# UNIT 7 MACHINE TOOLS

## Structure



## 7.1 INTRODUCTION

From the very beginning of human race, man has been struggling for getting the objects round in shape and finally the stage came when wheel was invented. Since then continuous efforts have been made to evolve improved methods of manufacturing the cylindrical objects like a wheel, a shaft and other cylindrical objects which are needed by the world of technology for catering to the human needs. In the year 1797, Henry Maudslay, an Englishman, designed the first screw cutting engine lathe which is the force runner of the present day high speed, heavy duty production lathe, a machine tool which has practically given shape to our present day civilization by building machines and industries. The world of lathe has been making revolutionary advancements. Today we have low production lathe on one extreme and CNC (Computerized Numerically Controlled) like sophisticated lathes on the other side of the spectrum.

### Objectives

After studying this unit, you should be able to

- explain the function and specifications of lathe,
- describe the different parts of lathe and their functions,
- classify the types of lathe,

- distinguish between lathe accessories and attachments,
- describe the lathe operations,
- explain the types and geometry of cutting tool, and
- define the terms cutting speed, feed, depth of cut and machining time.

## 7.2 FUNCTION OF LATHE

Lathe is a machine tool which causes workpiece to revolve so that when cutting tool comes in contact with the workpiece it removes the metal in the form of chips. Workpiece can be held securely and rigidly on the machine tool between centres or by means of chuck. To cut the material easily the cutting tool should be harder than the material of workpiece. It should be rigidly held on the machine or should be fed in a definite way relative to the workpiece.

Arrangements for setting the direction of tool advancement and its rigid holding, are already provided on lathe machine.

## 7.3 TYPES OF LATHE

There are varieties of lathes and their design depends on the type of production and the nature of work. But all of them employ the same fundamental principle of operations and perform the same function. The lathe, which are widely used, may be classified and described below.

(a) Centre or engine lathe,

(b) Bench lathe,

(c) Tool room lathe,

(d) Speed lathe,

(e) Capstan and turret lathe,

(f) Special purpose lathe,

(g) Automatic lathe.

**Centre or Engine Lathe**

It is a common and general purpose lathe. As the workpiece can be held between two centres, it is denoted as centre lathe. The term **engine** is associated with the lathe owing to the fact that early lathes were driven by steam engines. But now-a-days all the centre lathes are driven by electric motor. Being easy to operate and simple in design, it is widely used for training purpose also.

**Bench Lathe**

These are normally set on benches and, therefore, are called bench lathe. It has the same features as centre lathe, but differs from this lathe only in size and mounting. It performs all the operations like centre or speed lathe but being smaller in size, mostly used for small and precision work.

**Tool Room Lathe**

A tool room lathe looks like a centre lathe but is built more accurately and has a wide range of a spindle speed from a very low to a high speed up to 2500 rpm and is equipped with many other extra accessories such as taper turning attachment, steady and follower rest, thread chasing dial, draw in collect attachment and coolant pump etc. It is specially used for precision work on tools, gauges, dies and in machining work where accuracy is the main consideration. Tool room lathe of same size is costlier than centre or engine lathe.

**Speed Lathe**

It is the simplest of all lathes and consists of a bed, a head stock, a tail stock and an adjustable slide (tool rest) for supporting the tool. Usually, speed lathe is driven by a variable speed electric motor which is fitted with head stock. Because hand tools are used and the cuts are light, the lathe is driven at high speed. The work is held between centres or attached to a face plate on the head stock. The speed lathe is commonly used in wood turning, metal spinning, centering for metal cylinders and polishing etc. The head stock construction is very simple and only two or three spindle speeds are available. Light cuts and high speeds necessitate the use of this machine where cutting force is minimum. The speed lathe has been so named because of the very high speed of the headstock spindle.

**Capstan and Turret Lathe**

These lathes are a major departure from centre or basic lathes and are used for production work. The distinguishing feature of these types of lathe is that the tail stock of a centre lathe is replaced by a circular turret (for capstan) and square or hexagonal turret (for turret). The principal characteristics of this type of lathes is that the tools for consecutive operations can be set up in readiness for doing operations in proper sequence.

The advantage is that many different types of operation can be done on a workpiece without resetting of work or tools and a number of identical parts can be produced in the minimum time with less skill, although skill is required only to set and adjust the tools properly.

The turret is mounted on either the sliding ram or the saddle which carries the tools for the various operations. The tools are mounted in proper sequence on the various faces of the turret, so that as it indexes around between operations, the proper tools are brought into position. For each tool there is a stop screw that controls the distance, the tool will feed. When this distance is reached, an automatic trip lever stops further movement of the tool by disengaging the drive clutch. In capstan lathe, only round bar shape of metallic piece is used as a raw material whereas for turret lathe it may be of any shape.

**Special Purpose Lathe**

As the name indicates, they are used for special purposes and for jobs which cannot be easily machined on standard type of lathe. The duplicating type of special purpose lathe is one for duplicating the shape of a flat or round template onto the workpiece. Devices operated by air, mechanically or by using hydraulic system, are used to coordinate the right movements of the tool to reproduce exactly the shape of template. The wheel lathe is made for machining the journals and turning the thread on rail road car and locomotive wheels. The gap bed lathe, in which a section of the bed adjacent to the head stock is recoverable, is used to swing extra large diameter pieces.

**Automatic Lathe**

Lathes that have their tools automatically fed to the work and withdrawn after performing the cycle of all desired operations are known as automatic lathes. They are semi-automatic or fully automatic types. In semi-automatic, operator holds the part to be machined in the lathe and finally removes it in finished shape. Lathes that are fully automatic are provided with a megazine feed so that a number of parts can be machined, one after the other, with little attention from the operator. An operator who has to look after five or six automatic lathes at a time will simply look after the general maintenance of the machine and cutting tool, load up a bar stock and remove finished products from time to time.

### 7.3.1 Size or Specification of a Lathe

The size or specifications of a lathe is expressed according to

(a) Swing,

(b) Admits between centres,

(c) Length of bed, and

(d) Height of centres.

