Unit-3: Lathe and Grinding machines
(Subject: Workshop Technology/Workshop Practice)

Unit-3: Lathe and Grinding machines

Lathe Machine; Introduction, working principle, its construction and specifications.

Lathe classification; Bench, Tool room, Capstan and Turret, Automatic and Special purpose lathes.

Lathe Operations: Plain and step turning, Taper turning; taper calculations, methods of taper turning, parting off, drilling, boring, knurling. Screw cutting on lathe-introduction to right and left threads, lathe setting for screw cutting-simple and compound gear trains. Cutting parameters - Speed, feed and depth of cut, machining time.

Lathe Accessories: Centres; live and dead centre, Chucks; three jaw universal chuck, four jaw independent chuck, magnetic chuck, air or hydraulic chuck, Lathe carriers or dogs, Driving plate, Face plate, angle plate, mandrels, rests; steady and follower.

Lathe Attachments; Grinding attachment, Milling attachment, Taper turning attachment

Grinding Machine: Introduction- Abrasive tools, stones and sticks, grinding wheels– materials, specifications, selection of grinding wheels, Trucing and dressing of grinding wheels, abrasives-natural and artificial, speed, feed and depth of cut, use of coolants.

Types of grinding machines; cylindrical grinders, surface grinders, centreless grinders, special grinding machines

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1.1 INTRODUNCTION

Lathe is one of the most versatile and widely used machine tools all over the world. It is commonly known as the mother of all other machine tool. The main function of a lathe is to remove metal from a job to give it the required shape and size. The job is securely and rigid1y held in the chuck or in between centers on the lathe machine and then turn it against a single point cutting tool which wi11 remove meta1 from the job in the form of chips. Fig. 1.1 shows the working principle of lathe.

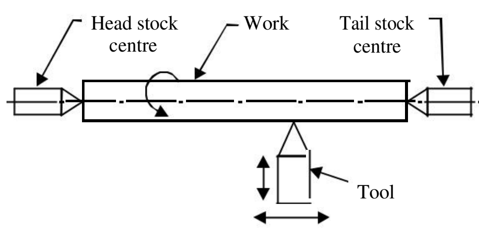

Fig. 1.1 Working principle of lathe machine

1.2 TYPES OF LATHE

Lathes are manufactured in a variety of types and sizes, from very small bench lathes used for precision work to huge lathes used for turning large steel shafts. But the principle of operation and function of all types of lathes is same. The different types of lathes are:

1. Speed lathe
2. Centre or engine lathe
3. Bench lathe
4. Tool room Lathe
5. Capstan and Turret 1athe
6. Special purpose lathe

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1.2.1 Centre Lathe or Engine Lathe

The term “engine” is associated with this lathe due to the fact that in the very early days of its development it was driven by steam engine. This lathe is the important member of the lathe family and is the most widely used.

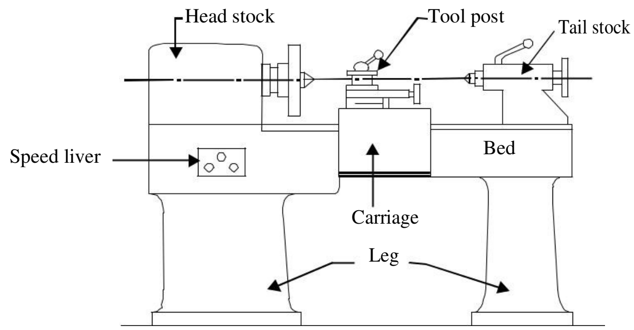


Fig. 1.2 Principal components of a central lathe

1.3 CONSTRUCTION OF LATHE MACHINE

A simple lathe comprises of a bed made of grey cast iron on which headstock, tailstock, carriage and other components of lathe are mounted. Fig.1.3 shows the different parts of engine lathe or central lathe. The major parts of lathe machine are given as under:

1. Bed
2. Head stock
3. Tailstock
4. Carriage
5. Feed mechanism
6. Thread cutting mechanism

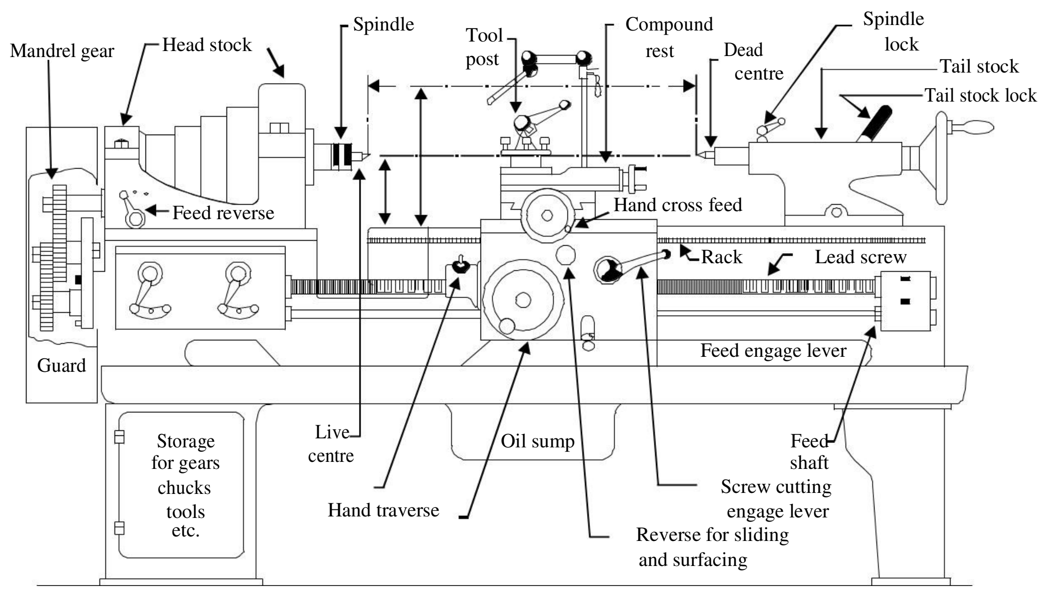


Fig. 1.3 Different parts of engine lathe or central lathe

1.3.1 Bed

The bed of a lathe machine is the base on which all other parts of lathe are mounted. On left end of the bed, headstock of lathe machine is located while on right side tailstock is located. The carriage of the machine rests over the bed and slides on it. On the top of the bed there are two sets of guideways-innerways and outerways. The innerways provide sliding surfaces for the tailstock and the outerways for the carriage. The guideways of the lathe bed may be flat and inverted V shape.

1.3.2 Head Stock

The main function of headstock is to transmit power to the different parts of a lathe. It comprises of the headstock casting to accommodate all the parts within it including gear train arrangement. The main spindle is adjusted in it, which possesses live centre to which the work can be attached. It supports the work and revolves with the work, fitted into the main spindle of the headstock.

1.3.3 **Tail Stock**

Fig. 1.4 shows the tail stock of central lathe, which can be easily set or adjusted for alignment or non-alignment with respect to the spindle centre and carries a centre called dead centre for supporting one end of the work. The dead centre can be mounted in ball bearing so that it rotates with the job avoiding friction of the job with dead centre as it important to hold heavy jobs.

