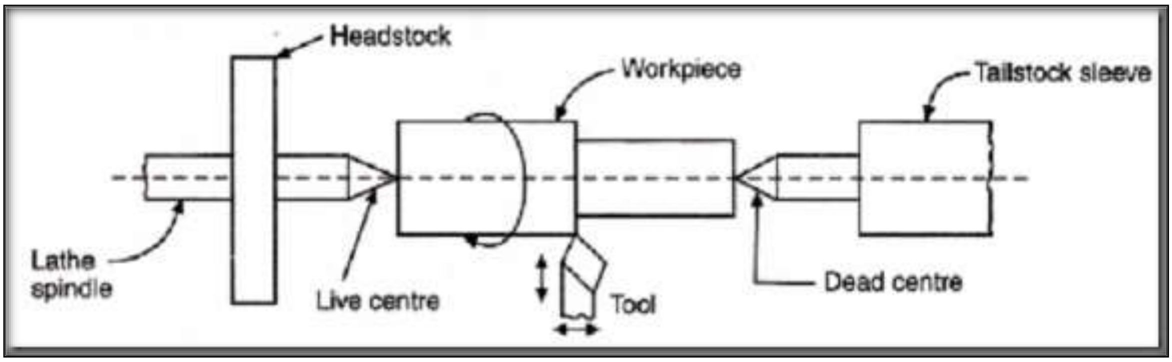
LATHE MACHINES

2.1 Engine lathe

Lathe is the oldest machine tool invented, starting with the Egyptian tree lathes. It is the father of all machine tools. Its main function is to remove material from a work piece to produce the required shape and size. This is accomplished by holding the work piece securely and rigidly on the machine and then turning it against the cutting tool which will remove material from the work piece in the form of chips. It is used to machine cylindrical parts. Generally single point cutting tool is used. In the year 1797 Henry Maudslay, an Englishman, designed the first screw cutting lathe which is the forerunner of the present day high speed, heavy duty production lathe.

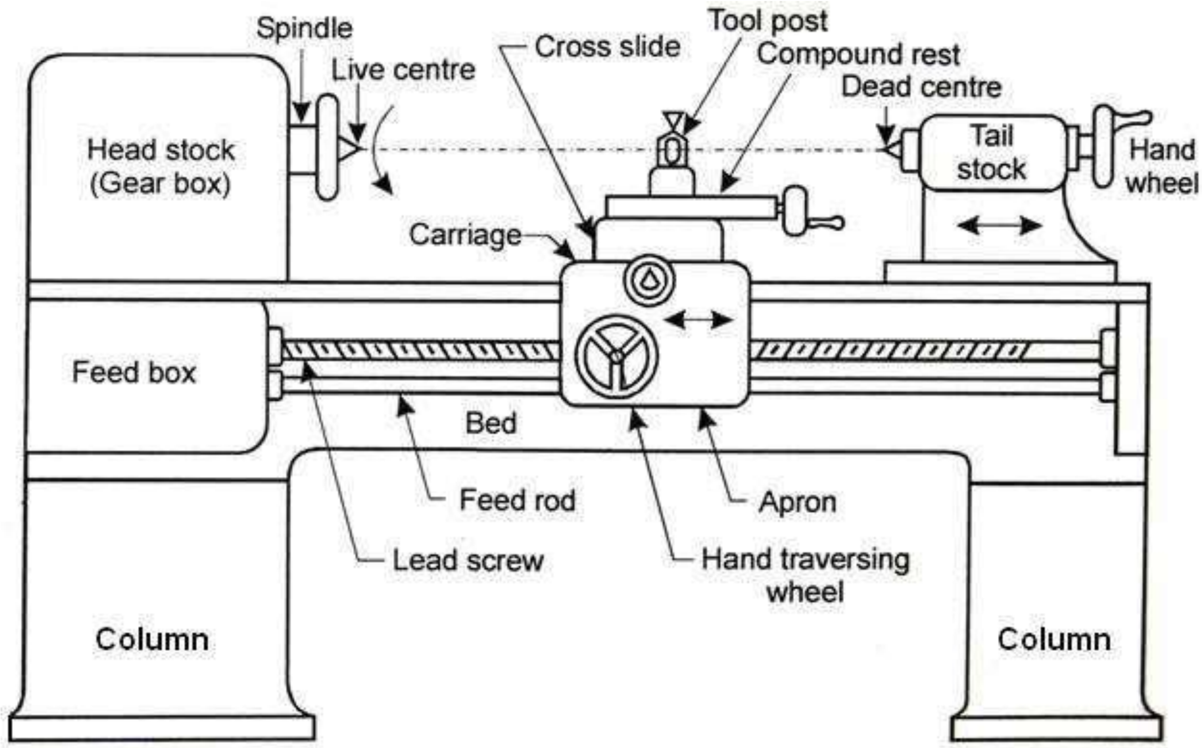
2.2 Principle of working

The lathe is a machine tool which holds the workpiece between two rigid and strong supports called centers or in a chuck or face plate which revolves. The cutting tool is rigidly held and supported in a tool post which is fed against the revolving work. The normal cutting operations are performed with the cutting tool fed either parallel or at right angles to the axis of the work. The cutting tool may also be fed at an angle relative to the axis of work for machining tapers and angles.



CONSTRUCTIONAL FEATURES

Major parts of a centre lathe



Amongst the various types of lathes, centre lathes are the most versatile and commonly used. Fig. 2.1 shows the basic configuration of a center lathe. The major parts are:

Headstock: It holds the spindle and through that power and rotation are transmitted to the job at different speeds. Various work holding attachments such as three jaw chucks, collets, and centres can be held in the spindle. The spindle is driven by an electric motor through a system of belt drives and gear trains. Spindle rotational speed is controlled by varying the geometry of the drive train.

Tailstock: The tailstock can be used to support the end of the work piece with a center, to support longer blanks or to hold tools for drilling, reaming, threading, or cutting tapers. It can be adjusted in position along the ways to accommodate different length work pieces. The tailstock barrel can be fed along the axis of rotation with the tailstock hand wheel.

Bed: Headstock is fixed and tailstock is clamped on it. Tailstock has a provision to slide and facilitate operations at different locations. The bed is fixed on columns and the carriage travels on it.

Carriage: It is supported on the lathe bed-ways and can move in a direction parallel to the lathe axis. The carriage is used for giving various movements to the tool by hand and by power. It carries saddle, cross-slide, compound rest, tool post and apron.

Saddle: It carries the cross slide, compound rest and tool post. It is an H-shaped casting fitted over the bed. It moves alone to guide ways.

Cross-slide: It carries the compound rest and tool post. It is mounted on the top of the saddle. It can be moved by hand or may be given power feed through apron mechanism.

Compound rest: It is mounted on the cross slide. It carries a circular base called swivel plate which is graduated in degrees. It is used during taper turning to set the tool for angular cuts. The upper part known as compound slide can be moved by means of a hand wheel.

Tool post: It is fitted over the compound rest. The tool is clamped in it.

Apron: Lower part of the carriage is termed as the apron. It is attached to the saddle and hangs in front of the bed. It contains gears, clutches and levers for moving the carriage by a hand wheel or power feed.

Feed mechanism: The movement of the tool relative to the work piece is termed as "feed". The lathe tool can be given three types of feed, namely, longitudinal, cross and angular.

