21
CHAPTER

LATHE MACHINE

21.1 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 rigidly held in the chuck or in between centers on the lathe machine and then turn it against a single point cutting tool which will remove metal from the job in the form of chips. Fig. 21.1 shows the working principle of lathe. An engine lathe is the most basic and simplest form of the lathe. It derives its name from the early lathes, which obtained their power from engines. Besides the simple turning operation as described above, lathe can be used to carry out other operations also, such as drilling, reaming, boring, taper turning, knurling, screw-thread cutting, grinding etc.

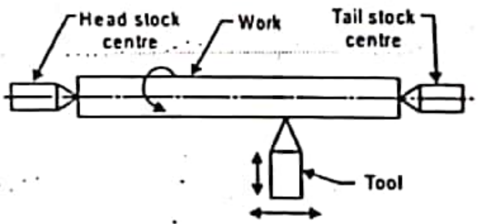


Fig. 21.1 Working principal of lathe machine

21.2 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
   (a) Wood working
   (b) Spinning
   (c) Centering
   (d) Polishing

2. Centre or engine lathe
   (*a*) Belt drive
   (*b*) Individual motor drive
   (*c*) Gear head lathe
3. Bench lathe
4. Tool room Lathe
5. Capstan and Turret lathe
6. Special purpose lathe
   (*a*) Wheel lathe
   (*b*) Gap bed lathe
   (*c*) Duplicating lathe
   (*d*) T-lathe
7. Automatic lathe

Some of common lathes are described as under.

21.2.1 Speed Lathe

Speed lathe is simplest of all types of lathes in construction and operation. The important parts of speed lathe are following-

(1) Bed

(2) Headstock

(3) Tailstock, and

(4) Tool post mounted on an adjustable slide.

It has no feed box, leadscrew or conventional type of carriage. The tool is mounted on the adjustable slide and is fed into the work by hand control. The speed lathe finds applications where cutting force is least such as in wood working, spinning, centering, polishing, winding, buffing etc. This lathe has been so named because of the very high speed of the headstock spindle.

21.2.2 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. Similar to the speed lathe, the engine lathe has all the basic parts, e.g., bed, headstock, and tailstock. But its headstock is much more robust in construction and contains additional mechanism for driving the lathe spindle at multiple speeds. An engine lathe is shown in Fig. 21.2. Unlike the speed lathe, the engine lathe can feed the cutting tool both in cross and longitudinal direction with reference to the lathe axis with the help of a carriage, feed rod and lead screw. Centre lathes or engine lathes are classified according to methods of transmitting power to the machine. The power may be transmitted by means of belt, electric motor or through gears.

22.2.3 Bench Lathe

This is a small lathe usually mounted on a bench. It has practically all the parts of an engine lathe or speed lathe and it performs almost all the operations. This is used for small and precision work.

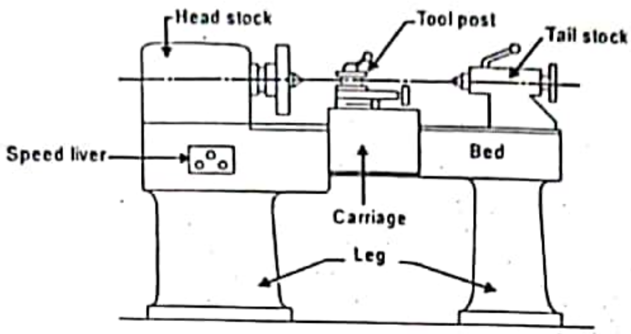


Fig. 21.2 Principal components of a central lathe

22.2.4 Tool Room Lathe

This lathe has features similar to an engine lathe but it is much more accurately built. It has a wide range of spindle speeds ranging from a very low to a quite high speed up to 2500 rpm. This lathe is mainly used for precision work on tools, dies, gauges and in machining work where accuracy is needed.

22.2.5 Capstan and Turret Lathe

The development of these lathes results from the technological advancement of the engine lathe and these are vastly used for mass production work. The distinguishing feature of this type of lathe is that the tailstock of an engine lathe is replaced by a hexagonal turret, on the face of which multiple tools may be fitted and fed into the work in proper sequence. Due to this arrangement, several different types of operations can be done on a job without re-setting of work or tools, and a number of identical parts can be produced in the minimum time.

