-fro, and in doing so cuts the material held in the vice during the cutting stroke. Generally, the cutting action takes place in the forward stroke, which is also known as the cutting stroke. No cutting of material takes place during the return stroke of the ram which is termed as the idle stroke. The job is given an index feed with the help of a cross-rail mechanism fitted inside the table.

3. Classification Of Shapers

Shapers are classified in the following ways:

1) According to the length of stroke
    - (i) 30cm shaper
    - (ii) 40cm shaper
    - (iii) 60 cm shaper

2) According to the cutting action

   (i) Push type shaper

   (ii) Draw cut type shaper

3) According to the movement of the ram

   (i) Horizontal shaper

   (ii) Vertical shaper or slotter

4) According to the drive

   (i) Mechanical shapers

   (a) Crank-driven shapers (b) Geared shaper

   (i) Hydraulic shapers

5) According to the method of transmitting power

   (i) All geared shaper

   (ii) Cone pulley belt-driven shaper

6) According to the movement of the table

   (i) Simple shaper

   (ii) Universal shaper

4. TYPES OF SHAPERS

A brief description of various types of shapers is used in a workshop as follows.

Standard shaper

This is the most commonly used form of shaper. It consists of plain table that mayor may not have vertical supports at its front. Some machines have a provision for the table to swivel around a horizontal axis parallel to the ram. The material is cut in the forward stroke of the tool and the return stroke is idle.

Horizontal shaper

In these shapers the ram reciprocates in the horizontal plane and so does the tool. They are similar to standard shapers with an additional plain table provided in the machine.

Draw cut shaper

This is similar to a standard shaper in construction but is comparatively heavier. Its main difference from the standard shaper is that it peels off metal chips during the backward stroke, whereas a standard shaper does so during the forward stroke.

Vertical shaper

In this type of shaper, the ram reciprocates in the vertical direction. It is also known as a slotter and is discussed later.

Universal shaper

This is also a horizontal shaper, with the main difference that it has a special type of table that can be swung about the horizontal axis parallel to the ram ways. The top of this table can also be tilted about another horizontal axis which is normal to the former axis. It is called a universal shaper since the job can be tilted in any direction through the required angle with the help of a swivel vice.

Crank shaper

Shapers whose ram reciprocates with the help of a crank mechanism are known as crank shapers.

Geared shaper

In geared shapers, the ram reciprocates with the spur gear mechanism. This type of shaper carries a rack under the ram for to-and-fro motion.

Hydraulic shaper

In this type of shaper, the movement to the ram is provided by hydraulic pressure. They are in great demand these days.

Contour shaper

Contour shapers are standard shapers fitted with an additional tracer mechanism. In this shaper a template and follower are used to produce a contour similar to the shape of the template. It is suitable for producing shapes that cannot be produced by other shapers.

5. Principal Parts of a Shaper

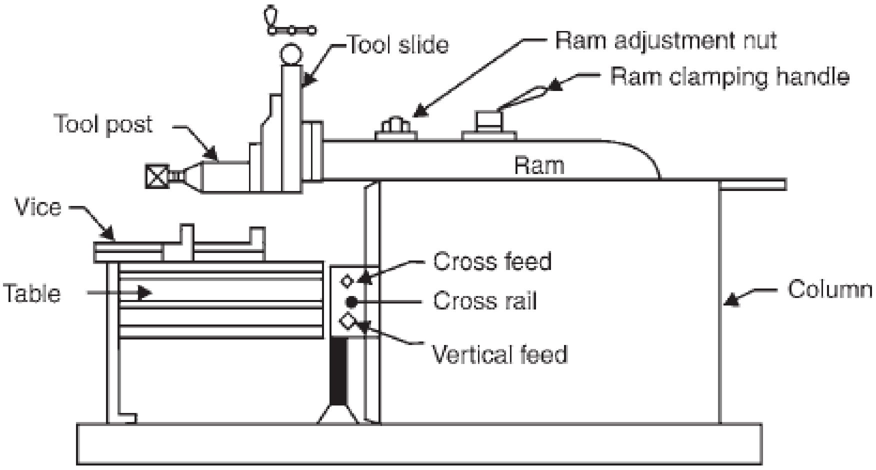


fig. Principal Parts of a Shaper

illustrates the principal parts of a shaper.

Base

It consists of a heavy robust cast iron structure that supports all the other parts of the machine.

Column

It acts as a housing for the electrical circuits and operating mechanism of a shaper. It also acts as a support for other parts of the machine, such as ram, cross-rail, tool heads, etc. It is mounted on a base.

Cross-rail

It is a heavy cast iron body attached to the column of a shaper machine. It is used for two purposes-for elevating the table and for cross-traverse of the table.

Table

It is a box-type construction with T-slots cut on it to hold the vice and jobs. It holds and supports the work piece during operations. It can be moved horizontally by a cross-rail mechanism to provide feed to the work piece. The table is mounted on the saddle. The two types of work tables commonly used on shapers are plain tables and universal tables. Generally, shapers are supplied with plain tables.