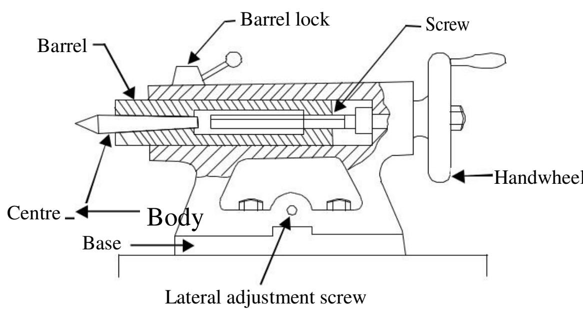


Fig. 1.4 Tail stock of central lathe.

1.3.4 **Carriage**

Carriage is mounted on the outer guide ways of lathe bed and it can move in a direction parallel to the spindle axis. It comprises of important parts such as apron, cross-slide, saddle, compound rest, and tool post. The lower part of the carriage is termed the apron in which there are gears to constitute apron mechanism for adjusting the direction of the feed using clutch mechanism and the split half nut for automatic feed. The cross-slide is basically mounted on the carriage, which generally travels at right angles to the spindle axis. On the cross-slide, a saddle is mounted in which the compound rest is adjusted which can rotate and fix to any desired angle. The compound rest slide is actuated by a screw, which rotates in a nut fixed to the saddle.

The tool post is an important part of carriage, which fits in a tee-slot in the compound rest and holds the tool holder in place by the tool post screw. Fig. 1.5 shows the tool post of centre lathe.

1.3.5 **Feed Mechanism**

Feed mechanism is the combination of different units through which motion of headstock spindle is transmitted to the carriage of lathe machine. Following units play role in feed mechanism of a lathe machine;

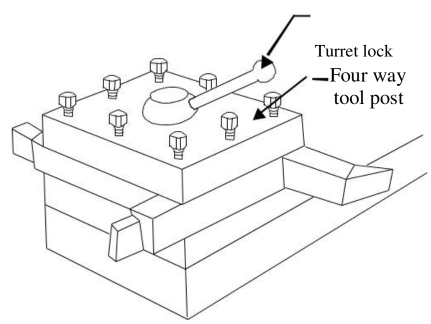


Fig. 1.5 Tool post of centre lathe

1. End of bed gearing
2. Feed gear box
3. Lead screw and feed rod
4. Apron mechanism

The gearing at the end of bed transmits the rotary motion of headstock spindle to the feed gear box. Through the feed gear box the motion is further transmitted either to the feed shaft or lead screw, depending on whether the lathe machine is being used for plain turning or screw cutting.

The feed gear box contains a number of different sizes of gears. The feed gear box provides a means to alter the rate of feed, and the ration between revolutions of the headstock spindle and the movement of carriage for thread cutting by changing the speed of rotation of the feed rod or lead screw.

The apron is fitted to the saddle. It contains gears and clutches to transmit motion from the feed rod to the carriage, and the half nut which engages with the lead screw during cutting threads.

1.3.6 **Thread Cutting Mechanism**

The half nut or split nut is used for thread cutting in a lathe. It engages or disengages the carriage with the lead screw so that the rotation of the leadscrew is used to traverse the tool along the workpiece to cut screw threads. The direction in which the carriage moves depends upon the position of the feed reverse lever on the headstock.

1.4 ACCESSORIES AND ATTACHMENTS OF LATHE

There are many lathe accessories provided by the lathe manufacturer along with the lathe, which support the lathe operations. The important lathe accessories include centers, catch plates and carriers, chucks, collets, face plates, angle plates, mandrels, and rests. These are used either for holding and supporting the work or for holding the tool. Attachments are additional equipments provided by the lathe manufacturer along with the lathe, which can be used for specific operations. The lathe attachment include stops, ball turning rests, thread chasing dials, milling attachment, grinding attachment, gear cutting attachment, turret attachment and crank pin turning attachments and taper turning attachment.

Lathe centers

The most common method of holding the job in a lathe is between the two centers generally known as live centre (head stock centre) and dead centre (tailstock centre). They are made of very hard materials to resist deflection and wear and they are used to hold and support the cylindrical jobs.

Carriers or driving dog and catch plates

These are used to drive a job when it is held between two centers. Carriers or driving dogs are attached to the end of the job by a setscrew. A use of lathe dog for holding and supporting the job is shown in Fig. 1.6. Catch plates are either screwed or bolted to the nose of the headstock spindle. A projecting pin from the catch plate or carrier fits into the slot provided in either of them. This imparts a positive drive between the lathe spindle and job.

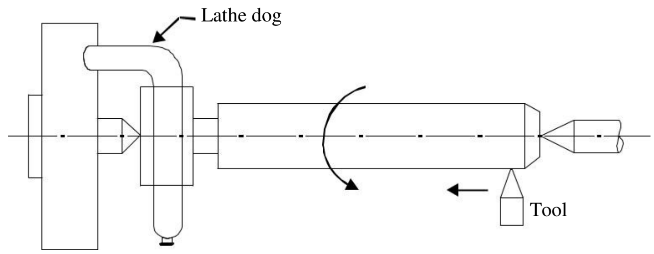


Fig. 1.6 Lathe dog

Chucks

Chuck is one of the most important devices for holding and rotating a job in a lathe. It is basically attached to the headstock spindle of the lathe. The internal threads in the chuck fit on to the external threads on the spindle nose. Short, cylindrical, hol1ow objects or those of irregular shapes, which cannot be conveniently mounted between centers, are easily and rigidly held in a chuck. Jobs of short length and large diameter or of irregular shape, which cannot be conveniently mounted between centers, are held quickly and rigidly in a chuck. There are a number of types of lathe chucks, e.g.

(1) Three jaws or universal
(2) Four jaw independent chuck
(3) Magnetic chuck
(4) Collet chuck
(5) Air or hydraulic chuck operated chuck
(6) Combination chuck
(7) Drill chuck.

Face plates

Face plates are employed for holding jobs, which cannot be conveniently held between centers or by chucks. A face plate possesses the radial, plain and T- slots for holding jobs or work-pieces by bolts and clamps. Face plates consist of a circular disc bored out and threaded to fit the nose of the lathe spindle. They are heavily constructed and have strong thick ribs on the back. They have slots cut into them, therefore nuts, bolts, clamps and angles are used to hold the jobs on the face plate. They are accurately machined and ground.

Angle plates

Angle plate is a cast iron plate having two faces machined to make them absolutely at right angles to each other. Holes and slots are provided on both faces so that it may be clamped on a faceplate and can hold the job or workpiece on the other face by bolts and clamps. The plates are used in conjunction with a face plate when the holding surface of the job should be kept horizontal.

Mandrels

A mandrel is a device used for holding and rotating a hollow job that has been previously drilled or bored. The job revolves with the mandrel, which is mounted between two centers.

It is rotated by the lathe dog and the catch plate and it drives the work by friction. Different types of mandrels are employed according to specific requirements. It is hardened and tempered steel shaft or bar with 60° centers, so that it can be mounted between centers. It holds and locates a part from its center hole. The mandrel is always rotated with the help of a lathe dog; it is never placed in a chuck for turning the job. A mandrel unlike an arbor is a job holding device rather than a cutting tool holder. A bush can be faced and turned by holding the same on a mandrel between centers. It is generally used in order to machine the entire length of a hollow job.