- When the tool moves parallel to the axis of the lathe, the movement is called longitudinal feed. This is achieved by moving the carriage.
- When the tool moves perpendicular to the axis of the lathe, the movement is called cross feed. This is achieved by moving the cross slide.
- When the tool moves at an angle to the axis of the lathe, the movement is called angular feed. This is achieved by moving the compound slide, after swivelling it at an angle to the lathe axis.

Feed rod: The feed rod is a long shaft, used to move the carriage or cross-slide for turning, facing, boring and all other operations except thread cutting. Power is transmitted from the lathe spindle to the apron gears through the feed rod via a large number of gears.

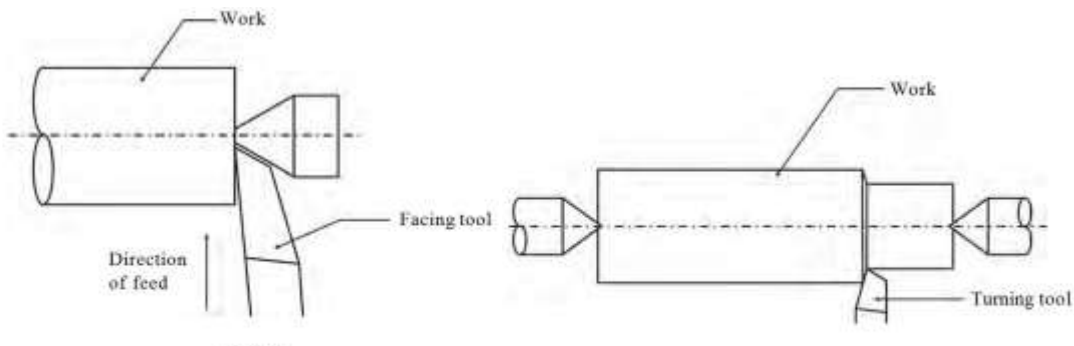
Lead screw: The lead screw is long threaded shaft used as a master screw and brought into operation only when threads have to cut. In all other times the lead screw is disengaged from the gear box and remains stationary. The rotation of the lead screw is used to traverse the tool along the work to produce screw. The half nut makes the carriage to engage or disengage the lead screw

Various Types of Operations Performed in Lathe Machine

Various operations are performed in a lathe machine other than plain turning. These are:-

1. Facing
2. Turning
   a. Straight turning
   b. Step turning
3. Chamfering
4. Grooving
5. Forming
6. Knurling
7. Undercutting
8. Eccentric turning
9. Taper turning
10. Thread cutting
11. Drilling
12. Reaming
13. Boring
14. Tapping

Facing: Facing is the operation of machining the ends of a piece of work to produce flat Surface Square with the axis. The operation involves feeding the tool perpendicular to the axis of rotation of the work.



Straight turning

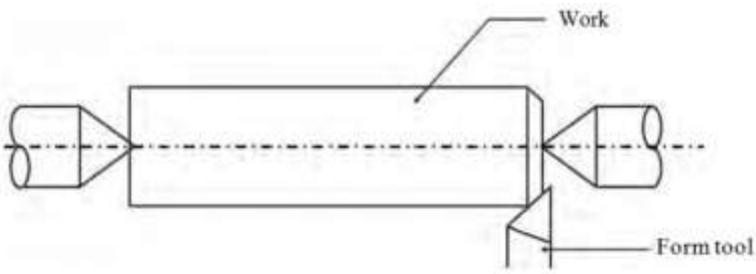
The work is turned straight when it is made to rotate about the lathe axis and the tool is fed parallel to the lathe axis. The straight turning produces a cylindrical surface by removing excess metal from the workpiece.

Step turning

Step turning is the process of turning different surfaces having different diameters. The work is held between centres and the tool is moved parallel to the axis of the lathe. It is also called shoulder turning.

Chamfering

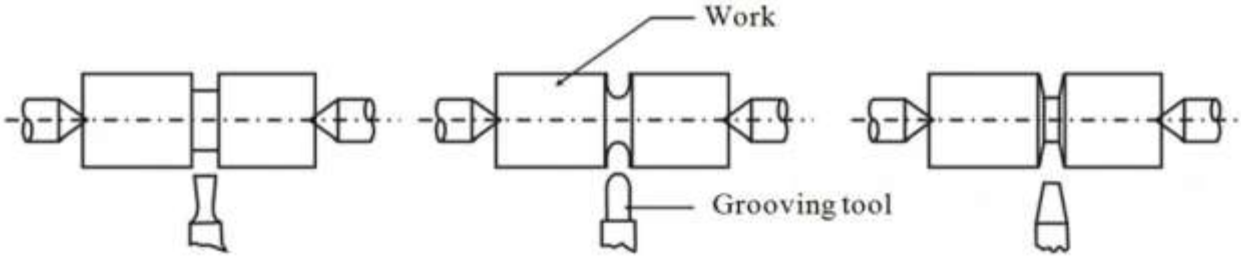
Chamfering is the operation of bevelling the extreme end of the workpiece. The form tool used for taper turning may be used for this purpose. Chamfering is an essential operation after thread cutting so that the nut may pass freely on the threaded workpiece.



Chamfering

Grooving

Grooving is the process of cutting a narrow groove on the cylindrical surface of the workpiece. It is often done at end of a thread or adjacent to a shoulder to leave a small margin. The groove may be square, radial or bevelled in shape.5



Grooving

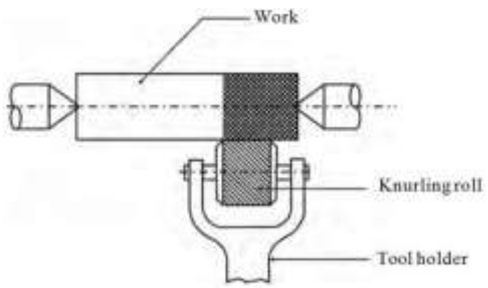
Forming

Forming is a process of turning a convex, concave or any irregular shape. For turning a small length formed surface, a forming tool having cutting edges conforming to the shape required is fed straight into the work.

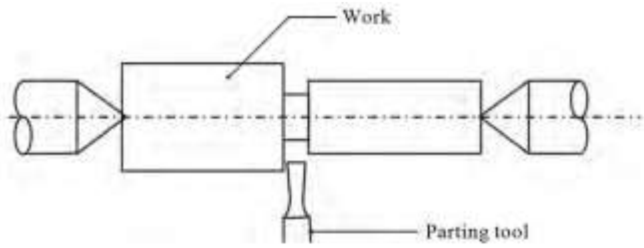
Knurling

Knurling is the process of embossing a diamond shaped pattern on the surface of the workpiece. The knurling tool holder has one or two hardened steel rollers with edges of required pattern. The tool holder is pressed against the rotating work. The rollers emboss the required pattern. The tool holder is fed automatically to the required length.

Knurls are available in coarse, medium and fine pitches. The patterns may be straight, inclined or diamond shaped.