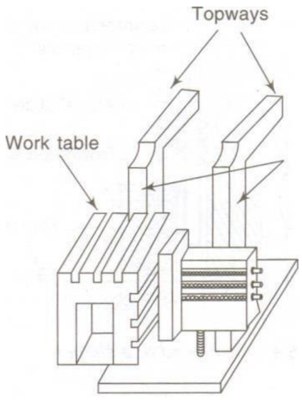


Fig. Supporting structure and table feed mechanism of a shaper

Ram

It is the reciprocating part of the shaper and carries the shaper head in front of it. The reciprocating motion of the ram takes place on accurately machined guideways on the top of the column. It gets its drive from the quick return mechanism, which is fitted inside the column to change its position relative to the job.

Tool head

The tool head of a shaper is used for holding the tool rigidly. It also provides vertical and angular feed movement of the tool and allows the tool to lift automatically to provide relief during its idle or return stroke. The vertical feed to the tool is provided by rotating the down feed screw handle. The apron can be swiveled towards the left or right after opening the apron swivel pin. During the cutting stroke, the clapper block fits securely into the clapper box and holds the tool rigidly. The return stroke acts as the idle stroke, and the tool is lifted upwards to prevent the tool from dragging the job.

Shaper head

It consists of a tool slide, tool post and clapper box and is clamped firmly to the front of the ram. It has a vertical feed screw for the vertical movement of the tool. The vertical movement can be measured accurately by means of a micrometer dial near the handle. The head can be swivelled to any angle to enable the tool to take angular cuts and for cutting from the sides of the job. It also consists of a tool holder that rests on a clapper box. The clapper box is fastened to the front of the shaper head slide and is free to point forward and fit on a taper pin which holds it in place. This provision is made in order to prevent the cutting tool from damaging the work during the idle stroke.

6. Shaper Size And Specification

The size of a shaper is specified by the maximum length of stroke or cut it can make. Usually the size of shaper ranges from 175 to 900 mm. Besides the length of stroke, other particulars, such as the type of drive (belt drive or individual motor drive), floor space required, weight of the machine, cutting to return stroke ratio, number and amount of feed, power input etc. are also sometimes required for complete specification of a shaper.

1. Maximum distance from table to ram
2. Size of side table top
3. Size of side table
4. Power of motor
5. Maximum vertical travel of tool slide.
6. Ram cycles per minute or strokes per minute
7. Approximate net weight
8. Floor space required

7. Quick Return Mechanism

All shapers, except draw cut shapers, cut in forward direction only, while the return stroke is idle. The time spent in the idle stroke is obviously wasted. Similarly, in a draw cut shaper, the backward stroke is the cutting stroke the forward stroke is wasted. However fast speed of the idle stroke may be, some time definitely wasted. Thus, it is the endeavour of designers to reduce the idle time to a minimum. Two commonly used mechanisms to achieve are (a) crank mechanism and (b) hydraulic mechanism

8. Crank Mechanism

Fig. shows the crank and slotted link driving mechanism of a shaper. It consists of a rocker arm called the fulcrum, fitted at the bottom. At the top it carries another short link L which is d to the block. The rocker arm consists of a slide block that slides up and down when the bull gear revolves. In the slide block revolved the crank pin P. The bull gear and slide are fitted together with a crank pin.

The crank pin is fitted to the slotted disc carrying a T-slot and can be moved to any desired position by means of bevel gears. The bull gear is driven by a bull gear pinion that is mounted on a power shaft. The bull gear while rotating makes the rocker arm swing about the fulcrum. The rocker arm in turn moves the ram to-and-fro. The angle traversed by the bull gear (and thus the rocker arm) during the cutting stroke is more than in the return stroke. Thus, the time taken by the cutting stroke is more than that taken by the return stroke. In other words, the cutting stroke is slower and the idle stroke faster. This is indicated by the velocity diagram at the top of the crank mechanism.

9. Operations Performed On A Shaper

- Horizontal cutting
- Cutting vertical and angular surfaces
- Irregular cutting
- Machining a thin job on a shaper
- Keyway cutting

Horizontal Cutting

A horizontal flat surface is produced by feeding the work in a horizontal direction under the re-ciprocating cutting tool. The cutting operations involve the following steps:

1. Thoroughly clean the vice and work piece and remove all burrs by scraping or filling

2. Place the job in a vice on a pair of parallels so that the job projects above the vice for easy operation of cut.

3. Place the work piece at a proper position in the vice and make sure that the vice jaws are set perpendicular to the ram

4. Select the proper tool and fit it in the tool holder.

5. Adjust the depth of the cut to be taken by means of the down feed handle of the tool holder.

6. Start the machine and feed it by hand. If needed, set the automatic feed and make the cut.

7. After the completion of the cut, check the dimensions and take more cuts as per requirements keeping in mind that the finishing cut to be taken is light

Cutting Vertical And Angular Surfaces

Before carrying out vertical cutting on a shaper, ensure that the work piece is held rigidly and properly on the table. The vertical cutting operation is carried out by giving vertically downward feed (Fig.) to the tool.