1.5 SPECIFICATION OF LATHE

The size of a lathe is generally specified by the following means:

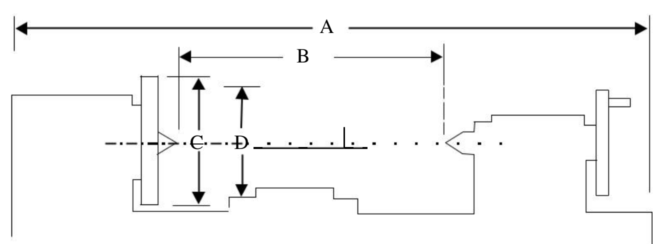
(*a*) Swing or maximum diameter that can be rotated over the bed ways.

(*b*) Maximum length of the job that can be held between head stock and tail stock centres.

(*c*) Bed length, which may include head stock length also.

(*d*) Maximum diameter of the bar that can pass through spindle or collect chuck of capstan lathe.

Fig. 1.7 illustrates the elements involved in specifications of a lathe. The following data also contributes to specify a common lathe machine.



A - Length of bed.
B - Distance between centres.
C - Diameter of the work that can be turned over the ways.
D - Diameter of the work that can be turned over the cross slide.

Fig. 1.7 Specifications of a lathe

(*i*) Maximum swing over bed

(*ii*) Maximum swing over carriage

(*iii*) Height of centers over bed

(*iv*) Maximum distance between centers

(*v*) Length of bed

(*vi*) Width of bed
(*vii*) Morse taper of center
(*viii*) Diameter of hole through spindle
(*ix*) Face plate diameter
(*x*) Size of tool post
(*xi*) Number of spindle speeds
(*xii*) Lead screw diameter and number of threads per cm.
(*xiii*) Size of electrical motor
(*xiv*) Pitch range of metric and inch threads etc.

1.6 LATHE OPERATIONS

For performing the various machining operations in a lathe, the job is being supported and driven by anyone of the following methods.

1. Job is held and driven by chuck with the other end supported on the tail stock centre.
2. Job is held between centers and driven by carriers and catch plates.
3. Job is held on a mandrel, which is supported between centers and driven by carriers and catch plates.
4. Job is held and driven by a chuck or a faceplate or an angle plate.

The above methods for holding the job can be classified under two headings namely job held between centers and job held by a chuck or any other fixture. The various important lathe operations are depicted through Fig. 1.8 (*a*), (*b*) and (*c*). The operations performed in a lathe can be understood by three major categories

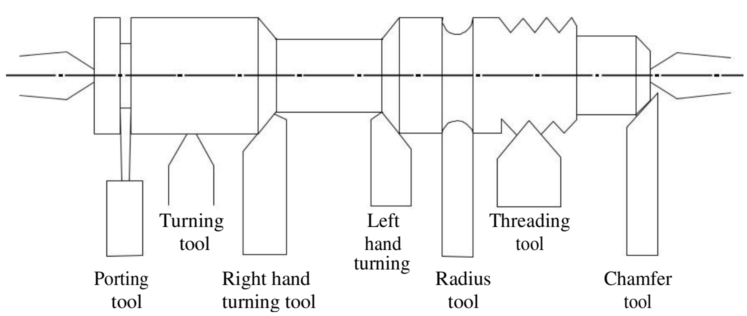


Fig. 1.8(a) Lathe operation

(*a*) Operations, which can be performed in a lathe either by holding the workpiece between centers or by a chuck are:

1. Straight turning	2. Shoulder turning
3. Taper turning	4. Chamfering
5. Eccentric turning	6. Thread cutting
7. Facing	8. Forming
9. Filing	10. Polishing
11. Grooving	12. Knurling
13. Spinning	14. Spring winding

(*b*) Operations which are performed by holding the work by a chuck or a faceplate or an angle plate are:

1. Undercutting	2. Parting-off
3. Internal thread cutting	4. Drilling
5. Reaming	6. Boring
7. Counter boring	8. Taper boring

9. Tapping

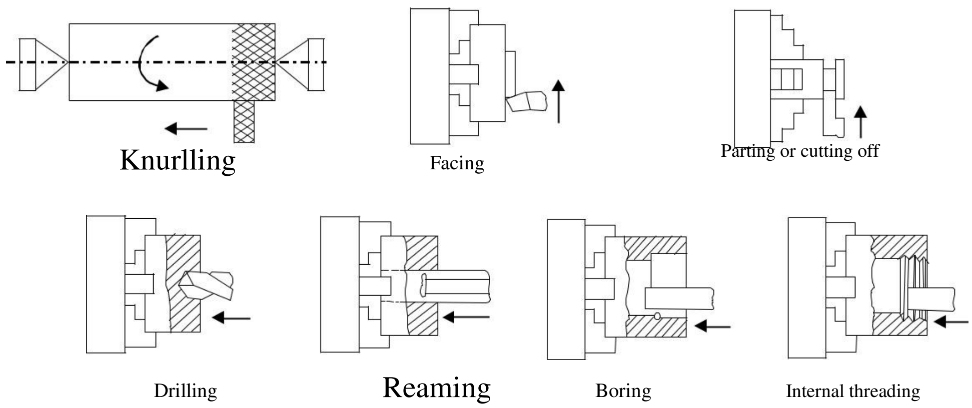


Fig. 1.8(b) Lathe operations

(*c*) Operations which are performed by using special lathe attachments are:

1. Milling 2. Grinding

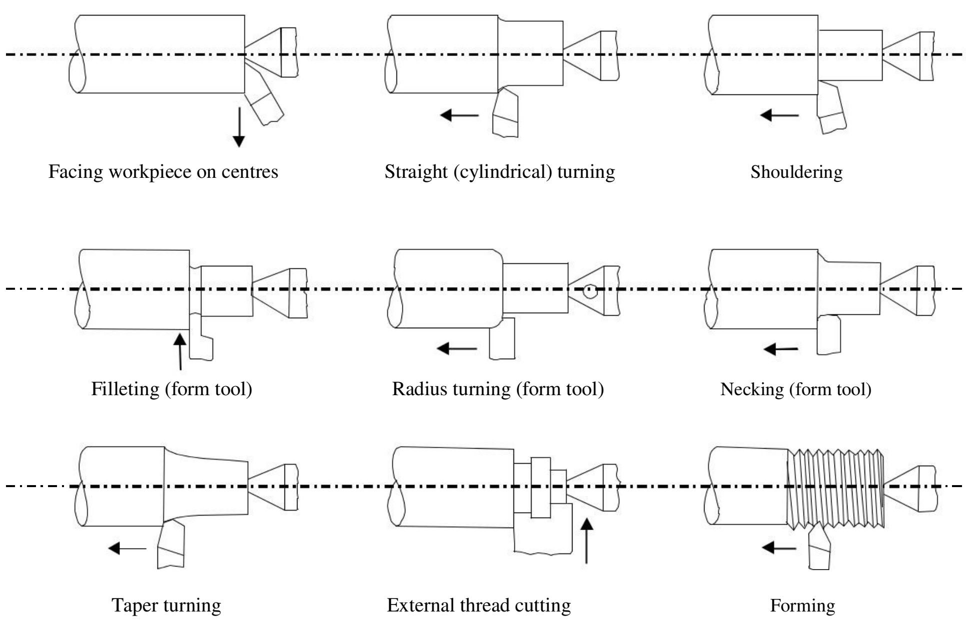


Fig. 1.8(c) Lathe operation

Some of the important operations performed on a lathe machine are discussed as under.