**Swing**

It is defined with respect to both bed and carriage. In respect of bed it is denoted as "maximum diameter of job that can be revolved over the bed in the presence of gap or without gap", whereas for carriage "maximum diameter of job that can be revolved over the carriage without touching it".

**Admits between Centres**

Means maximum possible distance that can be arranged between two centres (live and dead centres).

**Length of Bed**

It indicates the approximate floor space occupied by the lathe.

**Height of Centres**

It is measured from the lathe bed.

### 7.3.2 Description and Function of Lathe Parts

A lathe consists of the following main parts as shown in Figure 7.1

(a) Bed, Body or Frame

(b) Head Stock

(c) Tail Stock

(d) Carriage

**Bed, Body or Frame**

The lathe bed with body or frame forms the base of the machine. The tail stock and the head stock are located at both ends of the bed. A carriage rests slides over this bed. Bed shows the main guiding member of the tool. It should be rigid, resistant to wear and tear, capable to absorb vibration and shocks etc. Mostly, beds are made of cast iron alloyed with nickel and chromium. Many lathes are made with a gap in the bed. This gap is used to swing extra large diameter pieces.

**Head Stock**

It is secured permanently at the left hand end of lathe bed. It provides the mechanism of rotating the work at multiple speed along with driving and altering the spindle speed. All the parts related with feed mechanism are housed with the head stock. A hollow spindle is fitted in the bore of head stock. The front end of spindle hole has a standard morse taper. Therefore line centre is fitted into this hole with the help of taper sleeve.

**Tail Stock**

This part is located at the right hand end of the bed. It carries two functions :

(a) It supports the other end of the work when the workpiece is held between centre to centre.

(b) It can hold the tool for performing operations such as drilling, tapping and reaming etc.

Its body is made of cast iron which consists of Base and Top. Base is fixed on the bed and the top part is fitted on the base. The base can be moved along the bed ways. The top part can be adjusted sideways on both sides while off setting the centre for taper turning between centres. Spindle of tail stock is hollow shaft having a taper bore in front to suit the shanks of centres or drills etc. It has a clamping lever which tightens the spindle.

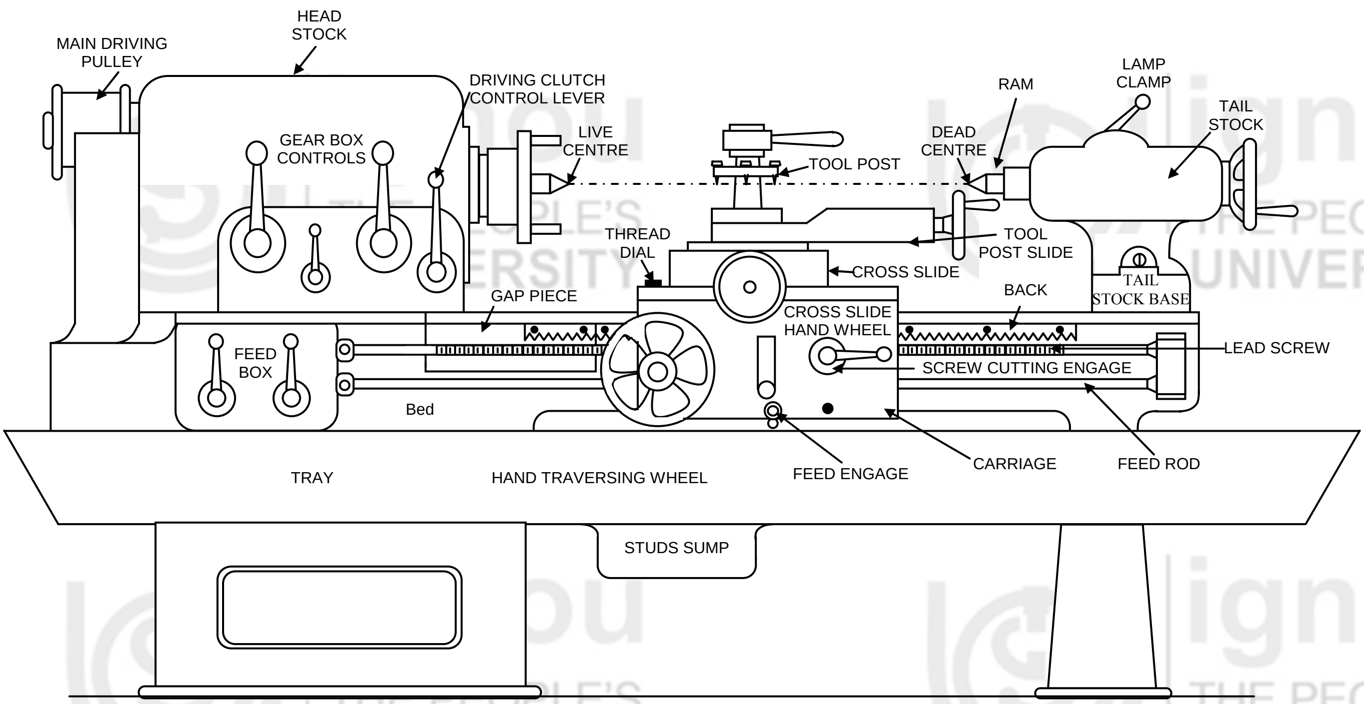



**Figure 7.1 : Different Parts of Lathe**

**Carriage**

The carriage has the following five parts which may be traversed along the bedways by hand or by power.

(a) Tool Post

(b) Compound Rest

(c) Cross Slide

(d) Saddle

(e) Apron

*Tool Post*

It is seated on the top of the compound rest for fixing the tool or the tool holder.

*Compound Rest*

It is mounted on the cross slide. It has a graduated circular disc which is termed as swivel disc. As compound rest is provided with a swiveling adjustment therefore it can be placed in various angle positions for short taper turning.

*Cross Slide*

It is mounted on the saddle and moves crosswise the bed by hand or by means of power feed. Operations such as grooving, parting off and facing are performed by means of cross slide.