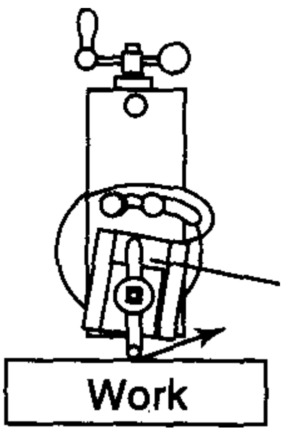


Fig. Horizontal cutting on a shaper

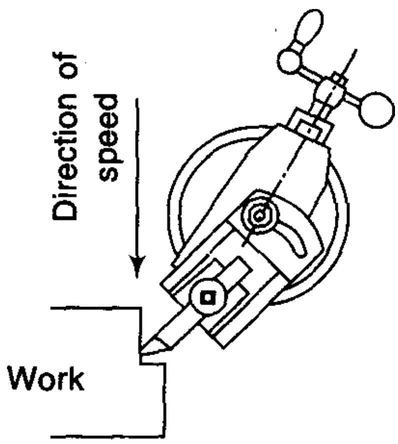


Fig. vertical cutting on a shaper

This process is used for finishing the sides of the block, squaring shoulders, squaring ends of the component, cutting V's and keyways. For taking angular cuts, the head is swivelled to the required angle and the apron is arranged in such a manner that the tool remains clear of the work while feeding down.

The angular surface can be machined by the following manner:

1. By supporting the work on tapered parallels in a vice.

2. By marking a layout line on the piece and holding job in a horizontal line with this layout line and then machining the component with a regular feed.

3. By holding the work in angular parallels

4. By swivelling the vice to an angular setting.

5. By swivelling the head of the shaper

.3 Irregular Cutting

An accurate irregular surface finish can be obtained by using a form tool whose surface, while cutting, forms the contours of the surface. Wider irregular cuts can be taken by marking a line and then taking the cuts. This can also be done by vertical hand feed along with a horizontal table feed. In taking irregular cuts, always start from the higher part of the work piece and proceed towards the lower part.

Key Way Cutting

Keyway cutting on a shaper is done by holding the work piece in a vice by using a V -block. axis of the shaft is set parallel to the movement of the stroke with the help of a dial indicator. The alignment of the shaft is done with indicator from the top and the side of the

The keyway cutting operation is carried like cutting a groove on a shaper External and internal keyway cutting procedures on a shaper are shown in fig. the main difference between groove cutting and keyway cutting lies in the method of holding the work piece.

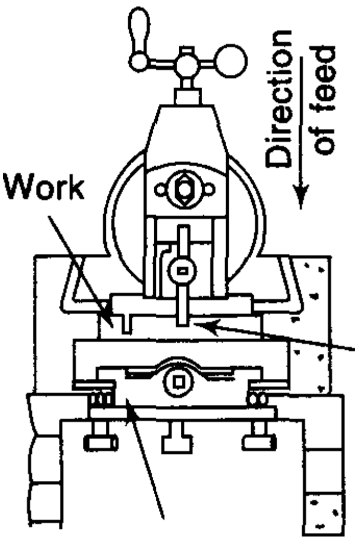


Fig cutting groove on a shaper

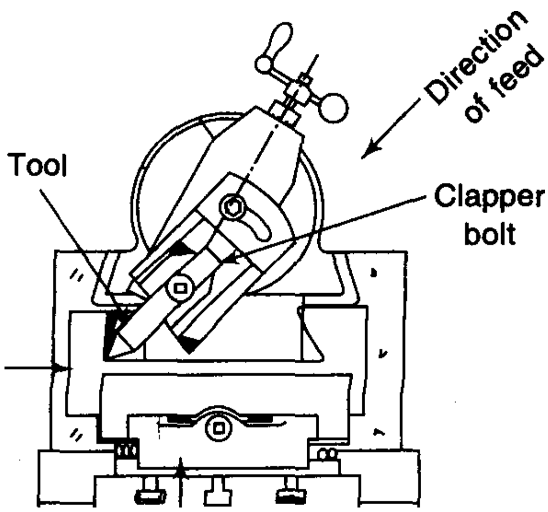


Fig. dovetail cutting on a shaper

10. Cutting Speed, Feed And Depth Of Cut

The machining of components is carried out to remove the surplus metal, bring the work to a given size and give a smooth finish to the surface. To achieve the desired goal at least two cuts, one for roughing and one for finishing are required on a job. For optimum use of a machine, a thorough knowledge of proper speed, feed and depth of cut is necessary.

The cutting speed of a shaper primarily depends on (a) the type of material to be cut (the harder the material, the lesser the speed or vice versa), (b) the amount of material to be removed and (c) the material of the cutting tool.

EXPERIMENT NO-5

Aim: - Study of Grinding Machine

1. Introduction

Grinding is a metal removing process performed with the help of grinding wheel. It is employed for finishing various parts, such as engine crankshafts, splined shafts, lathe guideways, long pipes, worms, toothed gears, pinions, racks, and surfaces. The various operations performed on grinding machines are

1) Grinding flat surfaces
2) Cutting off blanks
3) External and internal cylindrical grinding
4) Tapered and complexes surface grinding
5) Gear tooth grinding
6) Screw thread grinding
7) Cutting tools grinding

Grinding means abrasion by friction. In grinding, the material is removed by means of a rotating wheel. This process is similar to a milling cutter, except the geometry of the cutting process. Grinding wheels consist of a large number of abrasives that act as cutters for metal removing.