1.7 TAPERS AND TAPER TURNING

A taper is defined as a uniform increase or decrease in diameter of a piece of work measured along its length. In a lathe machine, taper turning means to produce a conical surface by gradual reduction in diameter from a cylindrical job. Taper in the British System is expressed in taper per foot or taper per inch.

$$\text{Taper per inch} = (D - d) / l$$

Where,

D = is the diameter of the large end of cylindrical job,

d = is the diameter of the small end of cylindrical job, and

l = is the length of the taper of cylindrical job, all expressed in inches,

When the taper is expressed in taper per foot, the length of the taper l is expressed in foot, but the diameters are expressed in inches.

A taper is generally turned in a lathe by feeding the tool at an angle to the axis of rotation of the workpiece. The angle formed by the path of the tool with the axis of the workpiece should correspond to the half taper angle. A taper can be turned by anyone of the following methods:

1. By swiveling the compound rest,
2. By setting over the tailstock centre,
3. By a broad nose form tool,
4. By a taper turning attachment,
5. By combining longitudinal and cross feed in a special lathe and
6. By using numerical control lathe

Some of the important taper turning methods are discussed as under.

1.7.1 Taper Turning by Swiveling the Compound Rest

This method uses the principle of turning taper by rotating the workpiece on the lathe axis and feeding the tool at an angle to the axis of rotation of the workpiece. The tool is mounted on the compound rest which is attached to a circular base, graduated in degrees. The compound rest can easily be swiveled or rotated and clamped at any desired angle as shown in Fig. 1.9 (a). The complete setup for producing a taper by swelling the compound rest is given in Fig. 1.9(b)

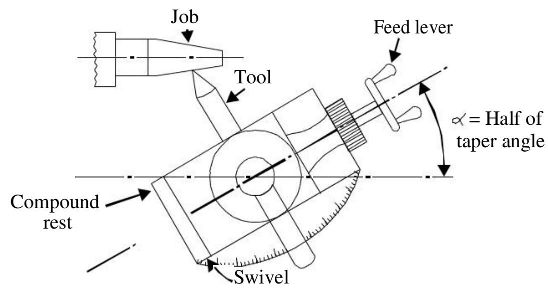


Fig. 1.9(a) Taper turning by swiveling compound rest

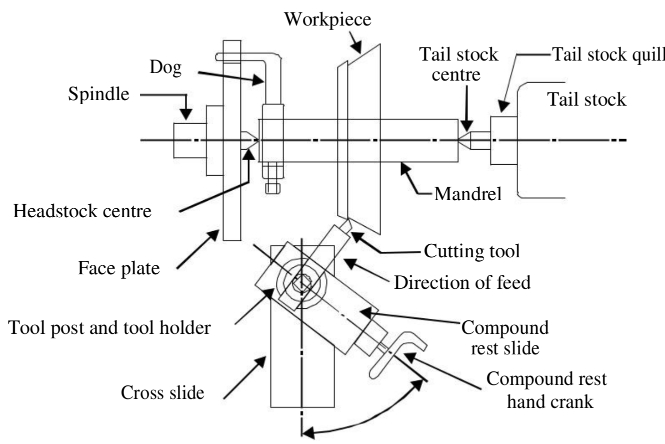


Fig. 1.9(b) Swiveling compound rest set-up

1.7.2 Taper Turning Attachment Method

This method is commonly employed for generating external tapers only. In this method, the taper turning attachment is bolted back of the lathe machine as shown in Fig.1.10. It

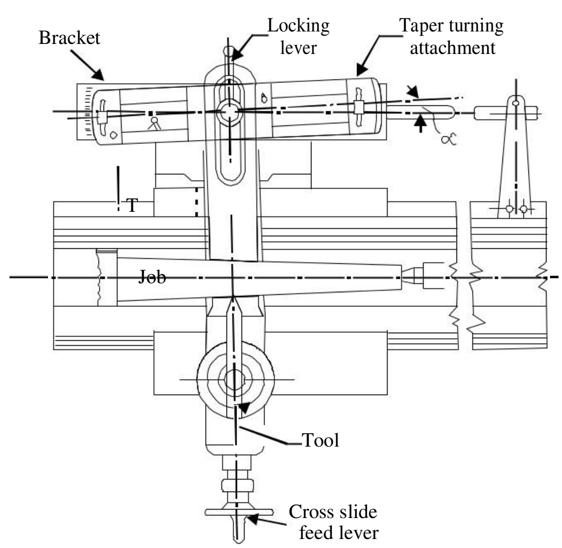


Fig. 1.10 Taper turning attachment

has guide bar which may be set at any desired angle or taper. As the carriage moves along the bed length aside over bar causes the tool to move in and out according to setting of the bar. The taper setting on the bar is duplicated on the job or work. The merit of this method is that the lathe centres are kept in alignment.

1.7.3 Taper Turning with Tailstock set over Method

This method is basically employed for turning small tapers on longer jobs and is confined to external tapers only. In this method, the tailstock is set over is calculated using Fig. 1.11 by loosening the nut from its centre line equal to the value obtained by formula given below.

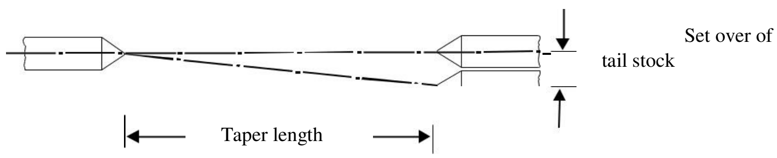


Fig. 1.11 Tailstock set over

Tail stock set over = Taper length × Sine of half of taper angle

$$(D - d) / 2 = l \times \sin(a/2)$$

Where, D = is the diameter of the large end of cylindrical job,

d = is the diameter of the small end of cylindrical job, and

l = is the length of the taper of cylindrical job, all expressed in inches,

a = taper angle

When a part length of the job is to be given taper then tail stock set

$$= ((D - d)/2)) \times (\text{total length of the cylindrical job/length of taper})$$

$$= l \times \sin(a/2) \times (\text{total length of the cylindrical job/length of taper})$$

1.8 THREAD CUTTING

Fig.1.14 shows the setup of thread cutting on a lathe. Thread of any pitch, shape and size can be cut on a lathe using single point cutting tool. Thread cutting is operation of producing a helical groove on spindle shape such as V, square or power threads on a cylindrical surface. The job is held in between centres or in a chuck and the cutting tool is held on tool post. The cutting tool must travel a distance equal to the pitch (in mm) as the work piece completes a revolution. The definite relative rotary and linear motion between job and cutting tool is achieved by locking or engaging a carriage motion with lead screw and nut mechanism and fixing a gear ratio between head stock spindle and lead screw. To make or cut threads, the cutting tool is brought to the start of job and a small depth of cut is given to cutting tool using cross slide.