21.2.6 Special Purpose Lathes

These lathes are constructed for special purposes and for jobs, which cannot be accommodated or conveniently machined on a standard lathe. The wheel lathe is made for finishing the journals and turning the tread on railroad car and locomotive wheels. The gap bed lathe, in which a section of the bed adjacent to the headstock is removable, is used to swing extra-large-diameter pieces. The T-lathe is used for machining of rotors for jet engines. The bed of this lathe has T-shape. Duplicating lathe is one for duplicating the shape of a flat or round template on to the job.

21.2.7 Automatic Lathes

These lathes are so designed that all the working and job handling movements of the complete manufacturing process for a job are done automatically. These are high speed, heavy duty, mass production lathes with complete automatic control.

21.3 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. 21.3 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

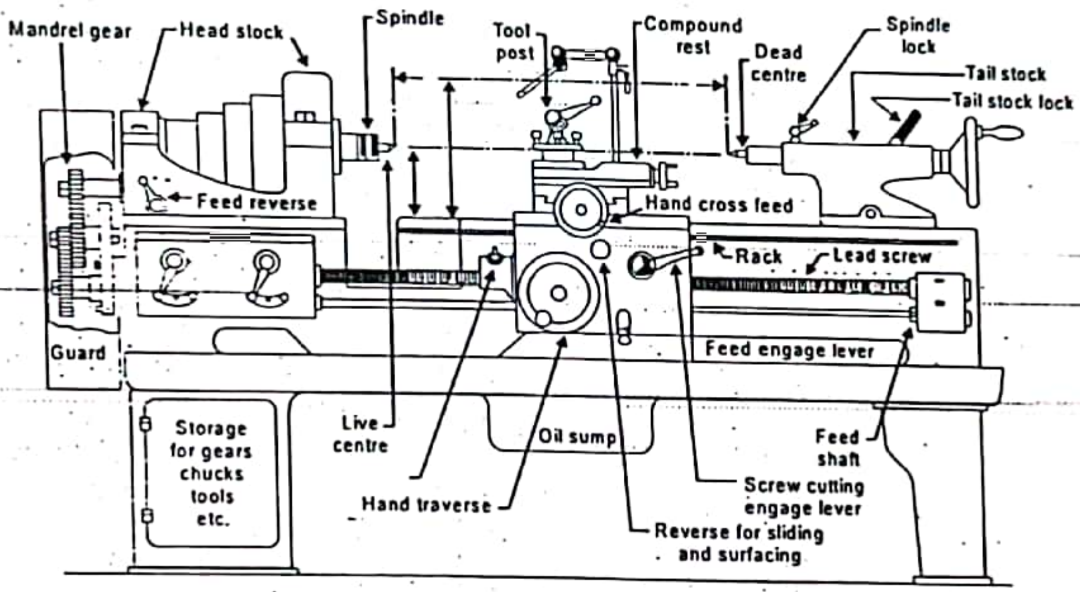


Fig. 21.3 Different parts of engine lathe or central lathe

21.3.1 Bed

The bed of a lathe machine is the base on which all other parts of lathe are mounted. It is massive and rigid single piece casting made to support other active parts of lathe. 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. Generally cast iron alloyed with nickel and chromium material is used for manufacturing of the lathe bed.

21.3.2 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. The cone pulley is also attached with this arrangement, which is used to get various spindle speed through electric motor. The back gear arrangement is used for obtaining a wide range of slower speeds. Some gears called change wheels are used to produce different velocity ratio required for thread cutting.

21.3.3 Tail Stock

Fig. 21.4 shows the tail stock of central lathe, which is commonly used for the objective of primarily giving an outer bearing and support the circular job being turned on centers. Tail stock 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. Both live and dead centers have 60° conical points to fit centre holes in the circular job, the other end tapering to allow for good fitting into the spindles. 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.

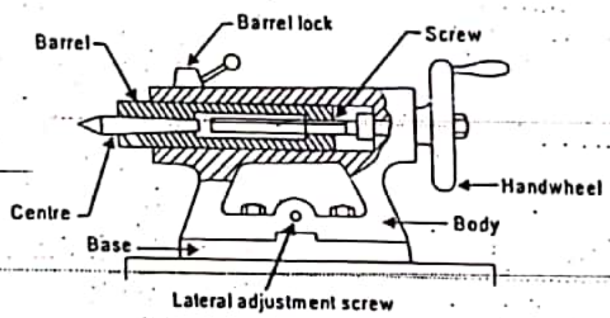


Fig. 21.4 Tail stock of central lathe.