*Saddle*

It is the part of carriage which slides along the bed ways and supports the tool post, cross slide and compound rest.

*Apron*

It is a rectangular shape of box which is suspended towards lead screw below the saddle. It has a gear train inside and a half nut. The feed lever and feed clutch are also housed in it. In other words, we can say that the apron contains the mechanism of controlling tool feeds and threading process.

**SAQ 1**

(a) Describe the function of lathe. What are the main parts of a lathe?

(b) How is the size of a lathe specified? What are the different types of lathe?

## 7.4 LATHE ACCESSORIES AND ATTACHMENTS

Devices which are used for job or tool holding purposes on lathe are known as lathe accessories whereas attachments of a lathe include additional equipments that are often used for doing specific work on a lathe. The attachments are used to increase the production and efficiency of the lathe.

### 7.4.1 List of Accessories and Attachments

Main accessories and attachments which are generally used are as follows :

**List of Accessories**

(a) Lathe Centres,

(b) Face Plate

(c) Driving Plate,

(d) Dog Carrier,

(e) Chucks,

(f) Angle Plate,

(g) Mandrels,

(h) Steady Rest,

(i) Follower Rest.

**List of Attachments**

(a) Taper Turning Attachment,

(b) Thread Chasing Dial,

(c) Grinding Attachment,

(d) Milling or Gear Cutting Attachment,

(e) Copying Attachment,

(f) Relieving Attachment.

## 7.4.2 General Description of Main Accessories and Attachments

### Lathe Centres

It is an important accessory. Its main function is to support the job. Figure 7.2 shows the different parts of a centre.

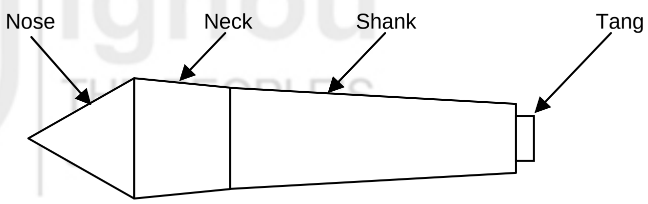



**Figure 7.2**

Nose or point is the front pointed portion having an angle of $60^o$. Its point is hardened and sharped if it is dead centre but for live centre it is only sharped not hardened.

Neck is the plain portion from the taper of nose.

Shank is the tapered portion after neck. It fits in the taper hole of spindle of head stock or tail stock. Tang is the parallel step after shank. It saves the shank when it is taken out of the spindle by hitting.

Generally, centres are made of high carbon steel and may be classified as plain centres, pipe centres, half centre, tipped centres and revolving centres. These are described below :

***Plain Centres***

Plain centres are of two types :

*Live Centre*

Live centre is one which is fitted in the head stock. It always rotates with the work, having $60^o$ nose angle.

*Dead Centre*

Dead centre is always fitted in the tail stock. It is hardened at nose which contains $60^o$ angle. As its name indicates, it remains in fixed position during machining operation therefore, it is subjected to friction. To reduce this friction it should always be lubricated with grease.

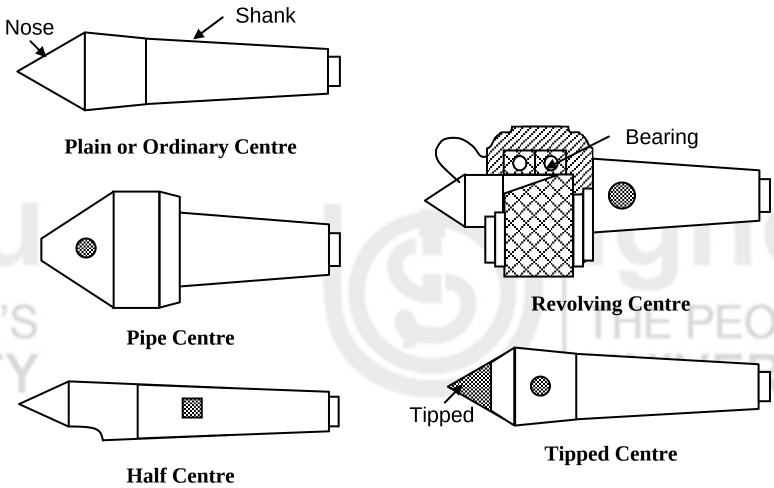



**Figure 7.3 : Types of Lathe Centre**

***Pipe Centres***

Pipe centres, having the nose angle about $90^o$, are used to support the pipes.

***Half Centres***

Half centre has its importance when tail stock side end is to be faced. As shown in Figure 7.3, about half conical portion of nose is removed so that the cutting tool can be approached conveniently upto the centre of cylindrical surface or in other words we can say that the whole cylindrical surface of end may be faced.

***Tipped Centres***

Tipped centre is specially used when the work is to be turned at high speed or the material is very hard.

***Revolving Centres***

Revolving centre consists of ball bearing which helps the centre to rotate with the job at tail stock side. It is preferred where machining work is done at high speed.

## Face Plate

It is a circular disc of cast iron. It has hole in the centre which is threaded to be screwed on the nose of the lathe spindle. It has number of holes and slots on its face. Slots are made to hold irregular or typical types of job as shown in Figure 7.4.