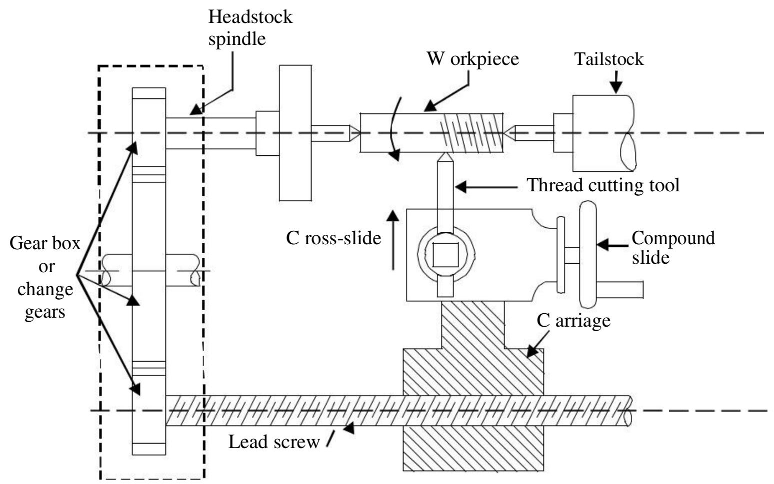


Fig. 1.14 Thread cutting

1.9 DRILLING ON A LATHE

For producing holes in jobs on lathe, the job is held in a chuck or on a face plate. The drill is held in the position of tailstock and which is brought nearer the job by moving the tailstock along the guide ways, the thus drill is fed against the rotating job as shown in Fig. 1.15.

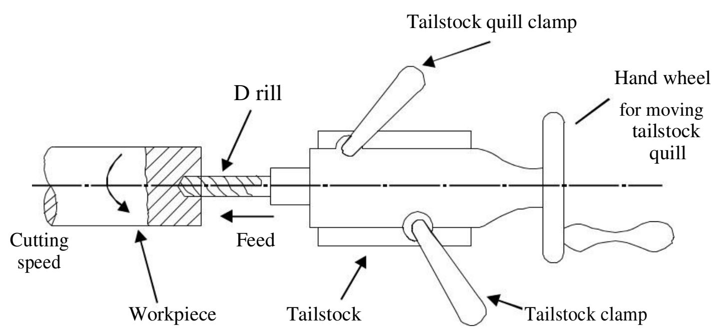


Fig. 1.15 Drilling on lathe

1.10 CUTTING SPEED

Cutting speed for lathe work may be defined as the rate in meters per minute at which the surface of the job moves past the cutting tool. Machining at a correct cutting speed is highly important for good tool life and efficient cutting. Too slow cutting speeds reduce productivity and increase manufacturing costs whereas too high cutting speeds result in overheating of the tool and premature failure of the cutting edge of the tool. The following factors affect the cutting speed:

(*i*) Kind of material being cut

(*ii*) Cutting tool material

(*iii*) Shape of cutting tool

(*iv*) Rigidity of machine tool and the job piece and

(v) Type of cutting fluid being used.

1.11 FEED

Feed is defined as the distance that a tool advances into the work during one revolution of the headstock spindle. It is usually given as a linear movement per revolution of the spindle or job. During turning a job on the center lathe, the saddle and the tool post move along the bed of the lathe for a particular feed for cutting along the length of the rotating job.

1.2.7 Leadscrew

The leadscrew is a long threaded shaft used as master screw. It is brought into operation during thread cutting to move the carriage to a calculated distance. Mostly leadscrews are Acme threaded.

The leadscrew is held by two bearings on the face of the bed. A gear is attached to the lead screw and it is called as gear on leadscrew. A half nut lever is provided in the apron to engage half nuts with the leadscrew.

Leadscrew is used to move the carriage towards and away from the headstock during thread cutting. The direction of carriage movement depends upon the direction of rotation of the leadscrew.When the leadscrew is kept stationary, the half nuts are engaged with the leadscrew to keep the carriage locked at the required position.

1.2.8 Feed rod

Feed rod is placed parallel to the leadscrew on the front side of the bed. It is a long shaft which has a keyway along its length. The power is transmitted from the spindle to the feed rod through tumbler gears and a gear train. It is useful in providing feed movement to the carriage except for thread cutting and to move cross-slide. A worm mounted on the feed rod enables the power feed movements.

1.3 Spindle mechanism

The spindle is located in the headstock and it receives the driving power from the motor. The spindle speed should be changed to suit different machining conditions like type of material to be cut, the diameter and the length of the work, type of operation, the type of cutting tool material used, the type of finish desired and the capacity of the machine. In order to change the spindle speeds, any one of the following methods are employed.

Step cone pulley drive

Back geared drive

All geared drive

1.3.1 Step cone pulley drive

It is simple in construction. The belt is arranged on the four different steps of the cone pulley to obtain four different speeds.

A step cone pulley is attached with the spindle contained within the headstock casting. The cone pulley has four steps (A, B, C & D). Another cone pulley having four steps (E, F, G and H) is placed parallel to the spindle cone pulley. Both the cone pulleys are connected by a flat belt. The belt can be arranged between the steps A & H, B & G, C & F and D & E. The cone pulley at the bottom is connected to the electric motor by a ‘V’belt. So the cone pulley at the bottom rotates at a particular speed.

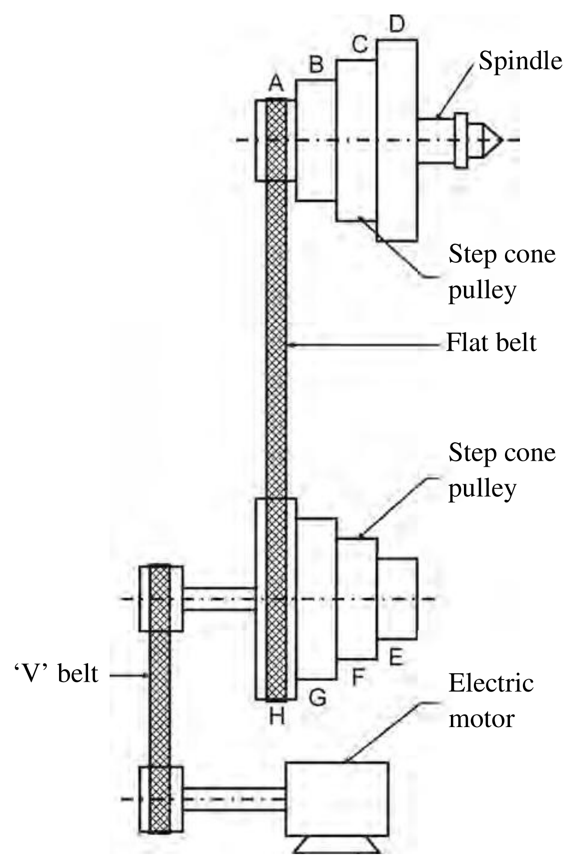


Fig 1.9 Step cone pulley drive

The belt is arranged on any of the four steps to obtain different spindle speeds. The spindle speed is increased if the belt is placed on the smaller step of the driven pulley. The spindle speed will be maximum when the belt is arranged between A & H and the speed will be minimum when the belt is arranged between D & E. *Step cone pulley drive is illus-trated in Fig 1.9*

1.3.2 Back gear mechanism

Back gear mechanism is housed within the headstock of the lathe. A step cone pulley having steps ABCD and a small pinion 'P' are mounted on the spindle and rotates freely on it. The gear 'S' is keyed to the headstock spindle. So, the spindle will rotate only when the gear 'S' rotates.