Knurling



Undercutting

The purpose of knurling is

1. To provide an effective gripping surface
2. To provide better appearance to the work
3. To slightly increase the diameter of the work

Undercutting

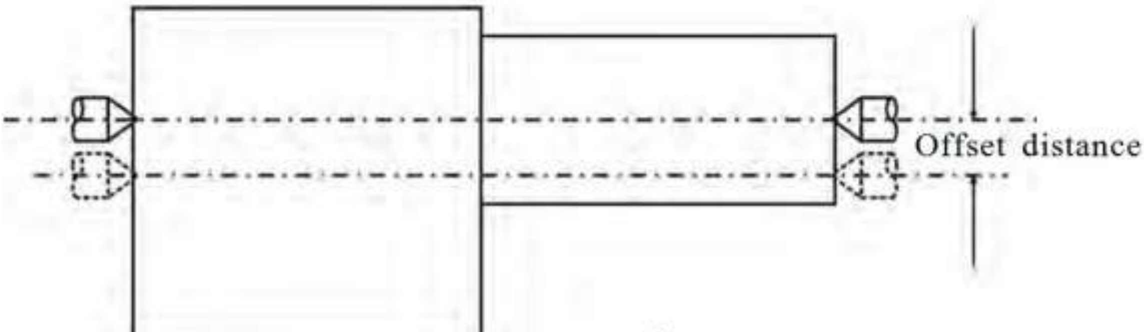
Undercutting is done

- At the end of a hole
- Near the shoulder of stepped cylindrical surfaces
- At the end of the threaded portion in bolts

It is a process of enlarging the diameter if done internally and reducing the diameter if done externally over a short length. It is useful mainly to make fits perfect. Boring tools and parting tools are used for this operation.

Eccentric turning

If a cylindrical workpiece has two separate axes of rotating, one being out of centre to the other, the workpiece is termed as eccentric and turning of different surfaces of the workpiece is known as eccentric turning. The distance between the axes is known as offset. Eccentric turning may also be done on some special machines. If the offset distance is more, the work is held by means of special centres. If the offset between the centres is small, two sets of centres are marked on the faces of the work. The work is held and rotated between each set of centres to machine the eccentric surfaces.



Eccentric turning

2.3 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.

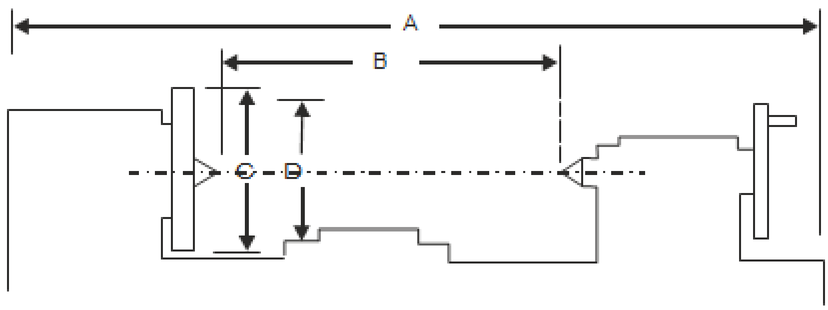


Fig. 21.7Specifications of a lathe

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.

In addition to the above specifications lathe is also specified by

(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
(xiii) Pitch range of metric and inch threads etc.

2.4 Types of lathe

Classification of lathes

Lathes of various designs and constructions have been developed to suit the various conditions of metal machining. But all types of lathes work on the same principle of operation and perform the same function.

The types generally used are:

- Bench lathe
- wood lathe
- Engine lathe
- Tool room lathe
- Capstan and turret lathe
- Automatic lathe
- Special-purpose lathe.

Bench lathe

It is a very small lathe and is mounted on bench or cabinet. It is used for small and; precision work since it is very accurate. It is usually provided with all the attachments and is capable of performing all the operations.

Speed lathe

It is power driven simplest type of lathe mostly used for wood turning. Tools are hand operated. Cone pulley is the only source provided for speed variation of the spindle.

Engine lathe or center lathe

It is a general-purpose lathe. It is normally used in all types of machine shops. It carries a great historical significance that in the very early days of the development of this machine it was driven by a steam engine. So it is called as engine lathe. The stepped cone pulley arrangement is often used for varying the speed of the lathe spindle. The cutting tools are controlled either by hand or by power.

Tool room lathe

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

Capstan and turret lathes

These are production lathes. Several tools are set on a revolving turret to facilitate in doing large number of operations on a job with the minimum wastage of time.

Automatic lathes

These are high speed, heavy duty, mass production lathes with complete automatic control. They are so designed that all the working and job handling movements of the complete manufacturing process for a job are done automatically. After the job is completed, the machine will continue to repeat the cycles producing identical parts even without the attention of an operator.

Another variety of this type of lathes includes the semi-automatic lathes in which the mounting and removal of the work is done by the operator whereas all the operations are performed by the machine automatically. Automatic lathes are available having single or multi spindles.

Special-purpose lathes

As the name implies, they are used for special purposes and for jobs, which cannot be accommodated for conveniently machined on a standard lathe. This category of lathes include such machines as crank shaft turning lathes, wheel lathe, camshaft lathe, duplicating lathe, T-lathe and vertical lathe, Gap-bed lathe etc.

Work holders tool holders

The work holding devices normally used should have the following provisions:

1) Suitable location

2) Effective clamping, and

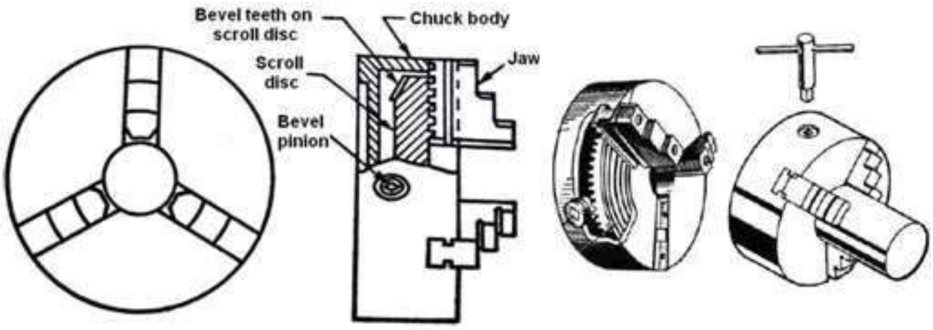
3) Support when required.

Chucks

The most common form of work holding device used in a lathe is the chuck. Chucks come in various forms with varying number of jaws.

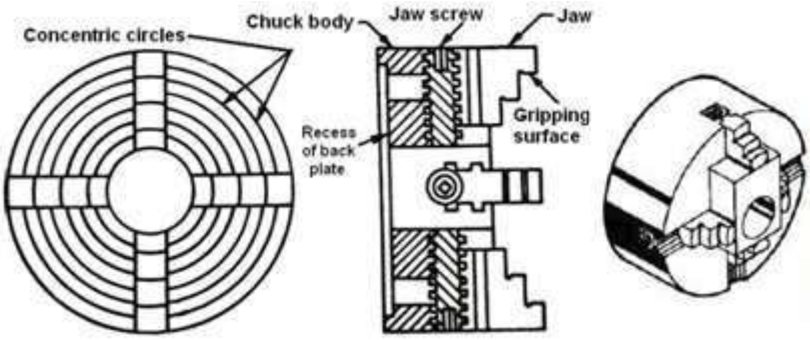
3-jaw chuck

3-jaw chuck or the self-centring chuck as shown in fig. is the most common one. The main advantage of this chuck is the quick way in which the typical round job is centred. All the three jaws mesh with the flat scroll plate. Rotating the scroll plate through a bevel pinion moves the entire three jaws radial inward or out ward by the same amount. Thus the jaws are able to center any job, whose external locating surface is cylindrical or symmetrical, like hexagonal. Through it is good for quick centering it has limitations in terms of the gripping force accuracy, which is gradually lost due to the wearing of the mating parts.