21.3.4 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. 21.5 shows the tool post of centre lathe.

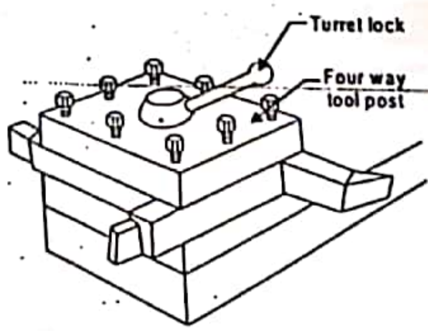


Fig. 21.5 Tool post of centre lathe

21.3.5 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-

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.

21.3.6 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.

21.4 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. 21.6. 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.

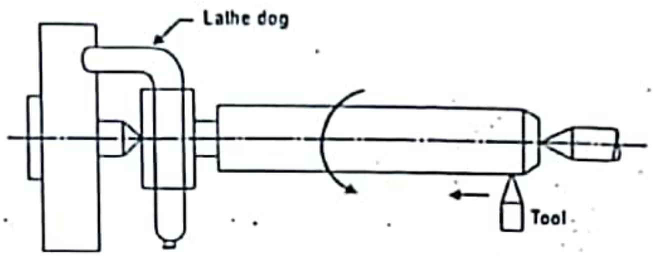


Fig. 21.6 Lathe dog

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, hollow 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 .

Rests

A rest is a lathe device, which supports a long slender job, when it is turned between centers or by a chuck, at some intermediate point to prevent bending of the job due to its own weight and vibration set up due to the cutting force that acts on it. The two types of rests commonly used for supporting a long job in an engine lathe are the steady or centre rest and the follower rest.

21.5 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. 21.7 illustrates the elements involved in specifications of a lathe. The following data also contributes to specify a common lathe machine.

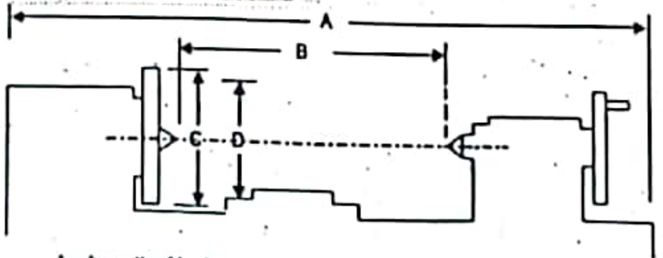


Fig. 21.7 Specifications of a lathe

(*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

21.5 SPECIFICATION OF LATHE

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

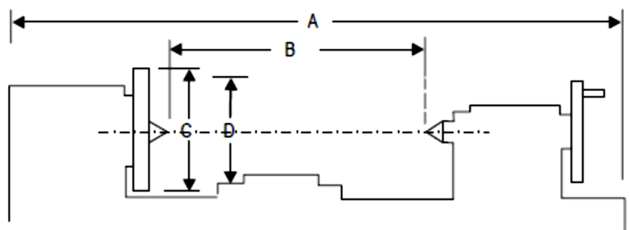
(*a*) Swing or maximum diameter that can be rotated over the bed ways

(*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. 21.7 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. 21.7 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

... shown in Fig. 26.17.

26·9 Lathe Operations

The most common operations which can be carried out on a lathe are facing, plain turning, step turning, taper turning, drilling, reaming, boring, undercutting, threading, and knurling. These operations are discussed as follows :

1. *Facing*. This operation is almost essential for all works. In this operation, as shown in Fig. 26.18, the workpiece is held in the chuck and the facing tool is fed from the centre of the workpiece towards the outer surface or from the outer surface to the centre, with the help of a cross-slide.

2. *Plain turning*. It is an operation of removing excess amount of material from the surface of the cylindrical workpiece. In this operation, as shown in Fig. 26.19, the work is held either in the chuck or between centres and the longitudinal feed is given to the tool either by hand or power.

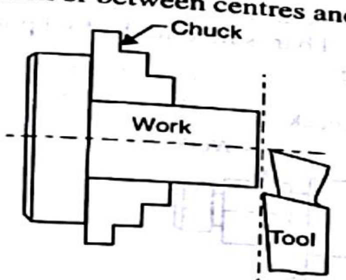


Fig. 26.18. Facing.