The step conepulley ABCD and the gear 'S' can be kept seperately or made as one unit with the help of a pin 'T'. When the pin is disengaged, the conepulley along with the gear P will rotate freely on the spindle and the spindle will not rotate. There is another shaft parallel to the spindle axis having back gears Q and R mounted on it. These back gears can be made to mesh with gears P and S or kept disengaged from them. The spindle can get drive either from the cone pulley or through back gears.

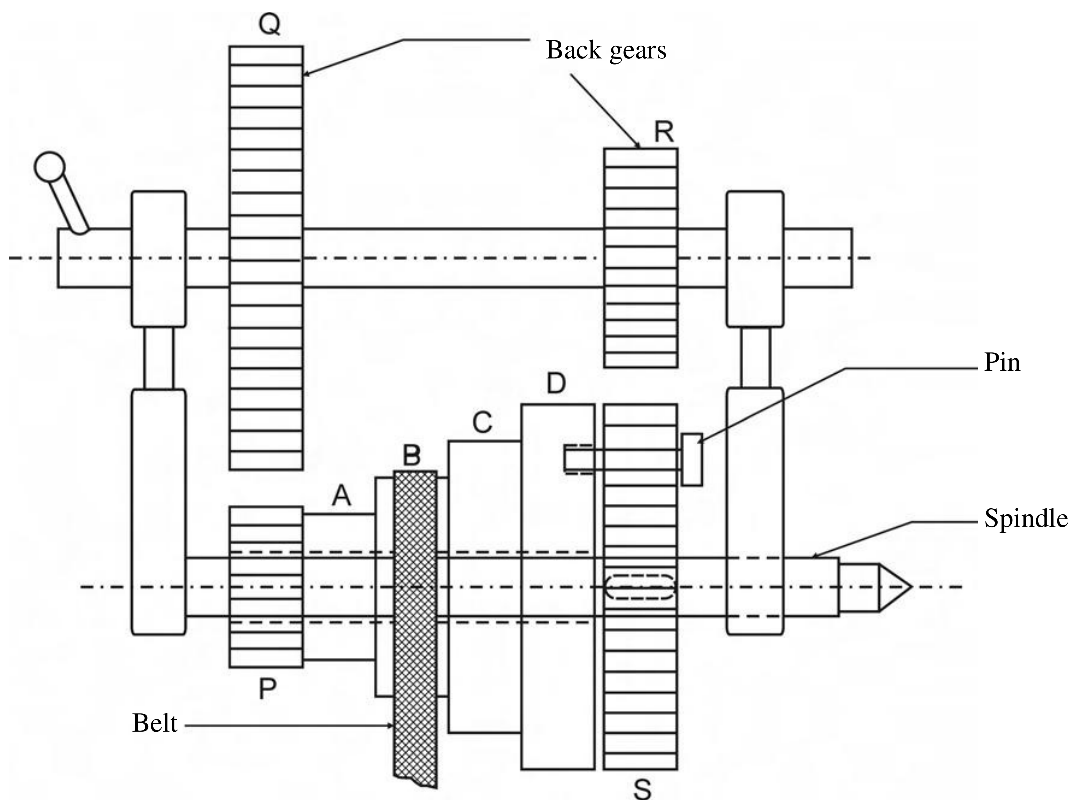


Fig 1.10 Back gear drive

Drive from step conepulley

When the spindle gets drive from the conepulley, the backgears Q and R are disengaged from the gears P and S. The pin 'T' is engaged with conepulley. The belt can be arranged on the steps A,B,C or D to get four different direct speeds for the spindle.*Back gear drive is illustrated in Fig 1.10*

Drive through back gears

Back gears Q and R are engaged with gears P and S. The pin 'T' is disengaged from the conepulley to make the conepulley and the spindle separate units. When the conepulley gets drive through the belt, the power is transmitted through the gears P,Q and R to the gear S. Because of number of teeth on these gears, the spindle rotates at slower speeds. By arranging the belt on the different steps of the cone pulley, four different spindle speeds are obtained.

Uses of back gear arrangement

The spindle gets four direct speeds through the conepulley and four slower speeds through the back gears.

Slower speeds obtained by this arrangement are useful when turning on larger workpieces and cutting coarse threads.

1.3.3 All geared headstock

Modern lathes are equipped with all geared headstocks to obtain different spindle speeds quickly. Casting of the all geared headstock has three shafts(1,2& 3) mounted within it. The intermediate shaft(2) has got three gears D, E and F as a single unit and rotate at the same speeds. The splined shaft(1) which is above the intermediate shaft has got three gears A, B and C mounted on it by keys. These three gears can be made to slide on the shaft with the help of a lever. This movement enables the gear A to have contact with the gear D or the gear B with gear E or the gear C with the gear F.

Likewise the spindle shaft(3) which is also splined has three gears G, H and I. With the help of a lever, these three gears can be made to slide on the shaft. This sliding movement enables the gear G to have contact with gear D or the gear H with the gear E or the gear I with the gear F. By altering the positions of the six gears namely A, B, C, G, H and I the following arrangements can be made within the headstock. Nine different spindle speeds are obtained. *All geared drive is shown in Fig 1.11*