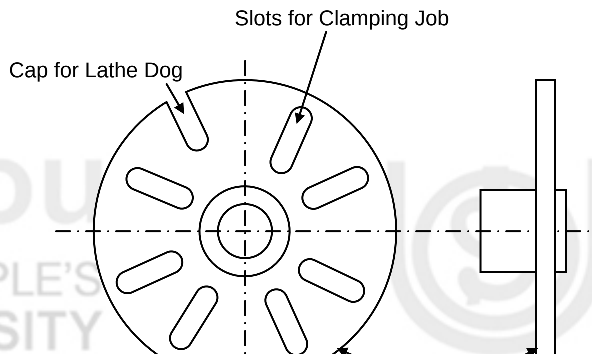
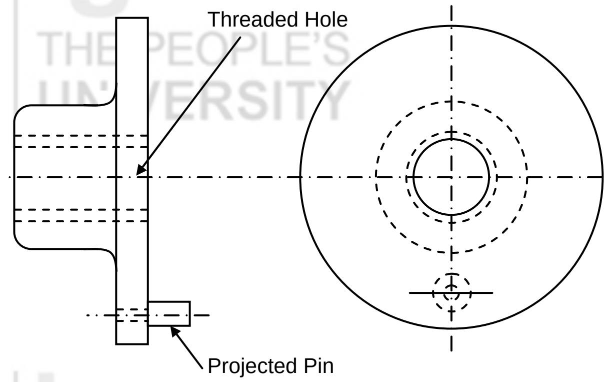


**Figure 7.4 : Face Plate**

## Driving Plate

It is also a circular disc of cast iron (Figure 7.5) which has a boss having internal threads to be screwed on the nose of the spindle. It has a hole which accommodate a pin to engage the straight tail of dog carrier. When bent tail type dog carrier is used, this pin is taken out and the bent portion of the tail is inserted in the hole.




**Side View** **Front View**

**Figure 7.5 : Driving Plate**

## Dog Carrier

Dog carrier is used when job is held between centres for machining purpose. The use of dog carrier along with driving plate is shown in Figure 7.6.

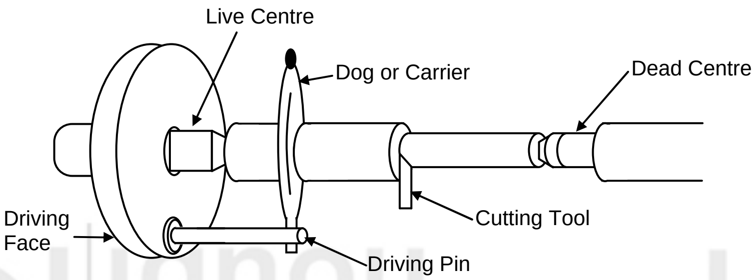



**Figure 7.6**

## Chuck

It is a vice which can be screwed on threaded portion on spindle nose. Live centre is taken out from head stock spindle while using a chuck. Chuck provides an efficient and true device for holding the work on lathe machines. There are a great variety of chucks. The most common types are discussed as under :

*Independent or Four Jaw Chuck*

This type of chuck has four jaws and each jaw is independently actuated and adjusted by a key for holding the job. Almost all types of job, e.g. cylindrical, square or irregular shapes can be held in this chuck (Figure 7.7).

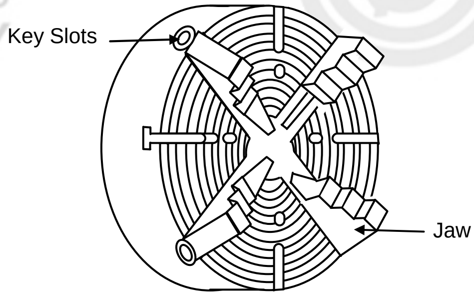



**Figure 7.7**

*Self Centring or Three Jaw Universal Chuck*

In this chuck, all the three jaws move in or out position simultaneously by turning the key in key slot and thus the workpiece may be automatically held in the centre. The movement of key rotates the scroll disc through the bevel pinion (Figure 7.8). The jaws are fitted on the scroll disc. The rotation of scroll gives the jaws a linear motion in the direction either away from centre or towards the centre.

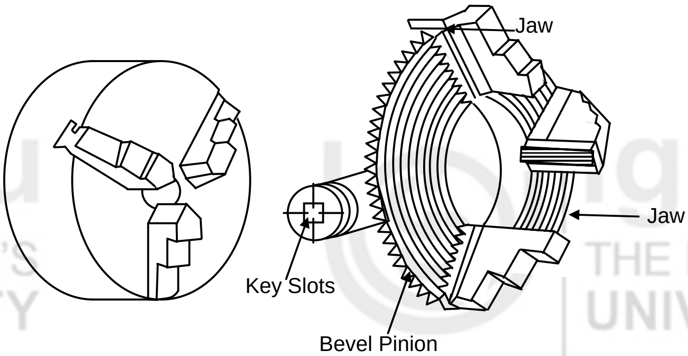



**Figure 7.8**

### Angle Plate

It is used for holding the work on the face plate. When the work is such that it cannot be mounted directly on the face plate, the angle plate holds the work and it is mounted on the face plate.

### Mandrels

Mandrel is a hardened piece of round mild steel bar used for holding the hollow section parts of cylindrical shapes on the lathe with the purpose of turning outside surface of work. It is necessary that the hole in the workpiece must be concentric with the outer surface. Parts like gear blanks, pulleys and bushed etc. are turned with the help of mandrels.

### Steady Rest

It is used in turning for long jobs. There is a possibility of its bending or springing away from the tool. The result will be that the job will not be turned in true shape. To prevent this the job surface on tail stock side is supported by steady rest. It support to work on three jaws and thereby avoiding the chances of workpiece deflection. Steady rest is fitted on the bed in place of tail stock (Figure 7.9).

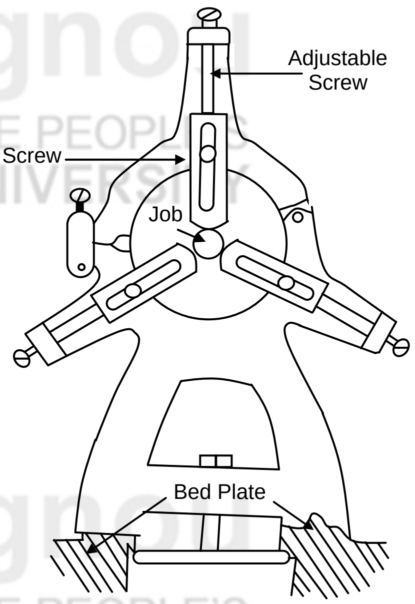



**Figure 7.9**

## Follower Rest

It is also known as traveling rest. While turning a long and thin cylindrical piece between centres, the follower rest is used to prevent the workpiece from being turned out of line due to the pressure of the cutting tool (Figure 7.10). Being connected with the carriage it travels with the cutting tool. It consists of two jaws only. During machining time, cutting tool acts as a third jaw also and itself given the support to the job.