4-jaw chuck

The independent jaw chuck has four jaws, which can be moved in their slots, which are independent of each other, thus clamping any type of configuration. Since each of these jaws can be moved independently any irregular surface can be effectively centred. Better accuracy in location can be maintained because of the independent movement. However more times is spent in fixturing a component in a 4-jaw compared to the 3-jaw chuck. This is generally used for heavy work-pieces and for any configuration.



The jaws in a 4-jaw chuck can be reversed for clamping large diameter work-piece as shown in Fig. The soft jaws are sometimes used in these chucks for clamping surface of a component whose surface is already finished and which is likely to be disfigured by the hard surface of the normal jaws used in them.

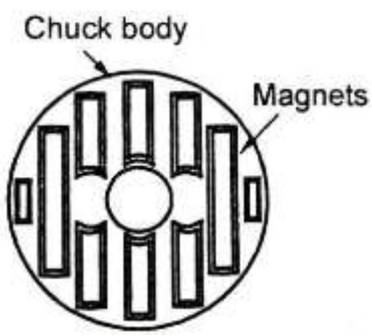
Difference between 3- jaw & 4- Jaw chuck

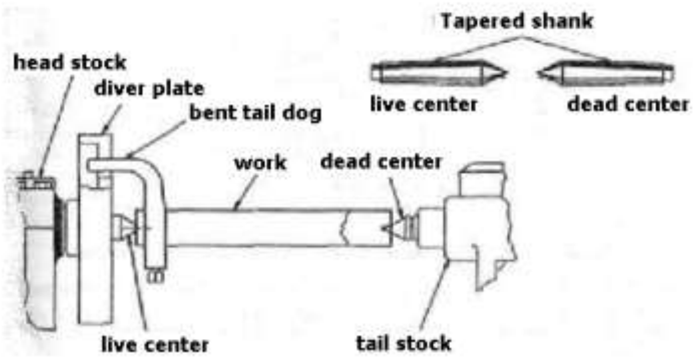
DIFFERENCE BETWEEN 3 & 4 JAW CHUCK

Setting up of work is easy	Setting up of work is difficult
Has less gripping power	More gripping power
Depth of cut is comparatively less	More depth of cut can be given
Heavier jobs cannot be turned	Heavier jobs can be turned
Workpieces cannot be set for eccentric turning	Workpieces can be set for eccentric turning

Magnetic chuck

This is used for holding thin jobs. When the pressure of jaws is to be prevented, this chuck is used. The chuck gets magnetic power from an electro-magnet. Only magnetic materials can be held on this chuck. Fig. 2.11 shows the magnetic chuck.





Centres

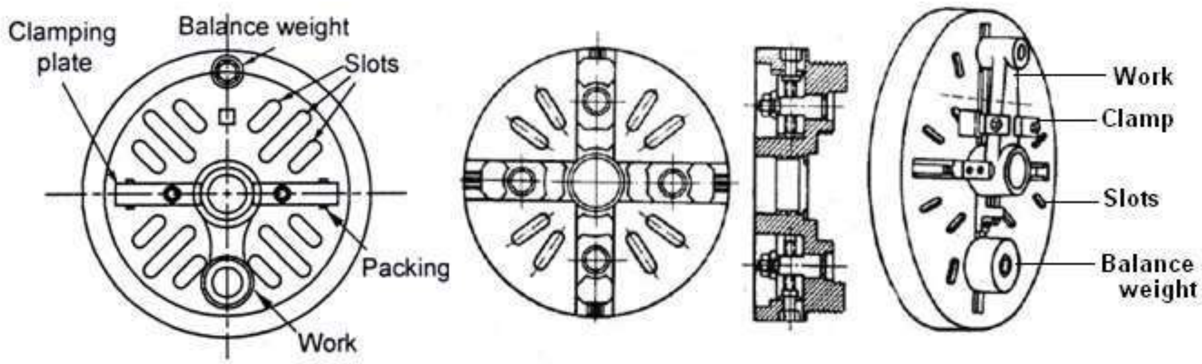
In such cases the long work-piece ends are provided with a center hole as a shown in Fig. Through these centre holes the centers mounted in the spindle and the tailstock would rigidly locate the axis of the work-piece. Centres as shown in fig would be able to locate the central axis of the workpiece, however would not be able to transmit the motion to the work-piece from the spindle. For this purpose, generally a carrier plate and dog as shown in Fig would be used. The centre located in the spindle is termed as live canter while that in the tailstock is termed the dead centre. The shank of the center is generally finished with a morse a taper, which fits into the tapered hole of the spindle or tailstock. The live centre rotates which the work-piece and hence it remains soft. The dead centre does not rotate, and hence it is hardened as it forms the bearing surface. However, in case of heavier work-piece the relative movement between the workpiece and the dead centre causes a large amount of heat generated. In such cases, a revolving centre is used. In this the centre is mounted in a roller bearing and it thus rotates freely, reducing the heat generated at the tailstock end. In cases where a facing operation is to be carried out with centres, a half centre is sometimes used.

Some of the precautions to be observed during the use of centres are:

1. The centre hole in the work must be clean and smooth and have an angle of 60° bearing surface, large enough to be consistent with the diameter of the work. For heavier work this may be made 75° to 90°.
2. The bearing must take place on the countersunk surfaces and not on the bottom of the drilled hole.

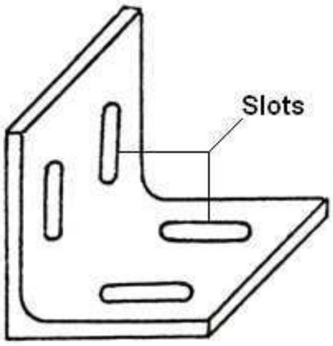
Faceplate

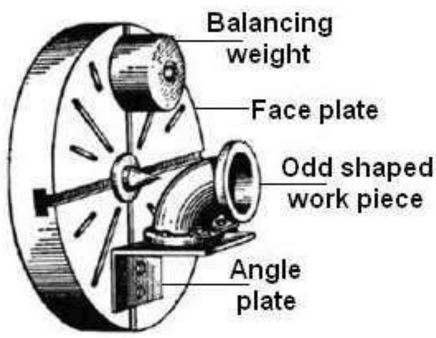
For odd shaped components a faceplate is more widely used where the locating and clamping surfaces need not be circular. This has radial slots on the plate as shown in Fig. for the purpose of locating the component and clamped by means of any standard clamps. The method is somewhat similar to the clamping of work-piece on a milling machine table using the T-slots on the table. However, in view of the fact that the faceplate rotates, the component is likely to be off centre. This would cause vibrations due to the mass unbalance. A balancing mass would therefore have to be provided as shown in Fig. Sometimes angle plates along with the faceplate may have to be used for typical components where the locating surface is perpendicular to the plane of the plate as shown in fig.