Grinding was primarily used for removing small stock from work pieces. These days grinding is used mainly for the following purposes:

1) To remove a small amount of metal from work pieces and finish them to close tolerances
2) To obtain a better surface finish
3) To machine hard surfaces that cannot be
4) machined by high-speed steels
5) Sharpening of cutting tools
6) Grinding of threads
7) Sometimes it is used for removing bigger stocks of metals.

Abrasives used for making grinding wheels are very hard, have poor heat sensitivity and can thus be used at high speeds. The biggest advantage of grinding wheels is their self-sharpening property.

2. Manufacture of Grinding Wheels

The manufacture of grinding wheels involves the following steps:

1) Ascertain the purity of the abrasive.

2) Crush the abrasive into small particles.

3) Again remove the impurity, if any. Magnetic impurities are removed by magnetic separators. Dust and soluble impurities are removed by passing a stream or water over the particles.

4) Sieve the particles to the required size.

5) Mix the abrasive particles with a calculated amount of bonding material.

6) Pour the materials in moulds, press and dry.

7) After drying, bake the moulds by heating to a suitable temperature.

8) Cut the mould to the required shape and size.

9) Inspect the component and test for proper working.

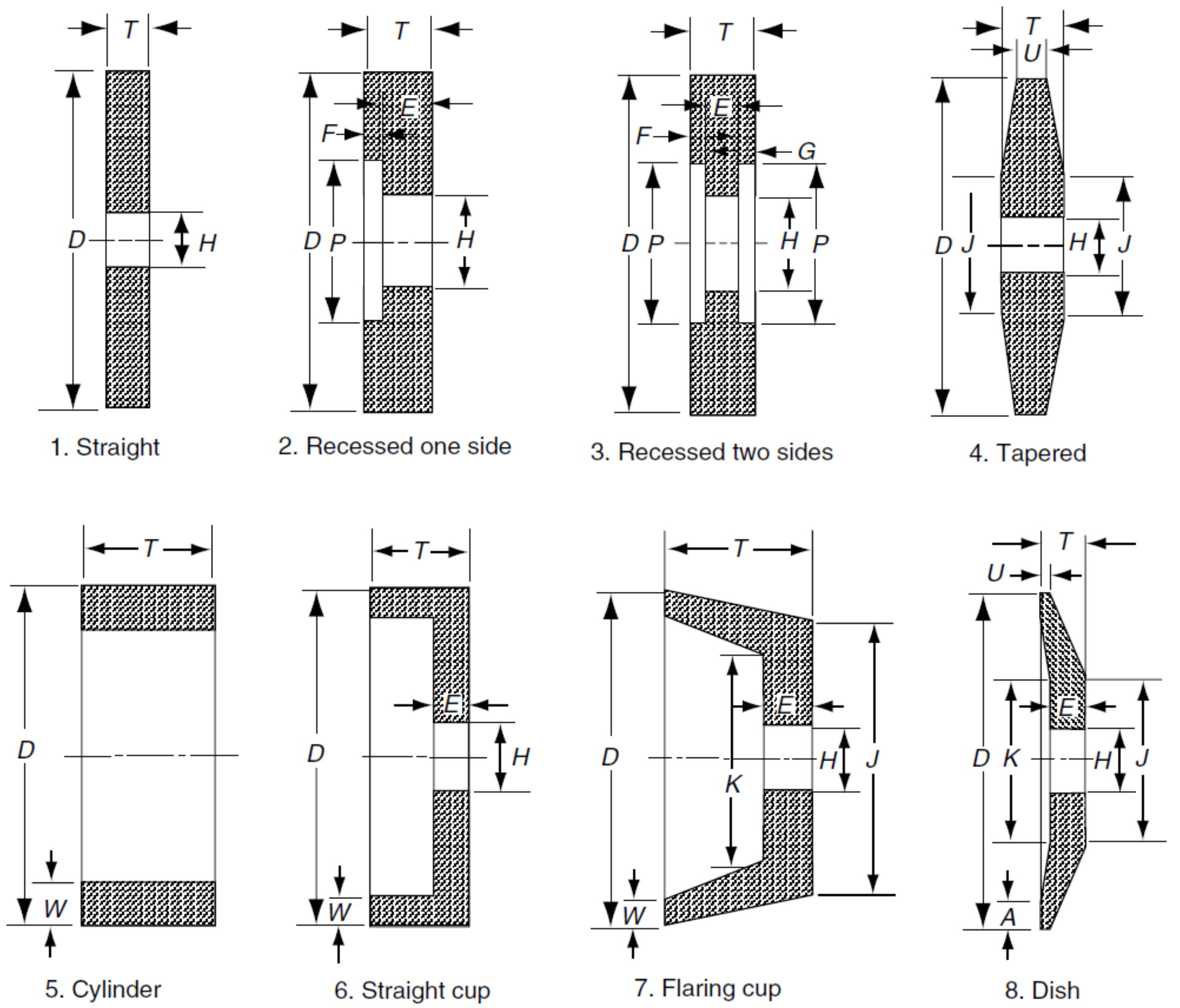


Fig Standard shapes of Grinding wheels

3. Terminology Used In Grinding

Abrasive

Any substance used for abrading, grinding, polishing and lapping of materials.