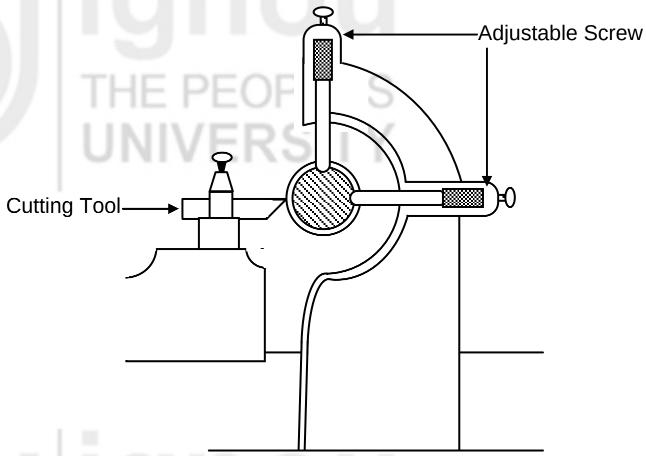



**Figure 7.10**

## Taper Turning Attachment

In this method, the workpiece rotates around the bed axis and the cutting tool moves at an angle. Generally, lathes are equipped with taper turning attachment for machining external and internal type of taper turning.

A taper turning attachment is in the form of a guide which is graduated and bolted to the back of lathe.

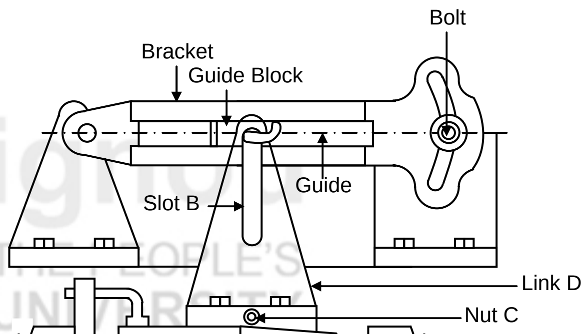


**Figure 7.11**

It is adjusted to any desired angle with the axis of lathe. As the carriage moves along the lathe bed, a slide over the bar causes the tool to move in or out according to the setting of the bar. Thus the taper setting of the bar is duplicated on the work.

In Figure (7.11), a bracket is attached to the lathe bed. It carries a guide bar that can be swivelled to the required angle. The guide bar is clamped in set position by bolt. Guide block is connected to the lathe cross slide by link and lock. It is free to slide along the guide bar. To allow the cross slide to travel freely on its ways it must be disconnected from saddle by loosening the cross feed screw nut which will disengage the cross slide on longitudinal feed of the saddle. Guide block will slide along guide bar. The guide block is linked to the cross slide, so it will travel with the tool in direction of guide bar. After each cut, the tool is fed in the depth of cut by rotating handle of compound rest which should be positioned at right angle to its normal position. The guide bar should be set parallel with the taper on which the tool is applied. The guide bar is swivelled to the desired taper angle.

The angle for swivelling the guide bar can be determined by the given formula

$$\tan \alpha = \frac{D - d}{2l}$$

where $D$ = major diameter in mm,

$d$ = minor diameter in mm, and

$l$ = length of taper in mm.

## Thread Chasing Dial

During threads cutting operation, we have to take several cut. For this the threading tool has to be withdrawn from the thread on completion of each cut and again brought to the starting position. Then, the tool must follow the previously cut thread otherwise the threads will be spoiled (Figure 7.12).

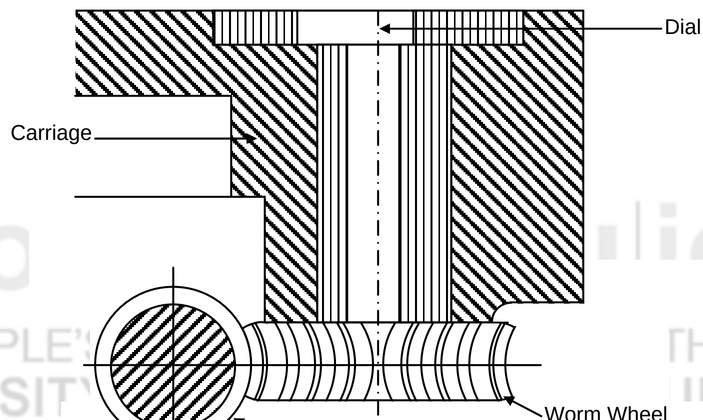


**Figure 7.12 : Thread Chasing Dial**

The chasing dial overcomes the difficulty of catching the threads at exact position of start. It consists of a graduated dial which is connected to a worm wheel. The worm wheel is in mesh with the lead screw, so that if the saddle is stationary, the lead screw acts as a worm and rotates the chasing dial. When half nut is engaged, the tool starts travelling but the dial remains stationary with one of the graduation opposite the arrow. When the cut is completed, the saddle is returned back to the starting point. Practically, in disengage position of nut the dial remains always in rotating position. When the graduated line comes opposite the arrow, the nut can be engaged and the tool will follow its original cut.

### Grinding Attachment

It consists of a bracket, grinding wheel and an electric motor. Grinding attachment mounted on the compound rest in place of tool posts. For grinding purpose, the job is held either in a chuck or between centres. It can grind hardened work also and ensures a fine finish.

### Milling or Gear Cutting Attachment

It consists of a vertical pillar to which a horizontal arbor is attached which can be indexed to required degrees and the job is mounted on this arbor. The milling cutter is mounted on another arbor which is held between centres. The gear cutting is done by rotating cutter at the bottom of the gear blank. Cross slide moves the job against rotating cutter. Indexing of the gear is formed by a dividing head or indexing head attached with the job holding arbor. The entire attachment is mounted on the cross slide.