Angle plate

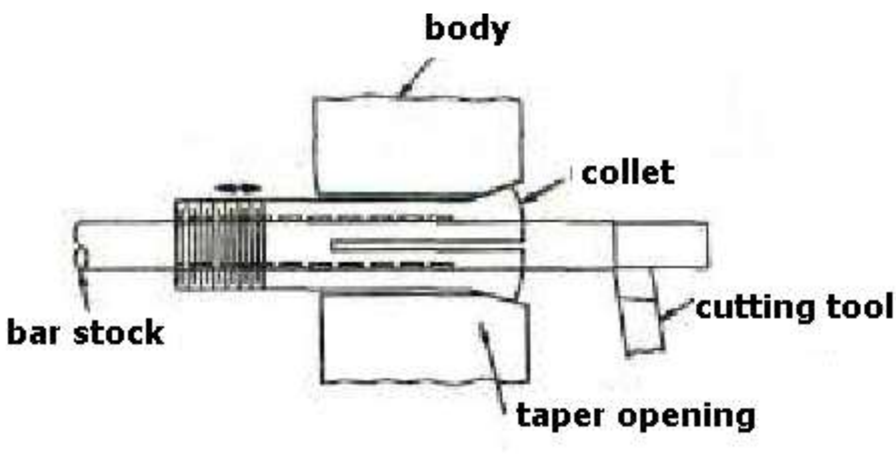
Angle plate is a cast iron plate that has two faces at right angles to each other. Holes and slots are provided on both faces as shown in Fig. 2.13 (a). An angle plate is used along with the face plate when holding eccentric or unsymmetrical jobs that are difficult to grip directly on the face plate as shown in Fig. 2.13 (b).





Collet chuck

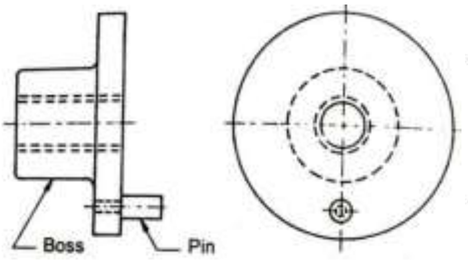
A collet has a sleeve as the holding part, which is slit along the length at a number of points along the circumference as shown in fig. When uniform pressure is applied along the circumference of the sleeve, these segments elastically deflect and clamp the component located inside. Since the deflection of the sleeve is in the elastic range, it springs back once the clamping pressure is removed, thus releasing the component located inside. This clamping method is very accurate and fast in operation and holds the work uniformly over the entire circumference. However, the size range in which a collet becomes operation is very small in view of the limit on the elastic deformation allowed. Thus a large number of chucks need to be maintained in the inventory to the variety of diameters to be worked in the machine tool. This is normally used for large-scale production where saving in terms of the locating and clamping time is desirable.

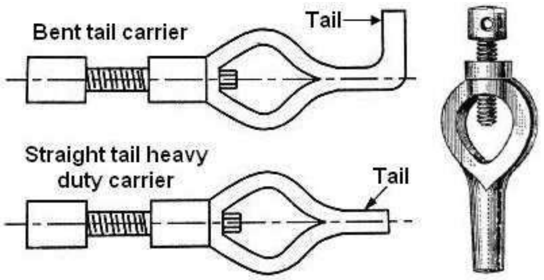


With additional support from the tailstock

Catch plate or driving plate

It is circular plate of steel or cast iron having a projected boss at its rear. The boss has a threaded hole and it can be screwed to the nose of the headstock spindle. The driving is fitted to the plate. It is used to drive the work piece through a carrier or dog when the work piece is held between the centres.





Carriers or Dogs

It is used to transfer motion from the driving plate to the work piece held between centres. The work piece is inserted into the hole of the dog and firmly secured in position by means of set screw. The different types of carriers are shown in Fig 2. 15.

Mandrels

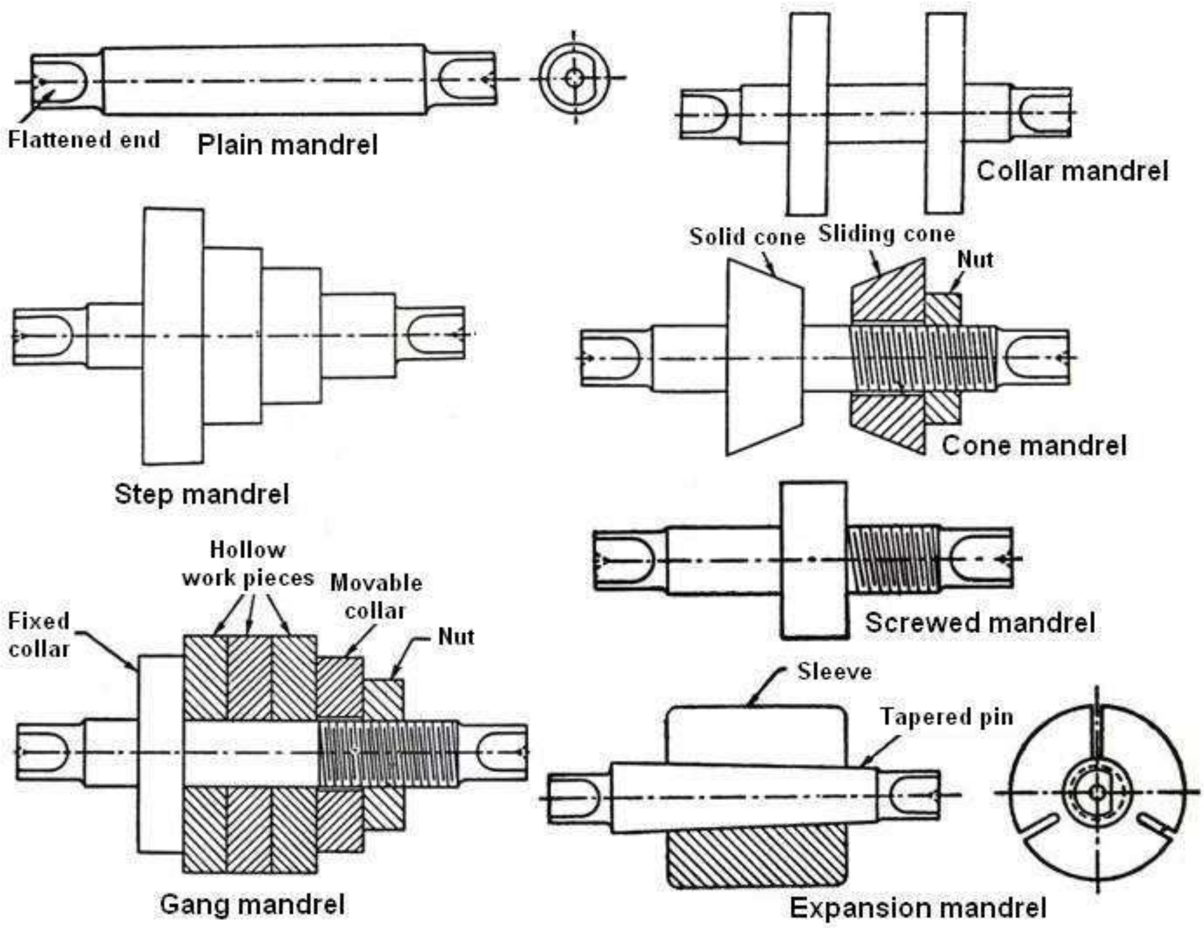
A mandrel is a device used for holding and rotating a hollow work piece that has been previously drilled or bored. The work revolves with the mandrel which is mounted between two centres. The mandrel should be true with accurate centre holes for machining outer surface of the work piece concentric with its bore. To avoid distortion and wear it is made of high carbon steel.

The ends of a mandrel are slightly smaller in diameter and flattened to provide effective gripping surface of the lathe dog set screw. The mandrel is rotated by the lathe dog and the catch plate and it drivestheworkbyfriction.Differenttypesofmandrelsareemployedaccordingtospecific requirements. Fig. 2.16 shows the different types of mandrels in common use.