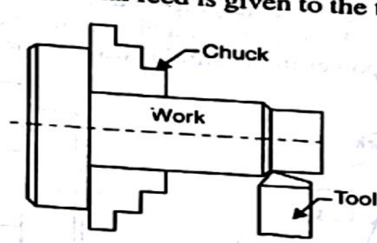


Fig. 26.19. Plain turning.

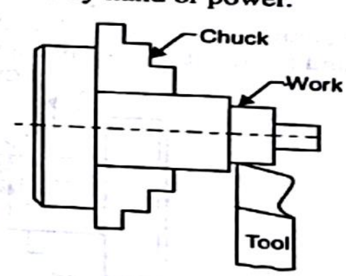


Fig. 26.20. Step turning.

3. *Step turning*. It is an operation of producing various steps of different diameters in the workpiece, as shown in Fig. 26.20. This operation is carried out in the ...

4. ...

Fig. 26.18. Facing.

Fig. 26.19. Plain turning.

Fig. 26.20. Step turning.

3. *Step turning*. It is an operation of producing various steps of different diameters in the workpiece, as shown in Fig. 26.20. This operation is carried out in the similar way as plain turning.

4. *Taper turning*. It is an operation of producing an external conical surface on a workpiece. A small taper may be produced with the help of a forming tool or chamfering tool, but the larger tapers are produced by swivelling the compound rest, as shown in Fig. 26.21, at the required angle or by offsetting the tailstock or by taper turning attachment.

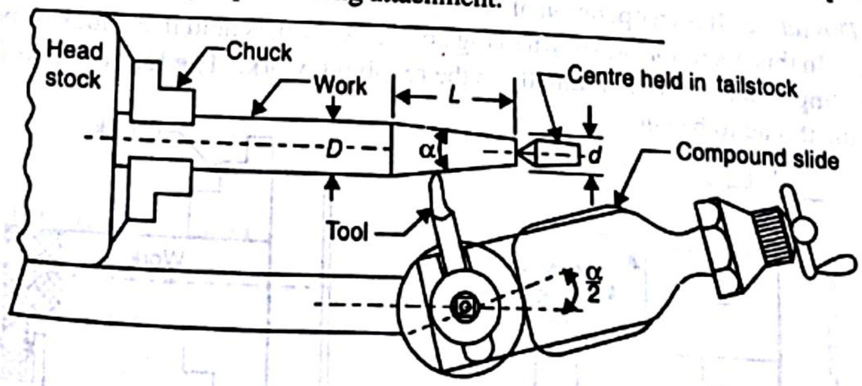


Fig. 26.21. Taper turning.

Note. If D is the larger diameter, d is the smaller diameter and L is the length of taper, as shown in Fig. 26.21, then

$$\text{Taper} = \frac{D-d}{L}$$

5. *Drilling*. It is an operation of making a hole in a workpiece with the help of a drill. In this operation, as shown in Fig. 26.22, the workpiece is held in a chuck and the drill is held in the tailstock. The drill is fed manually, into the rotating workpiece, by rotating the tailstock hand wheel.

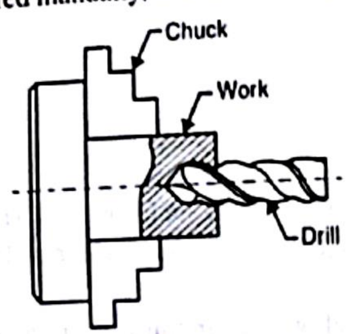


Fig. 26.22. Drilling.

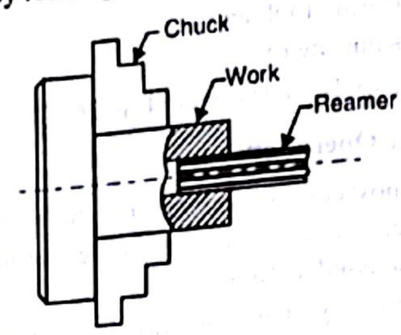


Fig. 26.23. Reaming.

6. *Reaming*. It is an operation of finishing the previously drilled hole. In this operation, as shown in Fig. 26.23, a reamer is held in the tailstock and it is fed into the hole in the similar way as for drilling.