### Copying Attachment

This is also known as tracer attachment. Pneumatic or hydraulic types of copying attachment are generally used. In hydraulic type, it consists of an auxiliary slide which is fitted on the cross-slide of the lathe. A piston and cylinder is fitted on the rear end of slide which is operated by hydraulic pressure. An bent overarm is already attached to it and the free end of this arm works as tracer. The tracer end of the arm moves along the profile of desired shape while the other end is guided by the tracer end. The other end operates an air nozzle which operates Hydraulic mechanism and this mechanism controls the movement of tool. The tool practically copies the same shape as needed by the tracer arm.

### Relieving Attachment

Relieving process is generally done on the taps, reamers and milling cutters etc. For this process, relieving attachment is used. It consists of an auxiliary slide mounted on the cross slide in place of compound rest. The tool post is mounted on this auxiliary slide. A cam rotates under the relieving slide which guides the tool in and out.

**SAQ 2**

(a) Make a list of different accessories and attachments used with lathe.

(b) Differentiate between dead centre, live centre and revolving center.

(c) What are the different methods for taper turning operation? Explain any one in brief.

(d) What are the different types of jaw used in lathe machines?

## 7.5 LATHE OPERATIONS

A standard machine is that which is able to deal with a variety of work and a wide range of operations can be performed on it. Special purpose machine is that which has been designed for specific purpose and only performs one or limited range of operations.

A centre lathe is an example of standard lathe because on this machine we can perform the following operations :

(a) Turning

(b) Facing

(c) Parting off

(d) Knurling

(e) Thread cutting

(f) Grooving

(g) Drilling

(h) Boring

(i) Reaming

These operations are described below in detail.

**Turning**

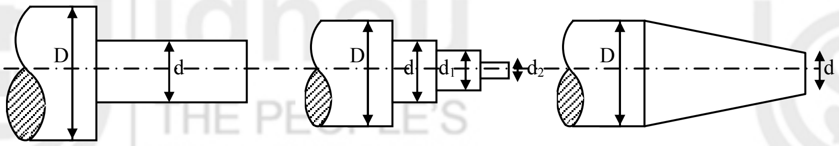
It is the removal of material from the outside diameter of a cylindrical job to obtain one or more finished diameter. Usually, there are three types of turning which are given below :

(a) Plain or straight or parallel turning.

(b) Stepped turning.

(c) Taper turning.

In plain turning machining is done in this way that after removal of material, finished diameter at both the ends of length remains equal. Turning operation where the entire length is divided in steps of different diameter but each step individually finished by using plain turning is known as stepped turning. Taper turning is the operation in which the material is removed from the job to produce a conical shape. All the three types of turning are shown in Figure 7.13.




Plain Turning  Stepped Turning  Taper Turning

**Figure 7.13**

## Plain Turning and Stepped Turning

In plain turning, the workpiece is turned straight throughout the entire length when it is made to rotate about the lathe axis, and the cutting tool is fed along the lathe axis. The plain or straight turning produces a cylindrical surface after machining.

In stepped turning, the workpiece is turned in such a way that throughout the turning length it forms the steps of different diameters.

After facing and centering at both ends faces, the job is mounted between the centres using a dog carrier attached to the workpiece, the bent tail of dog carrier is fitted into the slot provided on the driven plate. If the workpiece is mounted on a chuck, care should be taken to centre it accurately with the lathe axis. The trueness of the workpiece held on a chuck is tested by holding a scriber or a dial indicator against the rotating workpiece. Turning tool is clamped on the tool post by keeping its cutting edge approximately at the lathe axis or slightly above it.

## Taper Turning

Generally, the following methods are used for taper turning :

(a) By swivelling compound rest

(b) By setting over the tail stock

(c) By taper turning attachment

(d) By forming or broad-nose tool

*By Swivelling Compound Rest*

This method is used to produce short or steep tapers. The principle of this compound rest is that axis of workpiece rotates parallel to the bed axis and the cutting tool moves at the desired angle where the compound rest is already swivelled.

Let the swivelled angle of compound rest with lathe axis is ‘θ’. ‘*L*’ shows the length, on which taper turning takes place. We can calculate the swivelled angle of compound rest in respect of lathe axis by following formula :

$$\tan \theta = \frac{D - d}{2L}$$

where ‘*D*’ and ‘*d*’ are the larger and smaller diameters respectively.

*By Setting Over the Tail Stock*

Long tapers may be turned by holding the workpiece between centres by moving the tail stock to one side of lathe axis. In this method, the axis of revolving job makes an angle with lathe axis while the cutting tool moves parallel to the lathe axis. The tail stock is off-setted in terms of mm. If the tail stock is set-over towards the operator, the taper will be turned in which the larger diameter will be on the head stock side. If the tail stock is set over away from the operator, it will turn a taper with its larger diameter on tail stock side. The tail stock set over can be calculated by the formula;

$$\text{Off set in mm} = \frac{D - d}{2l} \times L$$

where $D$ = major diameter in mm,

$d$ = minor diameter in mm,

$l$ = taper length in mm, and

$L$ = full length of job in mm.

*By Taper Turning Attachment*

Long tapers are more easily and accurately turned by using the taper turning attachment which is already discussed in this unit.

*By Forming Tool*

It is also denoted as "Broad nose tool" taper turning method. Short external types of taper can be turned with a form tool. In this particular method, both holding of job as well as feed of tool are parallel to the lathe axis and the taper is given directly by the cutting edge of cutting tool which is formed in inclined shape as per desired taper angle.

## Facing

It is the machining of the ends of a workpiece to make the ends smooth. For this operation, the cutting tool is fed perpendicular to the lathe or workpiece axis by means of cross slide.

## Parting Off

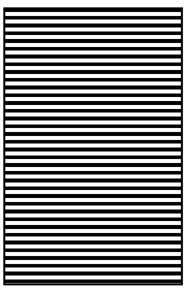
This operation involves cutting the work-metal into two parts by using parting off tool. Feed to the cutting tool is given in same manner as in case of facing operation.