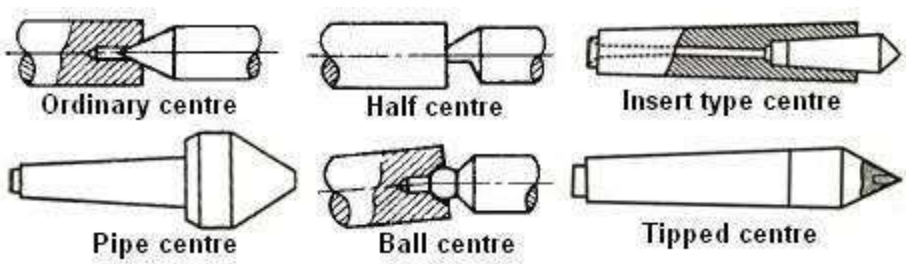
In-between centres (by catch plate and carriers)

Fig. Schematically shows how long slender rods are held in between the live centre fitted into the headstock spindle and the dead centre fitted in the quill of the tailstock. The torque and rotation are transmitted from the spindle to the job with the help of a lathe dog or catcher which is again driven by a driving plate fitted at the spindle nose.

Types of mandrels:



Depending upon the situation or requirement, different types of centres are used at the tailstock end as indicated in Fig. 2.18. A revolving centre is preferably used when desired to avoid sliding friction between the job and the centre which also rotates along with the job.



Ordinary centre: It is used for general works.

Insert type centre: In this the steel "insert" can be replaced instead of replacing the whole centre.

Half centre: It is similar to ordinary centre and used for facing bar ends without removal of the centre. Pipe centre: It is used for supporting pipes and hollow end jobs.

Ball centre: It has ball shaped end to minimize the wear and strain. It is suitable for taper turning.

Tipped centre: Hard alloy tip is brazed into steel shank. The hard tip has high wear resistant.

Revolving centre: The ball and roller bearings are fitted into the housing to reduce friction and to take up end thrust. This is used in tail stock for supporting heavy work revolving at a high speed.

Mounting of tools in centre lathe

Different types of tools, used in centre lathes, are usually mounted in the following ways:

HSS tools (shank type) in tool post.

HSS form tools and threading tools in tool post. Carbide and ceramic inserts in tool holders. Drills and reamers, if required, in tailstock. Boring tools in tool post.

Fig. 2.22 (a and b) is typically showing mounting of shank type HSS single point tools in rotatable (only one tool) and index able (up to four tools) tool posts. Fig. 2.22 (c) typically shows how a circular form or thread chasing HSS tool is fitted in the tool holder which is mounted in the tool post.

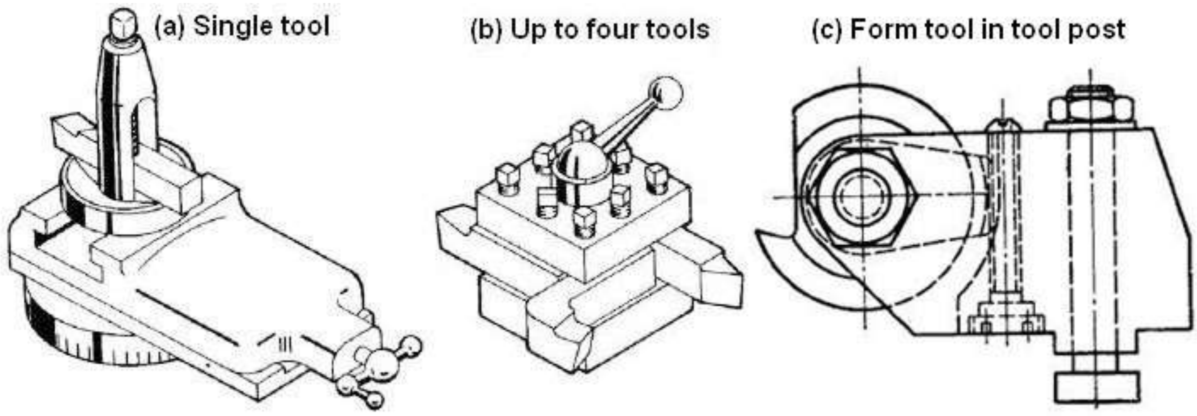


Fig. 2.22 Mounting of (a and b) shank type tools in tool post and (c) form tool in tool post

Carbide, ceramic and cermet inserts of various size and shape are mechanically clamped in the seat of rectangular sectioned steel bars which are mounted in the tool post. Fig. 2.23 (a, b, c and d) shows the common methods of clamping such inserts. After wearing out of the cutting point, the insert is indexed and after using all the corner tips the insert is thrown away.

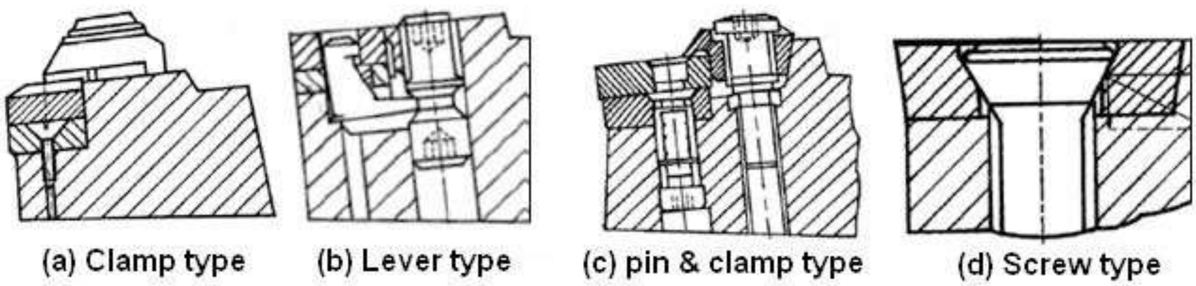
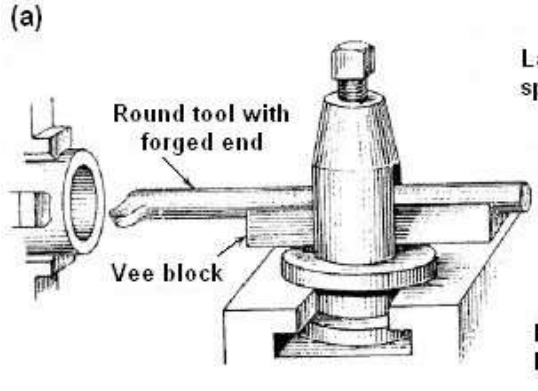


Fig. 2.23 Mounting of tool inserts in tool holders by mechanical clamping

For originating axial hole in centre lathe, the drill bit is fitted into the tailstock which is slowly moved forward against the rotating job as indicated in Fig. 2.24. Small straight shank drills are fitted ina drill chuck whereas taper shank drill is fitted directly into the tailstock quill without or with a socket.

Often boring operation is done in centre lathe for enlarging and finishing holes by simple shank type HSS boring tool. The tool is mounted on the tool post and moved axially forward, along with the saddle, through the hole in the rotating job as shown in Fig. 2.25 (a). For precision boring in centre lathe, the tool may be fitted in the tailstock quill supported by bush in the spindle as shown in Fig. 2.25 (b).