7. *Boring*. It is an operation of enlarging of a hole already made in a workpiece. In this operation, as shown in Fig. 26.24, a boring tool or a bit mounted on a rigid bar is held in the tool post and fed into the work by hand or power in the similar way as for turning.

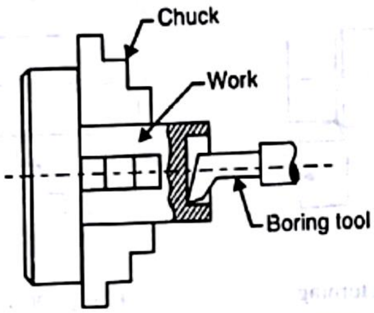


Fig. 26.24. Boring.

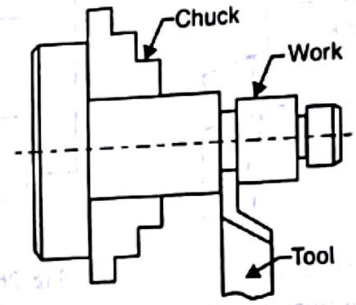


Fig. 26.25. Undercutting.

8. *Undercutting or Grooving.* It is an operation of reducing the diameter of a workpiece over a very narrow surface. In this operation, as shown in Fig. 26.25, a tool of appropriate shape is fed into the revolving work upto the desired depth at right angles to the centre line of the workpiece.

9. *Threading.* It is an operation of cutting helical grooves on the external cylindrical surface of workpiece. In this operation, as shown in Fig 26.26, the work is held in a chuck or between centres and the threading tool is fed longitudinally to the revolving work. The longitudinal feed is equal to the pitch of the thread to be cut.

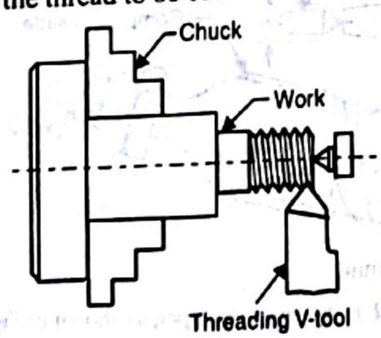


Fig. 26.26. Threading.

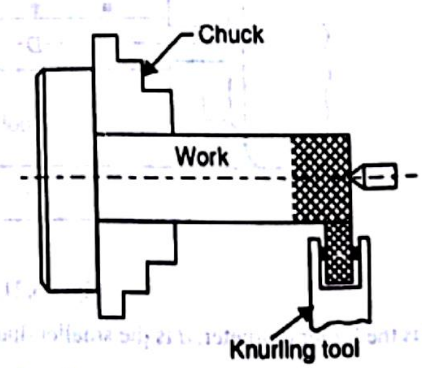


Fig. 26.27. Knurling.

10. *Knurling.* It is an operation of providing knurled surface on the workpiece. In this operation, as shown in Fig. 26.27, a knurled tool is moved longitudinally to a revolving workpiece surface. The projections on the knurled tool reproduce depressions on the work surface.

26·10 Terms Used in Lathe Machining

The following terms are commonly used while machining a workpice on lathe.

1. *Cutting speed.* It is defined as the speed at which the metal is removed by the tool from the workpiece. In other words, it is the peripheral speed of the work past the cutting tool. It is usually expressed in metres per minute.

2. *Feed.* It is defined as the distance which the tool advances for each revolution of the work. It is usually expressed in millimetres.

3. *Depth of cut.* It is defined as the depth of penetration of the tool into the workpiece during machining. In other words, it is the perpendicular distance measured from the machined surface to the unmachined surface of the workpiece. It is usually expressed in millimetres.

3.27 FORMING

Forming is the process of turning a convex, concave or of any irregular shape. Form-turning may be accomplished by the following methods:

1. Using a forming tool.
2. Combining cross land longitudinal feed.
3. Tracing or copying a template.

For turning a small length of formed surface, a forming tool having cutting edges conforming to the shape required is fed straight into the work. Forming tools are not supposed to remove much of the material and is used mainly for finishing formed surfaces. Usually two types of forming tools are used -- straight and circular. Straight type is used for wider surfaces and the circular type for narrower surfaces. Fig.3.64 illustrates forming operations performed by straight or circular tools. The cross feed ranges from 0.01 to 0.08 mm per revolution and the cutting speed is slightly less than that of the straight turning.