## Knurling

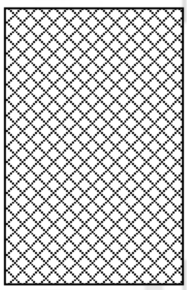
It is the process of producing rough surface of embossing diamond shaped pattern on a smooth surface of a cylindrical job. Knurling provides an effective gripping surface on a job to prevent it from slipping when operated by hand. Knurling, as shown in Figure 7.14, may be of two types :

(a) straight or parallel, and

(b) diamond type.



Straight or Parallel Knurling



Diamond Knurling

**Figure 7.14 : Types of Knurling**

Knurling is done by means of knurling tool which consists of a set of hardened steel rollers. The teeth are cut on the steel rollers in different pattern. For knurling operation, the knurling tool is forced with the workpiece which is already arranged in revolving condition.

## Thread Cutting

In thread cutting operation, there is a certain ratio of motion between the travel of tool and the rotation of the spindle. This ratio is directly effected by the lead screw which is attached to the lathe spindle through gears.

General set up for thread cutting is shown in Figure 7.15. For cutting threads of different pitches, the stud (driver gear) and lead screw gear (driven gear) are changed as per desired ratio of revolution between the spindle and the lead screw. The ratio between the teeth on stud and lead screw gear can be calculated by the given formula,

$$\frac{\text{Nos of teeth on Driver (Stud)}}{\text{Nos of teeth on Driven (Lead screw)}}$$

$$= \frac{5}{127} \times \frac{\text{Lead of threads on job in mm}}{\text{Lead of thread on lead screw in inches}}$$

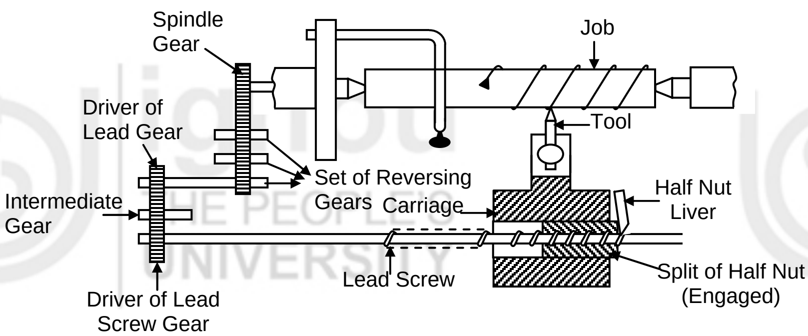



**Figure 7.15**

This formula is used when metric pitch is to be cut on a job by means of English standard lead screw (threads pitches in inches).

## Grooving

This operation is also denoted as necking. Usually, grooves are cut on a cylindrical surface in narrow shape by means of grooving tool. The cutting edge of grooving tool is kept narrow.

## Drilling

For making a standard size of hole in a workpiece by means of drill is known as drilling operation. For this operation, drill is held in tail stock spindle.

## Boring

Boring is the operation of enlarging a drilled hole by means of a boring tool. The boring tool is fitted on a boring bar which is held in tail stock spindle.

## Reaming

It is the operation of finishing a drilled hole to an accurate dimension with the help of reamer as a tool. The reamer is held on the tail stock spindle.

# 7.6 CUTTING TOOLS

A cutting tool, commonly known as tool bit, is a piece of steel or alloy usually similar to square in shape and is of various sizes and lengths. The material of cutting tool must be harder than the job material then only it can cut. It should be tough enough to withstand the forces encountered during cutting condition. The shape of cutting tool should allow the cutting edge to penetrate the workpiece in most efficient way.

## 7.6.1 Types of Cutting Tool

The cutting tool may be classified as under :

**According to the Purpose**

It may be defined as per name of operation such as turning, facing, threading, grooving and boring tools etc.

**According to the Direction of Travel**

Such as right hand and left hand tools.

**According to the Manufacturing Method**

As per manufacturing method, tools may be classified as forged type or tipped type. Forged types are those which are forged to the required shape from a high carbon steel or high speed steel blank. The tipped tools are tipped of high speed steel tips or connected carbide tips. These tips are brazed on low carbon steel shank or held in special tool holders.

## 7.6.2 Description of Cutting Tools

**Turning Tool**

Commonly two types of turning tool – Rough Turning Tool and Finish Turning Tools – are used. Rough tool is used to remove the maximum amount of metal in a minimum time while a finish turning tool is used to remove the very small amount of metal. Single-point turning tools are used in practice. The cutting angles of tools are so ground that it can solve the machining purpose.

**Thread Cutting Tool**

Threads are formed on a cylindrical surface by a single point thread cutting tool with its cutting edges ground to the shape and size of the thread to be cut. The shape of the tool is determined by the included angle at the nose of the tool which should correspond to the angle of the thread. The size or cross section of the cutting edges of the tool depends upon the pitch of thread.

**Facing Tool**

It removes metal by its side cutting angle edges. Therefore no top rake is necessary in a facing tool.

**Grooving Tool**

It is just similar to a parting off tool. The cutting edges may be formed square, '*V*' shaped or rounded according to the shape of groove to be cut.

**Chamfering Tool**

A plain turning tool may be used as a chamfering tool when the cutting edges are set at the angle of chamfer. Whenever a large number of chamfer works are to be cut, a special chamfering tool with its side cutting edges ground to the angle of chamfer is used.

**Parting Off Tool**

It is made as narrow as possible to remove minimum of metal. The width of cutting edge ranges from 3 to 12 mm only. The length of cutting edge which penetrates into the work should be slightly longer than the radius of workpiece being cut.

Various types of tool used on lathe machine are shown in Figure 7.16.

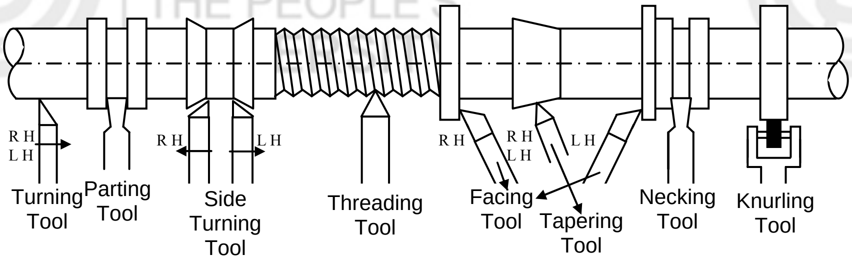



**Figure 7.16 : Tools Used on Lathe Machine**

## 7.6.3 Tool Geometry

A tool is ground to a given form to produce a cutting edge of a given shape in a given position in relation to the shank of tool, and to produce a form that will permit the cutting edge to be fed into the workpiece so that it may cut efficiently.