Bond

The material used for holding the abrasive grains together.

Centre less grinding

Grinding the diameter of the work piece without mounting on centres.

Cutting rate

The rate of metal removal during grinding in unit time.

Cylindrical grinding

Grinding the outer diameter of the work piece.

External grinding

Grinding the outside surface of any shape.

Floor stand grinder

An offhand grinder having a horizontal spindle with its base attached to the floor.

Grit or grain size

The size of the cutting particles of a grinding wheel.

Grade or hardness

It is the strength by which the grains are held together, arbitrarily designated as A to Z, A being the softest and Z the hardest.

Internal grinding

Grinding the inside surface of the work piece.

Loading

The process of filling the chips in the pores of the grinding wheel during a grinding operation.

Planer type grinder

Surface grinder resembling an open side planer in shape.

Precision grinding

Grinding within exceedingly fine limits.

Roll grinding machine

A machine used for grinding cylindrical rolls.

Rough grinding

Grinding operation used mainly for removing the stock.

Snagging or fettling

Grinding of jobs, risers, fins, etc. of castings.

Surface grinding

Grinding of a plane surface. Swing frame grinder A suspended grinding machine, suspended from the centre. It can be turned or swung in any direction.

Universal grinding machine

A specially designed grinding machine on which cylindrical, internal surface, and tool and cutter grinding can be done

Selection of grinding wheel

The various factors that need consideration for selection of a grinding wheel are abrasives, grain size and shape, type of bond, bond strength and hardness. A brief description of these elements follows.

Abrasive

The selection of an abrasive depends upon the material to be ground. Silicon carbide (SiC) and aluminium oxide (AI203) are abrasives commonly used for grinding wheels. Silicon carbide is used for hard materials while aluminium oxide is used for soft materials.

Grain size

The conventional practice followed in grinding is to use coarse-grained wheels for soft materials and fine-grained wheels for hard materials. Medium sizes are used for operations requiring stock removal and finish. For fine finish, soft wheels are preferred.

Grain size is determined by the mesh number and can be broadiy divided into very coarse, coarse, medium, fine and very fine. The mesh number denotes the number of meshes per linear inch (25.4 mm) of the screen, through which the grains pass when graded after crushing.

Grade

The grade refers to the hardness of a wheel. A hard material resists wear and tear and increases wheel life. Grains are held together by binding materials. The binding materials must hold the abrasive until it is completely used. On the basis of hardness, grinding wheels can be classified as very hard, hard, medium, soft and very soft. The hardness of grinding wheels is denoted by letters A to Z

Structure

The structure of a grinding wheel represents the voids between the abrasives. The material of the grinding wheel has a marked effect on the structure. The chips of a harder material are smaller in size and the rate of metal removal is low. For such purposes, wheels of lesser porosity are used. Wheels of greater porosity are used for removal at a higher rate. The structure is denoted by the numbers 1-15.

Area of contact

The area of contact between the grinding wheel and the work piece largely affects the grain size and grade. The area of contact is large in internal grinding and surface grinding. When the area of contact is large, the total effect of the forces is distributed over a large area, resulting in lesser pressure. Thus, softer grinding wheels are used for internal grinding, while harder wheels are used for external grinding.

Wheel speed

The speed of a grinding wheel is influenced by the grade and the bond. The higher the speed of a grinding wheel, the softer it is. However, the speed of grinding wheels cannot be increased beyond permissible limits.

Work speed

The speed at which the work piece traverses across the wheel face is known as the work speed. The higher the speed of work, the greater is the wear and tear of the wheel. If the work speed is low, the wheel wear is also low. However, low speed results in local overheating, produces deformation and lowers the hardness of work pieces by producing tempering treatment. Most grinding machines are provided with variable speed mechanisms. As the diameter of the wheel decreases, the speed needs to be increased accordingly to provide optimum working conditions

4. Making System For Grinding Wheel

IS: 551-1966 lays down the rules for the marking system of grinding wheels. The marking system comprises seven standards. These are:

- Manufacturer's symbol (optional)

1) Type of abrasive
2) Grain size of abrasive
3) Grade of abrasive
4) Structure (optional)
5) Type of bond
6) Identification mark (optional).

The type of abrasive used has also been marked in this standard.

A denotes aluminum oxide

C denotes silicon carbide

The type of bond is designated by the following letters

V-Vitrified

S-Silicate

R-Rubber

RF-Rubber reinforced

B-Resinoid (synthetic resin)

BF-Resinoid reinforced

E-Shellac

Mg-Magnesia

5. Grinding machine

Metal working machines in which the cutting of metal is performed by abrasive action are known as grinding machines. Grinding machines can be classified in different ways.