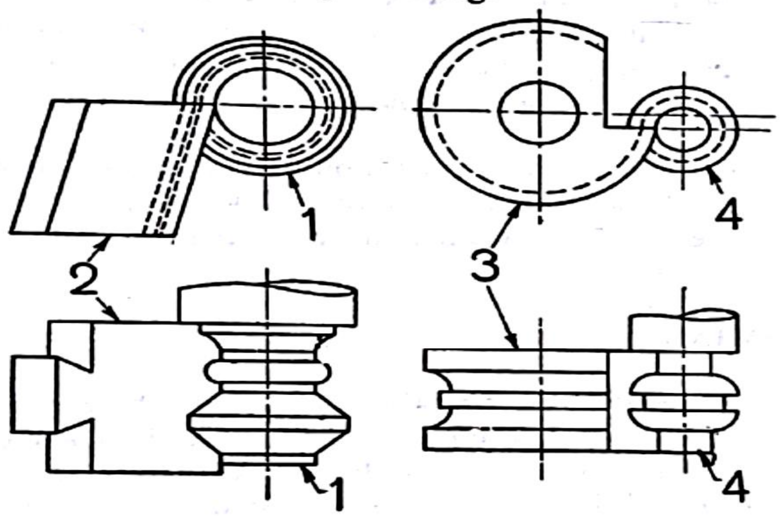


Figure 3.64 Forming operation
1. Work, 2. Straight forming tool, 3. Circular forming tool.

When the length of the formed surface is sufficiently great, the required shape may be obtained by using straight turning tool, which is fed into the work using both longitudinal and crossfeed simultaneously by hand. The process is tedious and requires much skill.

When a large number of wide, formed surfaces are to be turned, a template having the required shape is attached to the rear end of the lathe bed and the crossslide is attached to the guide block after disengaging the crossslide screw. With the longitudinal travel of the carriage, the tool will reproduce the contoured surface of the template as the guide block will trace the curved path.

Counterboring : Counterboring is the operation of enlarging a hole through a certain distance from one end instead of enlarging the whole drilled surface. It is similar to a shoulder work in external turning. The operation is similar to boring and a plain boring tool or a counterbore may be used.

3.31 INTERNAL THREAD CUTTING

The principle of cutting internal threads shown in Fig.3.66 is similar to that of an external thread, the only difference being in the tool used. The tool is similar to a boring tool with cutting edges ground to the shape conforming

to the type of the thread to be cut. The hole is first bored to the root diameter of the thread. For cutting metric thread, the compound slide is swiveled 30° towards the headstock. The tool is fixed on the tool post or on the boring bar after setting it at right angles to the lathe axis, using a thread gauge. The use of thread gauge is illustrated in Fig.3.67. The depth of cut is given by the compound slide and the thread is finished in the usual manner.

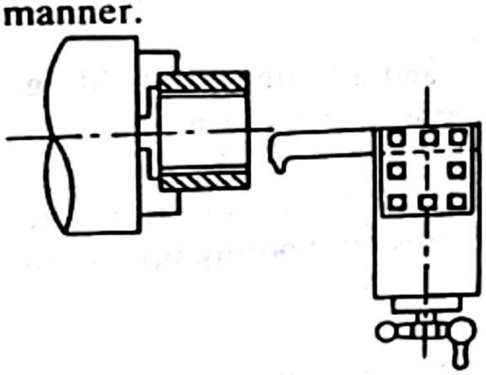


Figure 3.66 Internal thread cutting operation

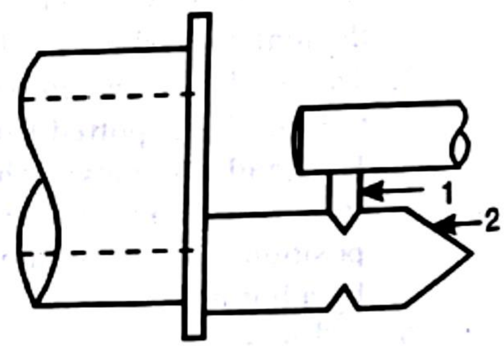


Figure 3.67 Use of thread tool gauge for internal thread cutting
1. Internal thread cutting tool,
2. Thread tool gauge.