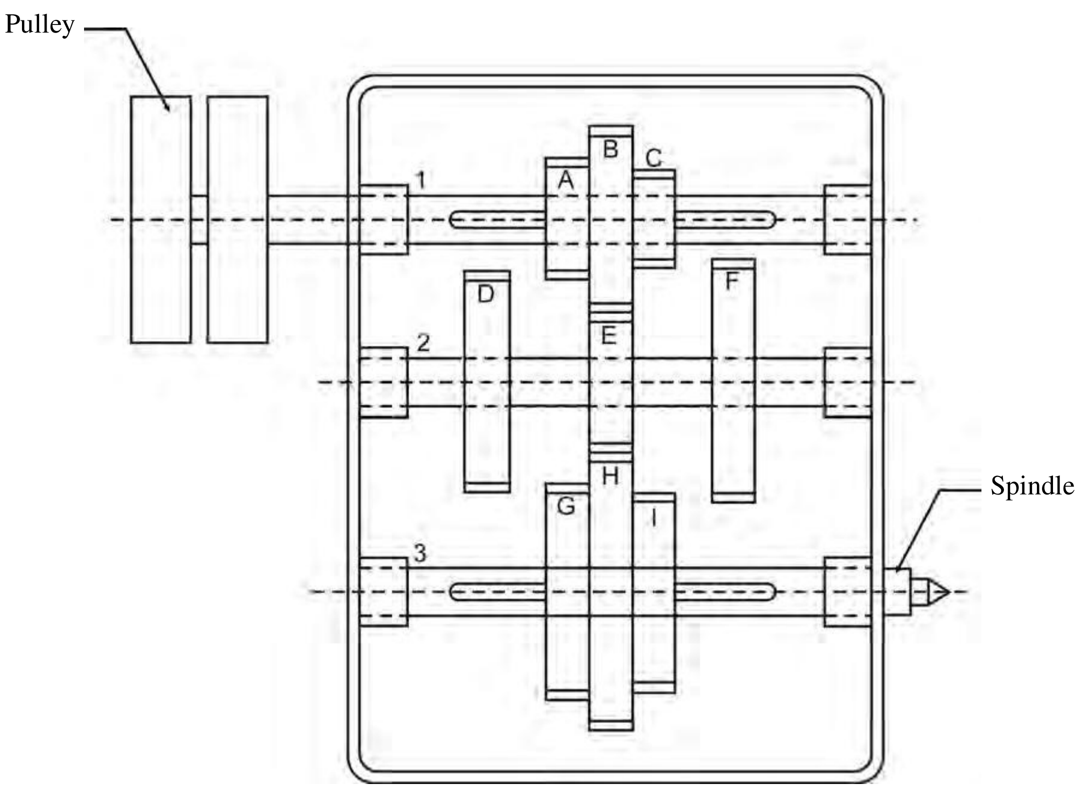


Fig 1.11 All geared drive

The gear combinations are

1. $\frac{A}{D} \times \frac{D}{G}$

2. $\frac{A}{D} \times \frac{E}{H}$

3. $\frac{A}{D} \times \frac{F}{I}$

4. $\frac{B}{E} \times \frac{D}{G}$

5. $\frac{B}{E} \times \frac{E}{H}$

4. $\frac{B}{E} \times \frac{F}{I}$

7. $\frac{C}{F} \times \frac{D}{G}$

8. $\frac{C}{F} \times \frac{E}{H}$

9. $\frac{C}{F} \times \frac{F}{I}$

Difference Between Capstan and Turret Lathe machine

S.no	Capstan Lathe	Turret Lathe
1	It is a Light weight machine.	It is a heavy weight machine.
2	In capstan lathe the turret tool head is mounted over the ram and that is mounted over the saddle.	In turret lathe the turret tool head is mounted over the saddle like a single unit
3	For providing feed to the tool, ram is moved.	For providing feed to the tool, saddle is moved.
4	Because of no saddle displacement, Movement of turret tool head over the longitudinal direction of bed is small along with the ram.	Turret tool head move along with the saddle over the entire bed in the longitudinal direction.
5	Used for shorter workpiece because of limited ram movement.	Used for longer workpiece because of saddle movement along the bed.
6	Its working operations are fast because of lighter in constructions.	Its working operations are slower because of heavier in constructions.
7	Heavy cuts on the workpiece cannot be given because of non-rigid construction.	Heavy cuts on the workpiece can be given because of rigid construction of machine.
8	For indexing turret tool head, the hand wheel of the ram is reversed and turret tool index automatically.	For indexing turret tool head, turret is rotated manually after releasing clamping lever.
9	The turret head cannot be moved in the lateral direction of the bed.	The turret head can be moved crosswise i.e. in the lateral direction of bed in some turret lathe.
10	In capstan lathe, Collet is used to grip the Job.	In turret lathe, power Jaw chuck is used to grip the Job.
11	Used for machining workpiece up to 60 mm diameter.	Used for machining workpiece up to 120 mm diameter.
12	These are usually horizontal lathes.	Turret lathes are available in horizontal and vertical lathes.

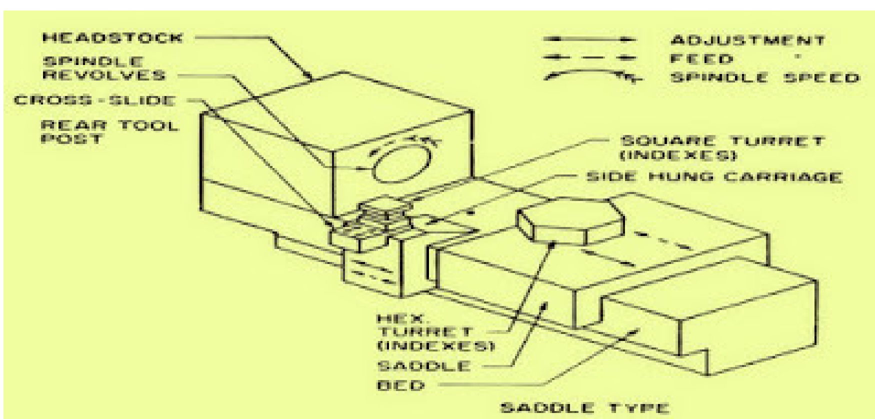
Capstan and Turret lathe machines

Lathe is a machine used to done various operations such as drilling, boring, knurling, thread cutting, facing etc. on the workpiece. In classical lathe machine such as in center lathe there is only one tool post and only one tool fitted in the tailstock, which usually takes time while changing tools for different operations.

There are certain difficulties that cannot be overcome by center lathes such as: the large time involvement while setting and movement of tool between the machining processes, unsuitable for mass production, less number of speeds, one tool fixation in the tailstock etc. Thus the center lathe is modified to capstan and turret lathe to overcome all these difficulties.

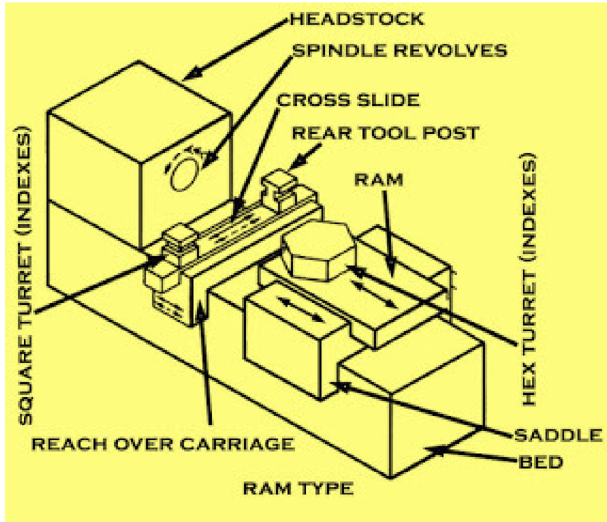
Capstan and Turret lathes are the advancement of the Engine lathes and center lathe, wherein the tailstock is replaced by a hexagonal turret tool head, having 6 different tools in the turret, where turret tool is rotate in each operation according to process requirement. These are used to produce large number of identical parts in minimum time and are used for mass productions in less time with maximum accuracy and precision. These are the semi automatic lathes which mean that all the machining process such as boring, drilling, thread cutting, facing, turning etc., without changing of tools, are to be done automatically and other functions like setting of tools, clamping of workpiece, cooling of process are to be done manually. These machines can be used to machine from small to large workpiece and are costlier than engine lathe because of having complex construction.

Capstan or Ram type lathe machine



The ram type lathe carries the hexagonal turret on a ram or a short slide. The ram slides longitudinally on a saddle and clamp on lathe bed ways. This type of machine is lighter in construction and its suitable for machining bar of smaller diameter. The tools are mounted on the square turret and six faces of the hexagonal turret. Ram moves from left to right the feeding movement is obtained.