According to the surface finish, grinding machines are classified as

1) Rough grinders
2) Fine or precision grinders

Rough grinders

These machines are generally used for the removal of stock rather than for accuracy. Rough grinders most commonly used are (a) bench grinders, (b) flexible shaft grinders, (c) swing frame grinders, and (d) abrasive belt grinders.

Precision grinders

Precision grinders are surface finish grinders, such as (a) surface grinders, (b) internal and external cylindrical grinders, (c) tool and cutter grinders, (d) centreless grinders, and (e) thread grinders.

According to the type of surface generated or work done, grinders can be classified as:

1) Cylindrical grinders
2) Internal grinders
3) Surface grinders
4) Tool and cutter grinders
5) Thread grinders
6) Crankshaft grinders
7) Roll grinder
8) Cam grinders
9) Tool post grinders
10) Way grinders.

Grinders 1-3 above can be said as general purpose grinders whereas 4-10 are special grinders.

Floor grinder

A floor grinder consists of an electric motor mounted on a suitable base. The motor consists of a rotor shaft extending from each side, with a grinding wheel mounted on each end, is shown in Fig. Floor grinders used for heavy duty bearings. They are used for sharpening tools, tool bits, boring tools, drills, etc.

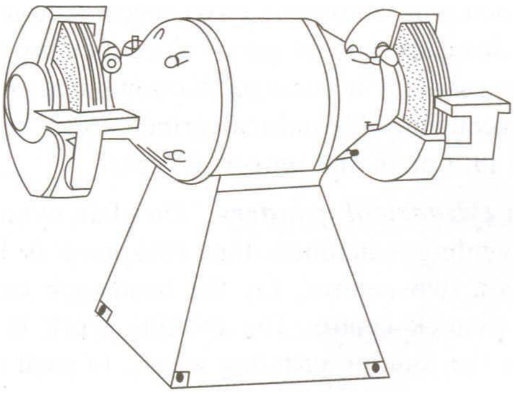


Fig Floor grinder

One side wheel of a floor grinder consists of coarse grains while the other consists of fine grains. A coarse grained wheel is used for rough grinding, snagging or heavy work. A fine grained wheel is used for grinding cutting tools.

A bench grinder is similar to a floor grinder except for the size. In size a bench grinder is much smaller than a floor grinder, and can be fitted on a bench. The applications and uses of a beneh grinder are similar to those of a floor grinder.

Portable Grinder

A portable grinder, as shown in Fig. resembles a portable drill in shape. It consists of a small electric motor fitted inside the casing at one end. The grinding wheel is mounted at the other end. It is used for the rough grinding of surfaces

Flexible shaft grinder

It consists of an electric motor that is kept practically stationary at a place. One end of the electric motor is connected to a flexible shaft. The other end of the flexible shaft is connected to a grinding wheel. The flexible shaft and thus the grinding wheel can be easily moved about to

different positions to remove stock of the material by grinding.

Swing Frame Grinder

This is a long, horizontal frame, freely suspended grinder, with its upper position attached to a spring loaded string. The other end of the string is attached to the top of the roof (or frame) and the grinder swings over the string. The frame carries a grinding wheel at one end and a motor at the other. Rotary motion is supplied to the grinding wheel from the motor by means of a belt. In operation, the frame is swung by the operator and the grinding wheel removes the stock. This type of grinder is used for rough work and heavy stock removal, particularly in foundries.

Abrasive belt grinder

This consists of a strip of abrasive cloth of exact length and width in the form of an endless belt. The abrasive cloth revolves over two drums, one of which is driven at high speeds. The smooth rear side of the belt slides over the drums while the abrasive side always forms the outer surface. The stock to be removed is fed over the belt by hand. The advantage of this process is that different curves can be given to the platen to produce different curvatures on the work piece.

Abrasive belt grinders are gaining in popularity and are mainly used for heavy stock removal.

Cylindrical Grinders

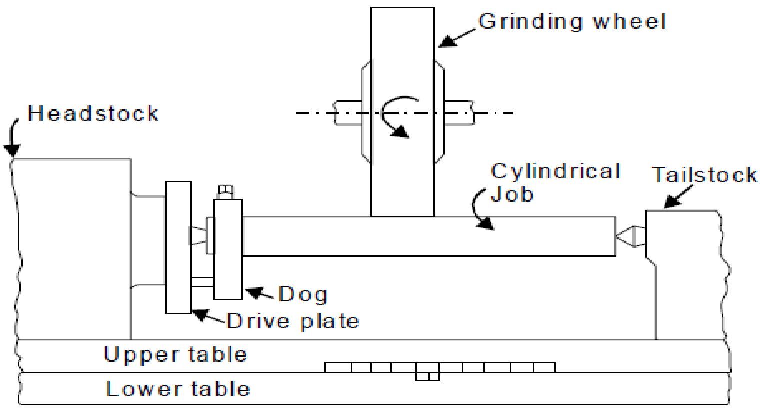


Fig. Principle of cylindrical grinding

The simplest of all cylindrical grinders is the tool post grinder. Grinding with tool post grinders is done on lathes. A lathe is generally used for grinding when a conventional grinding machine is not available, or the quantity of work is not large enough. It is also used for carrying out finishing operations after a turning operation on a lathe in one setting of a job. For operation the grinder is mounted on a lathe carriage and lathe feeding movements are utilised for traversing the grinding wheel in a manner similar to turning.