For proper grinding of the cutting tool, the cutting edge should keep its shape flat or curved as the case may be. For efficient cutting, the surface that form the cutting edge must be ground to "Certain Angles".

Different angles of lathe cutting tool and their significance should be studied thoroughly because a tool with proper cutting angles can cut material effectively with less generation of heat, and reduces chattering and breaking of the tools. Different angles of a cutting tool are shown in Figure 7.17.

The shank is that portion of the tool bit which is not ground to form cutting edges and is in rectangular cross section.

Face is that surface which face the workpiece.

Heel is the lowest portion of the side cutting and end cutting edge.

The nose is the conjunction of the side and end cutting edges.

The base is the under side of the shank.

The lip or cutting angle shows the included angle where the tool has been ground wedge-shaped.

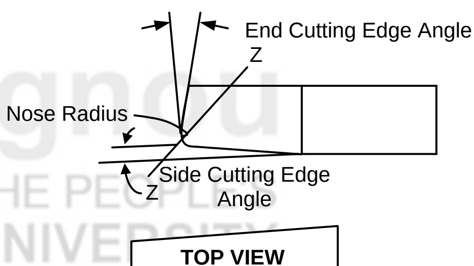


**Figure 7.17 : Different Angles of Cutting Tool**

The end cutting edge angle indicates that the plane which forms the end of a tool has been ground back at an angle sloping from the nose to the side of the shank, whereas the side cutting edge angle indicates that the plane which forms the flank or side of a tool has been ground back at an angle to the side of the shank. Chips are removed by this cutting edge.

The side clearance or side relief angle indicates that the plane that forms the flank or side of a tool has been ground back at an angle sloping down from the side cutting edge. Similarly, the end clearance or end relief shows that the nose or end of tool has been ground back at an angle sloping down from the end cutting edge.

The rake is the slope of the top away from the cutting edge. Each tool generally has a side and back rake angle. Back rake indicates that the plane which forms the face or top of a tool has been ground back at an angle sloping from the nose while side rake shows that the plane that forms the face or top of a tool has been ground back at an angle sloping from the side cutting edge.

### 7.6.4 Cutting Tool Signature

The signature is a sequence of numbers listing the various angles and the size of the nose radius. This numerical method of identification has been recommended by the American Standard Association.

The seven elements that comprise the signature of a single-point cutting tool are always defined in the following order; back rake angle, side rake angle, end relief angle, side relief angle, end cutting edge angle, side cutting edge angle and nose radius.

Let a tool is specified as “8-14-6-6-6-15-4”. It means, tool has $8^{o}$ back rake, $14^{o}$ side rake, $6^{o}$ end relief, $6^{o}$ side relief, $6^{o}$ end cutting edge and $15^{o}$ side cutting edge angles with 4 mm nose radius.

## 7.7 TERMS USED IN CUTTING OPERATIONS

Cutting speed, feed, depth of cut and machining time are the terms which are used in cutting operation. Study of all these terms is necessary to calculate the machining cost.

### 7.7.1 Cutting Speed

Cutting speed of a tool is the speed at which the metal is removed from any surface by the cutting tool. In lathe, it is the peripheral speed of the work past the cutting tool expressed in meter per minute

$$\text{Cutting speed} = \frac{\pi\, d\, n}{1000} \text{ meter / minute}$$

where $d$ = diameter of job in mm, and

$n$ = revolution per minute (rpm) of the work.

### 7.7.2 Feed

Feed is the displacement of the tool along the workpiece for each revolution of the work. It is expressed in millimeter per revolution.

### 7.7.3 Depth of Cut

It is the perpendicular distance measured from the machined surface to the uncut surface of the workpiece. For lathe the depth of cut is expressed as follow

$$\text{Depth of cut} = \frac{D - d}{2} \text{ mm}$$

where $D$ = dia of job in mm, and

$d$ = finished dia in mm (in single cut).

### 7.7.4 Machining Time

In lathe work, if the speed of job, feed of tool and the length of job are given, we can calculate the machining time by the following formula

$$\text{Machining Time for a Complete Cut} = \frac{l}{s \times n} \text{ minute}$$

where $l$ = length of job to be cut in mm,

$s$ = feed in mm / revolution, and

$n$ = rpm (revolution per minute).

## SAQ 3

(a) Name a few common types of operation, which can be performed on a lathe. Explain any one.

(b) Define cutting speed. Calculate the cutting speed of a job having 50 mm diameter and revolving at 490 rpm.

(c) How are feed and depth of cut usually expressed?

(d) Explain machining time. Calculate the machining time required for turning a job of 300 mm per length revolving at 120 rpm and feed of 0.15 mm per revolution.

(e) Write short notes on the following

   (i) Main parts of carriage

   (ii) Dog carrier and driving plate

   (iii) Thread chasing dial

   (iv) Taper turning by setting over the tail stock

   (v) Type of cutting tools.

## 7.8 SUMMARY

Lathe is considered to be the most widely used machine tool in engineering field for the manufacturing of cylindrical and conical shapes of jobs. In this unit, you have gained the adequate knowledge about its specification, function and main parts.

Devices which are used for proper holding the jobs and tools are known as accessories whereas the attachments of a lathe include additional equipments and are used to increase the rate of production and efficiency of a lathe.

For performing different operations such as turning, facing, knurling and threading etc, cutting tools are designed according to the nature of work and the quality of metal to be cut.

Certain angles are ground on the surface of tool for efficient cutting without chattering and breaking of the tool.

## 7.9 ANSWERS TO SAQs

Refer the relevant preceding text in the unit or other useful books on the topic listed in section 'Further Reading' to get the answers of the SAQs.