Turret or Saddle lathe



The hexagonal turret mounted directly on a saddle and the whole unit moves back and fourth on the bed ways to apply feed. This type of turret lathe is heavier in construction and is particularly used for larger diameter bar work.

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4. GRINDING MACHINE

4.1 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.

Grinding is done to obtain very high dimensional accuracy and better appearance. The accuracy of grinding process is 0.000025mm. The amount of material removed from the work is very less.

4.2 Types of grinding machines

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

1. Rough grinding machines
2. Precision grinding machines

4.2.1 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 stands grinding machine
4. Flexible shaft grinding machine
5. Swing frame grinding machine
6. Abrasive belt grinding machine

4.2.2 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

4.2.3 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

1. External cylindrical grinding machines
2. Internal cylindrical grinding machines

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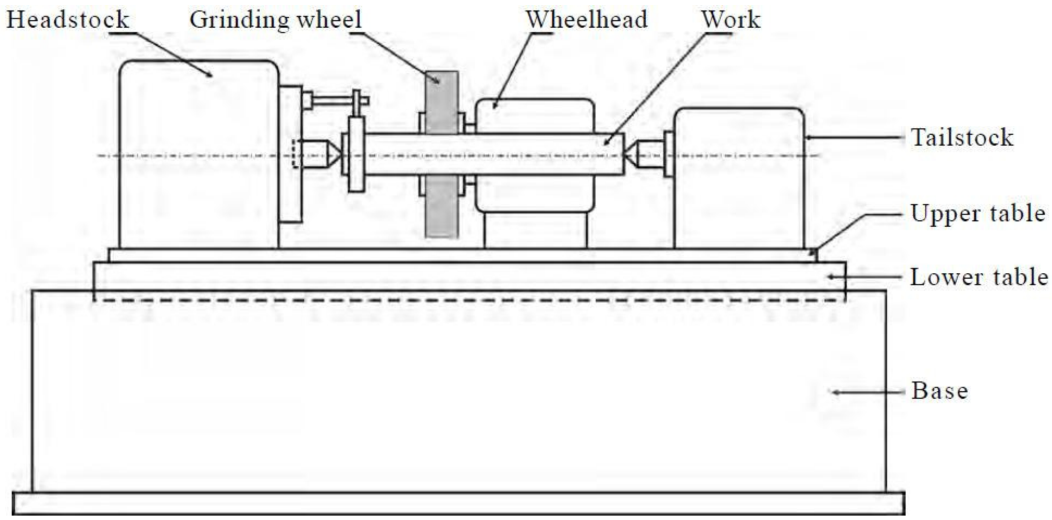

Fig 4.1 Cylindrical grinding machine

4.2.4 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:

1. Horizontal spindle and reciprocating table type
2. Horizontal spindle and rotary table type
3. Vertical spindle and reciprocating table type
4. 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.

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.

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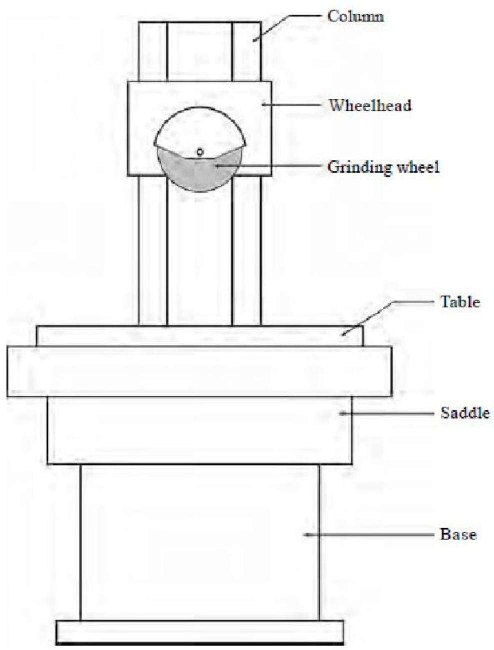

Fig 4.2 Horizontal spindle surface grinder

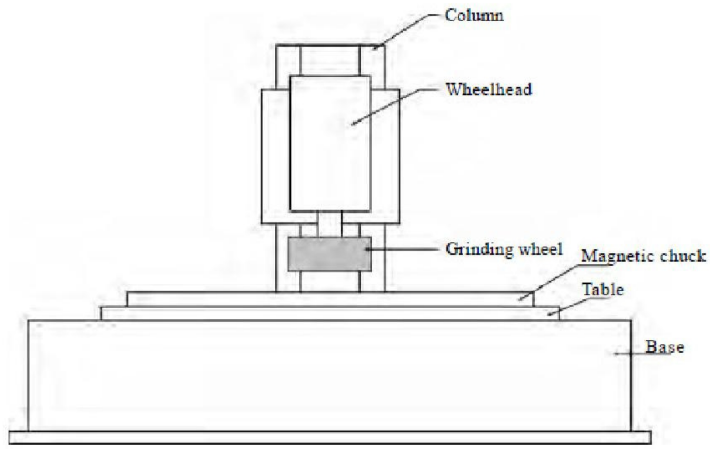

Fig 4.3 Vertical spindle surface grinder

4.5 Grinding machine operations

The process of grinding is the operation of removing excess material from metal parts by a grinding wheel made of hard abrasives. The following operations are generally performed in a grinding machine.

1. Cylindrical grinding
2. Taper grinding
3. Gear grinding
4. Thread grinding

4.5.1 Cylindrical grinding

Cylindrical grinding is performed by mounting and rotating the work between centres in a cylindrical grinding machine. The work is fed longitudinally against the rotating grinding wheel to perform grinding. The upper table of the grinding machine is set at 0° during the operation.

4.5.2 Taper grinding

Taper grinding on long workpieces can be done by swivelling the upper table. If the workpiece is short, the wheelhead may be swivelled to the taper angle. Another method of grinding external taper is to true the face of the grinding wheel by a diamond tool dresser to the required angle. In this case, the table and the wheelhead are not swivelled.

4.5.3 Gear grinding

The teeth of gears are ground accurately on gear grinding machines for their shape. Gear grinding is done by the generating process or by using a form grinding wheel. The generating process makes use of two saucer shaped grinding wheels. These wheels are used to grind two faces of successive teeth.

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4.5.4 Thread grinding

Thread grinding machines are used to grind threads accurately. The grinding wheel itself is shaped to the thread profile. These formed grinding wheels have one or multi threads on them.

4.6 Grinding wheel

A grinding wheel is a multi-tooth cutter made up of many hard particles known as abrasives having sharp edges. The abrasive grains are mixed with a suitable bond, which acts as a matrix to manufacture grinding wheels.

According to construction, grinding wheels are classified under three categories.

1. Solid grinding wheels
2. Segmented grinding wheels
3. Mounted grinding wheels

4.6.1 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.

1. Natural abrasives
2. Artificial abrasives

4.6.2 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.

4.6.3 Artificial abrasives

Artificial abrasives are of two types.

1. Silicon carbide abrasives
2. 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'.

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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'.

4.6.4 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

4.6.5 Grain size, Grade and Structure

Grain size (Grit)

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	

4.6.6 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	