All cylindrical grinders are equipped with mechanisms such as (a) work head, (b) work head spindle with suitable wheel turning mechanism, (c) wheel turning and feeding mechanism and (d) work holding devices. Most grinders are

provided with automatic cross-feeds. Automatic cross-feeds are advantageous since they not only ensure accuracy in mass production but also prevent accidents. Cylindrical grinders can be divided into plain and universal types.

Plain cylindrical grinders

On plain cylindrical grinding machines, the work piece is held between two centres, i.e. the headstock centre and tailstock centre. The rotating work is fed across the rotating grinding wheel.

Universal cylindrical grinders

Universal cylindrical grinders are similar in design to plain grinders except for some special features, such as

(i) live or dead headstock spindle, to hold the job in chucks or centres;

(ii) a headstock swivel mechanism, to swivel the headstock in a horizontal plane;

(iii) a wheelstock swivel mechanism to swivel the wheel to ±90° for grinding tapers.

(iv) the upper table can be swivelled with respect to a vertical axis for small angles in order to grind long tapers.

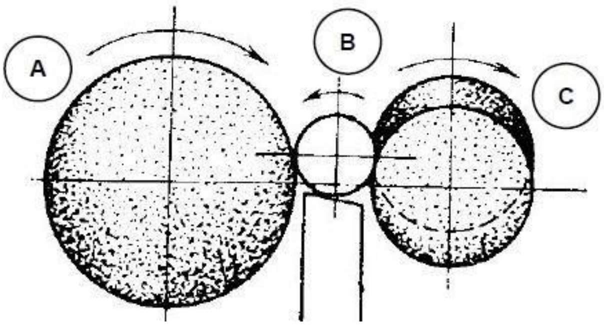
These factors provide great versatility to these grinders. Such grinders are used for tool room work.

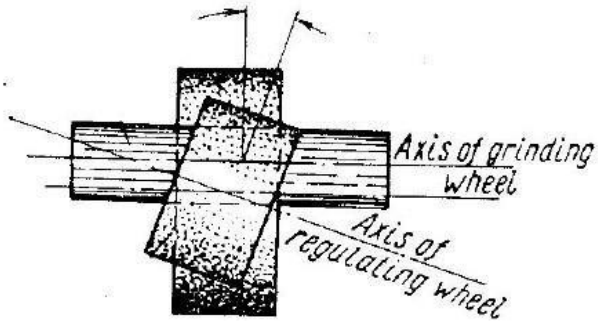
Centreless Grinding Machines

Centreless grinding machines eliminate the operation of holding the work piece between centres or fixtures. In these machines, the work is supported by the workrest and is backed by a regulating wheel. The regulating wheel controls the speed and the rate of feeding of the work-piece. The grinding wheel performs the grinding operation. The working principle of internal and external centreless grinders is the same. Many components, such as pistons, bushes, valves, tubes, rollers, etc. that do not possess centres and are hollow can be ground by centre less grinders.

A centre less grinding machine consists of a bed, a wheel head, a wheel housing, a wheel rest blade, a regulating wheel and two slides. The bed acts as a support for the wheel head. The upper slide consists of a wheel drive and wheel truing unit. The lower slide holds the work rest and the upper slide. The slides are mounted on a swivel plate. The machine is used for providing taper during indeed grinding.

The two common methods used for feeding the work (a) through feed, and (b) infeed





A: rotation of grinding
wheel B: work piece
rotation
C: reciprocation of worktable.

Depending upon the method of holding the work piece and technique of operation, internal grinding machines can be divided into (a) plain internal grinders (b) universal internal grinders and (c) chucking internal grinders. Internal grinders can also be classified as (a) horizontal spindle internal grinders and (b) vertical spindle internal grinders. Horizontal grinders are commonly used, whereas vertical spindle grinders are used sparingly for specific purposes.

A plain cylindrical grinder consists of a workhead and a wheelhead. The workhead houses the variable speed mechanism and the spindle. It either carries the chuck or the face plate, to hold the work piece. It can be swiveled to grind tapers. The wheel head carries the grinding wheel to perform internal grinding.

A universal internal grinder carries some features not found in plain internal grinders. Its work head is mounted on the cross-slide and pro vides a cross-feed to the work piece. The work head of these grinders can be swiveled to 90^0

Chucking type internal grinders consist of a reciprocating table with the work head mounted on it. The wheel head is mounted on the cross slide. The other features of these grinders are identical to those of plain grinders.

The following points need to be considered while working on internal grinders.

1. Grinding wheels used on internal grinders are generally softer then those employed on other grinders. This is due to the fact that contact between the wheel and work is more in internal grinders.

2. Wheels used on internal grinders should be as large as possible.

3. The dimensions of internal grinding wheels depend upon the diameter and the nature of operation.

4. The internal diameter of the bushes must be ground first. After internal grinding, slip the bush on an arbor and then grind the external diameter. The procedure produces accurate and concentric holes.

5. The allowances for internal grinding depends upon the size of the hole.

6. In a tool room, internal grinding is generally done dry. However, in production work, a coolant is required.

7. Internal grinding can be done on a lathe by mounting the portable grinder upon the carriage.

Surface Grinding Machine

Planer-type Surface Grinder

This is also known as a reciprocating table-type surface grinding machine. These grinders are used for grinding flat surfaces. This type of surface grinder may have a horizontal or a vertical spindle. The working principle of vertical grinder is shown in Fig. 12.15. The horizontal spindle carries the straight wheel while the vertical spindle carries the cup-shaped wheel. Cutting in horizontal spindle grinders is done on the periphery of the straight wheel, while in vertical spindle grinding, it is done by the edge of the revolving cup wheel. The work piece is held on a magnetic chuck and is passed against the revolving wheel to produce flat surfaces. Surfacegrinders are designated by the size of the table and its movement across the wheels

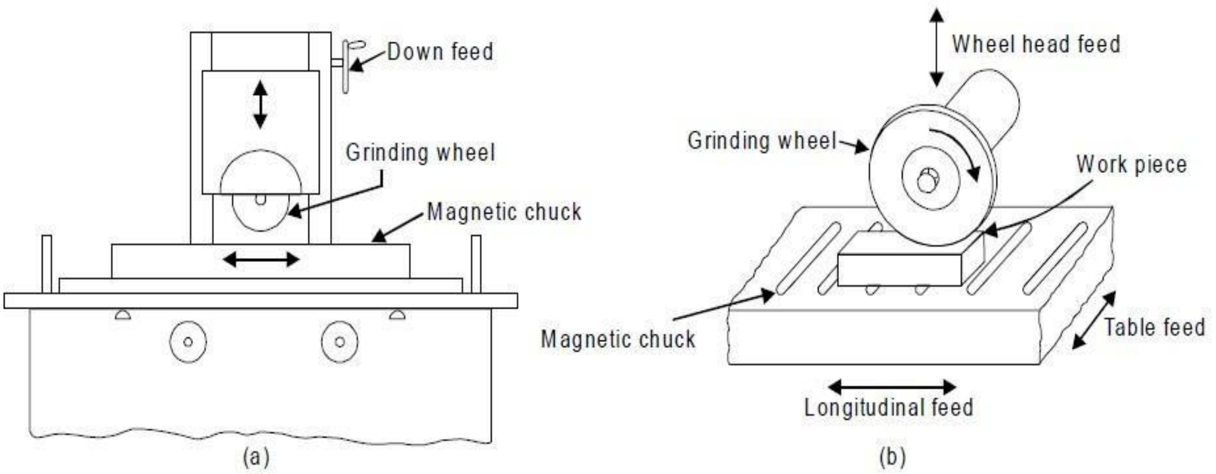


Fig. surface grinding machine and its principle

Rotary-type Surface Grinders

According to the position of the spindle, rotary-type surface grinders are also classified as (a) horizontal type and (b) vertical type. Like planer-type surface grinders, horizontal spindle surface grinders carry a straight wheel for the grinding operation. A cup wheel is used in vertical spindle rotary surface grinders.

Tool and Cutter Grinder

Milling cutters, reamers and drills should be sharpened whenever there is any indication of dullness. Reconditioning of extremely dull cutters not only requires the removal of much material, but also reduces the life of the cutter.

The main elements of a tool and cutter grinder are

1. Work head
2. Tailstock
3. Cylindrical grinding attachment
4. Internal grinding attachment
5. Swivelling vice for surface grinding
6. Centre attachment for grinding long reamers
7. End relieved disc cutter attachment
8. Gear milling cutter grinding attachment
9. Reamer relief grinding attachment
10. Radius truing attachment
11. Magnetic chuck
12. Radius grinding attachment
13. Collet chucking attachment
14. Wheel shoulder dressing attachment
15. Angle truing device
16. Inserted tooth cutter and face mill grinding
17. Right-hand tailstock
18. Wheel dressing attachment
19. Twist drills grinding attachment.

Crankshaft Grinders

A crankshaft grinder is basically a cylindrical grinder using the principle of plunge grinding. In plunge grinding the work rotates in a fixed position and the wheel is fed to produce cylinders. The principle of crankshaft grinding is shown in Fig. 12.17. It is mainly used for the production of crankshafts of automobile engines, aircraft engines and compressors. A crankshaft grinder can also be used for grinding cylindrical and tapered surfaces.

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Branch………………………… Semester……………… En No……………..........

Shop…………………………………..... Job No…………………………………….

Material required……………………...... Dimension…………………………………

Time allowed Hours……………………………………………..

Name of Job:				Date	Instructor's sign
Material issued on:					
Repeat Material issued on:					
WORK DETAILS					
Date	Time		Hours	Instructor's Sign	Remark
	From:	To:			
		Date		Instructor	Officer in Charge
Job Started on					
Job Completed on					

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	Date		Instructor	Officer in Charge	
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WORK DETAILS

Date	Time		Hours	Instructor's Sign	Remark
	From:	To:			
		Date		Instructor	Officer in Charge
Job Started on					
Job Completed on					