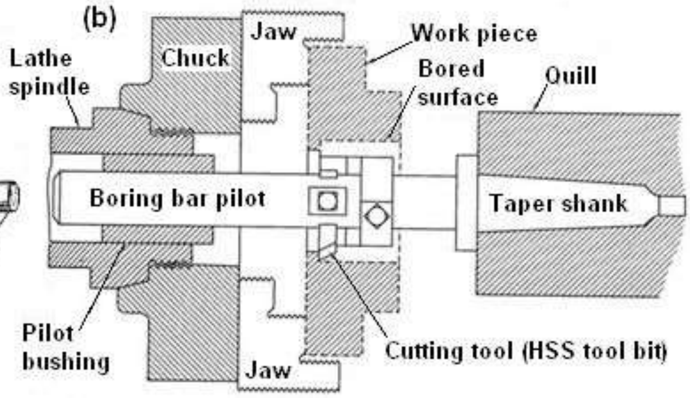


Fig. 2.25 (a) Boring tool mounted in the tool post Fig. 2.25 (b) Precision boring in centre lathe

2.5 Box tools taper turning, thread turning – for lathes and attachments

2.5.1 TAPER TURING METHODS

A taper may be defined as a uniform change in the diameter of a work piece measured along its length. Taper may be expressed in two ways:

Ratio of difference in diameter to the length. In degrees of half the included angle.

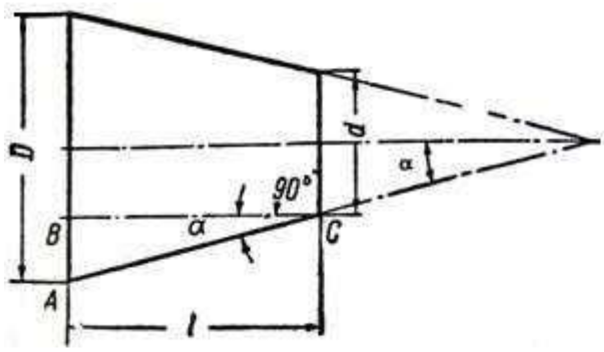


Fig. 2.31 shows the details of a taper

D - Large diameter of the taper.

d - Small diameter of the taper.

l - Length of tapered part.

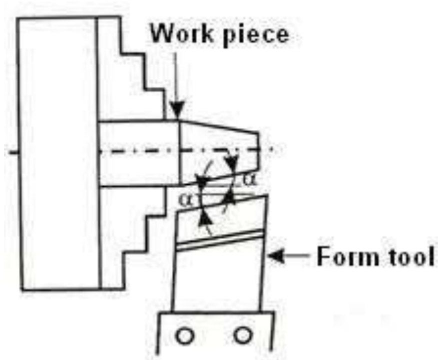
α - Half angle of taper.

Generally, taper is specified by the term conicity. Conicity is defined as the ratio of the difference in diameters of the taper to its length. Conicity, $K = \frac{D-d}{l}$

Taper turning is the operation of producing conical surface on the cylindrical work piece on lathe.

Taper turning by a form tool

Fig. 2.32 illustrates the method of turning taper by a form tool. A broad nose tool having straight cutting edge is set on to the work at half taper angle, and is fed straight into the work to generate a tapered surface. In this method the tool angle should be properly checked before use. This method is limited to turn short length of taper only. This is due to the reason that the metal is removed by the entire cutting edge will require excessive cutting pressure, which may distort the work due to vibration and spoil the work surface.



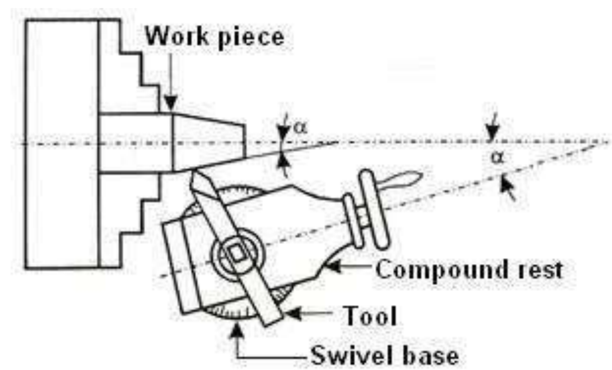


Fig. 2.32 Taper turning by a form tool Fig. 2.33 Taper turning by swivelling the compound rest

Taper turning by swiveling the compound rest. Fig. 2.33 illustrates the method of turning taper by swiveling the compound rest. This method is used to produce short and steep taper. In this method, work is held in a chuck and is rotated about the lathe axis. The compound rest is swiveled to the required angle and clamped in position.

The angle is determined by using the formula, $\tan\alpha = \frac{D-d}{2l}$

Then the tool is fed by the compound rest hand wheel. This method is used for producing both internal and external taper. This method is limited to turn a short taper owing to the limited movement of the compound rest. The compound rest may be swivelled at 450 on either side of the lathe axis enabling it to turn a steep taper. The movement of the tool in this method being purely controlled by hand, this gives a low production capacity and poorer surface finish.

Taper turning by offsetting the tailstock

Fig. 2.34 illustrates the method of turning taper by offsetting the tailstock. The principle of turning taper by this method is to shift the axis of rotation of the work piece, at an angle to the lathe axis, which is equal to half angle of the taper, and feeding the tool parallel to the lathe axis.

This is done when the body of the tailstock is made to slide on its base towards or away from the operator by a set over screw. The amount of set over being limited, this method is suitable for turning small taper on long jobs. The main disadvantage of this method is that live and dead centres are not equally stressed and the wear is not uniform. Moreover, the lathe carrier being set at an angle, the angular velocity of the work is not constant.

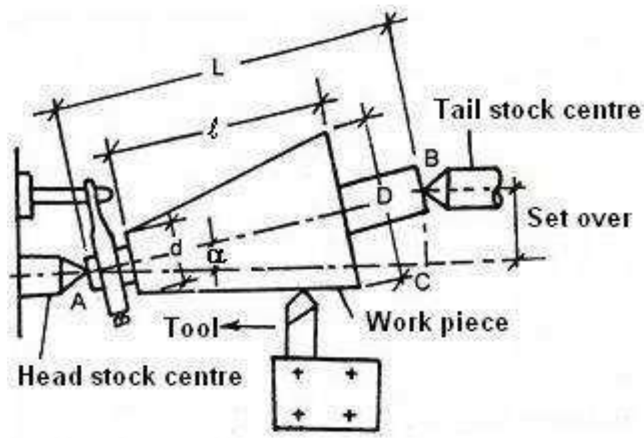


Fig. 2.34 Taper turning by offsetting the tailstock

The amount of set over required to machine a particular taper may be calculated as:

From the right angle triangle ABC in Fig.2.34; BC =AB sinα, where BC = set over

Set over = L sinα

If the half angle of taper (α), is very small, for all practical purposes, sinα = tanα

Set over = L tanα = L x $\frac{D-d}{2l}$ in mm

If the taper is turned on the entire length of the work piece, then l= L, and the equation (2.4) become:

Set over = L x $\frac{D-d}{2L}$=$\frac{D-d}{2}$

Being termed as the conicity or amount of taper, the formula (2.4) may be written in the following form:

Set over =$\frac{Entire length of the work X conicity}{2}$

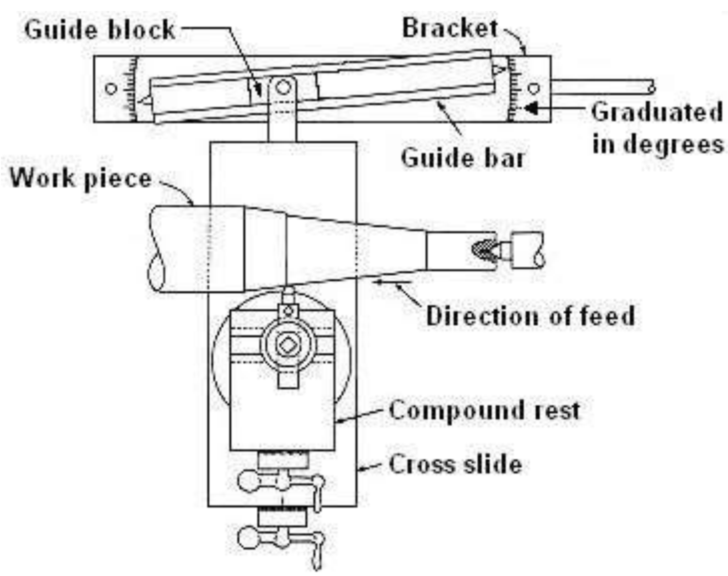
Taper turning by using taper turning attachment

Fig. 2.35 schematically shows a taper turning attachment. It consists of a bracket or frame which is attached to the rear end of the lathe bed and supports a guide bar pivoted at the centre. The guide bar having graduations in degrees may be swivelled on either side of the zero graduation and is set at the desired angle with the lathe axis. When this attachment is used the cross slide is delinked from the saddle by removing the binder screw. The rear end of the cross slide is then tightened with the guide block by means of a bolt. When the longitudinal feed is engaged, the tool mounted on the cross slide will follow the angular path, as the guide block will slide on the guide bar set at an angle to the lathe axis.

The required depth of cut is given by the compound slide which is placed at right angles to the lathe axis. The guide bar must be set at half taper angle and the taper on the work must be converted in degrees. The maximum angle through which the guide bar may be swivelled is 100 to 120 on either side of the centre line. The angle of swiveling the guide bar can be determined from the equation 2.2.

The advantages of using a taper turning attachment are:

- The alignment of live and dead centres being not disturbed; both straight and taper turning may be performed on a work piece in one setting without much loss of time.
- Once the taper is set, any length of work piece may be turned taper within its limit.
- Very steep taper on a long work piece may be turned, which cannot be done by any other method.
- Accurate taper on a large number of work pieces may be turned.
- Internal tapers can be turned with ease.



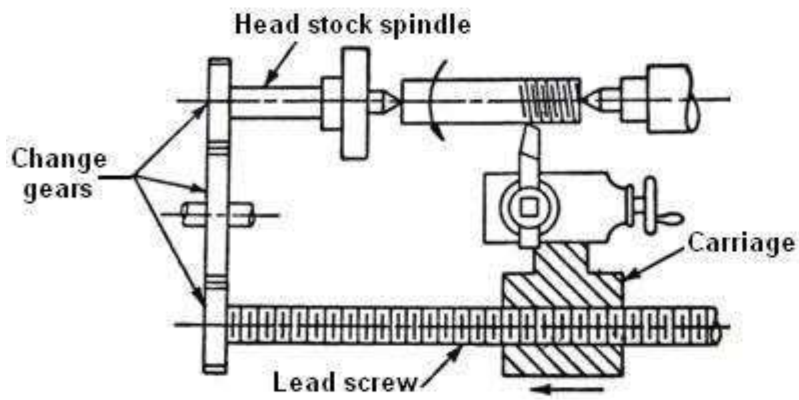
Taper turning by combining longitudinal feed and cross feed

Fig. 2.36 illustrates the method of turning taper by combining longitudinal feed and cross feed. This is a more specialized method of turning taper. In certain lathes both longitudinal and cross feeds may be engaged simultaneously causing the tool to follow a diagonal path which is the resultant of the magnitude of the two feeds. The direction of the resultant may be changed by varying the rate of feeds by changing gears provided inside the apron.

2.5.2 Thread Cutting Methods

Thread cutting is one of the most important operations performed in a centre lathe. It is possible to cut both external and internal threads with the help of threading tools. There are a large number of thread forms that can be machined in a centre lathe such as Whitworth, ACME, ISO metric, etc. The principle of thread cutting is to produce a helical groove on a cylindrical or conical surface by feeding the tool longitudinally when the job is revolved between centres or by a chuck (for external threads) and by a chuck (for internal threads). The longitudinal feed should be equal to the pitch of the thread to be cut per revolution of the workpiece.

The lead screw of the lathe has a definite pitch. The saddle receives its traversing motion through the lead screw. Therefore a definite ratio between the longitudinal feed and rotation of the headstock spindle should be found out so that the relative speeds of rotation of the work and the lead screw will result in the cutting of a thread of the desired pitch. This is effect by change gears arranged between the spindle and the lead screw or by the change gear mechanism or feed gear box used in a modern lathe. Thread cutting on a centre lathe is a slow process, but it is the only process of producing square threads, as other methods develop interference on the helix. Fig.2.37 illustrates the principle of thread cutting.



Change gear ratio

Centre lathes are equipped with a set of change gears. A typical set contains the following change gears with number of teeth: 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 110, 120, 125 and 127. The change gear ratio (icg) must be transformed by multiplying numerator and denominator by a suitable number, to obtain gears available in the change gear set.

The change gear ratio may result either in a 'Simple gear train' or 'Compound gear train'. In modern lathes using quick change gears, the correct gear ratio for cutting a particular thread is quickly obtained by simply shifting the levers in different positions which are given in the charts or instruction plates supplied with the machine.

Calculation for change gear ratio

Metric thread on Metric lead screw

Calculation for change gear ratio for cutting metric thread on a centre lathe with a metric lead screw is as follows;

$$\frac{Driverteeth}{driventeeth} = \frac{Leadscrewturn}{Spindleturn} = \frac{Pitchofthethreadtobecut}{Pitchoftheleadscrew}$$

Example 2.1: The pitch of the lead screw is 12 mm, and the pitch of the thread to be cut is 3 mm. For this condition the change gear ratio is as follows;

$$\frac{Driverteeth}{driventeeth} = \frac{Pitchofthethreadtobecut}{Pitchoftheleadscrew} = \frac{3}{12} = \frac{1}{4} = \frac{1\ X\ 20}{4\ X\ 20} = \frac{20}{80}$$

Therefore the driver gear will have 20 teeth and the driven gear will have 80 teeth. This is effect by simple gear train.

Example 2.2: The pitch of the lead screw is 6 mm, and the pitch of the thread to be cut is 1.25 mm. For this condition the change gear ratio is as follows;

$$\frac{Driverteeth}{driventeeth} = \frac{Pitchofthethreadtobecut}{Pitchoftheleadscrew} = \frac{1.25}{6} = \frac{1.25\ X\ 4}{6\ X\ 4} = \frac{5}{4} X \frac{1}{6} = \frac{5\ X\ 10}{4\ X\ 10} X \frac{1\ X\ 20}{6\ X\ 20}$$

$$= \frac{50\ X\ 20}{40\ X\ 120}$$

Therefore the driver gears will have 50 teeth & 20 teeth and the driven gears will have 40 teeth & 120 teeth. This is effect by compound gear train.

Metric thread on British or English standard lead screw

Calculation for change gear ratio for cutting metric thread on a centre lathe with a British or English standard lead screw may be carried out by introducing a translating gear of 127 teeth. If the lead screw has *n* threads per inch and the thread to be cut has *p* mm pitch then;

$$\frac{\text{Driver teeth}}{\text{Driven teeth}} = \frac{\text{Pitch of the thread to be cut}}{\text{Pitch of the lead screw}} = \frac{p}{1/_n} = \frac{p\,n}{25.4} = \frac{p\,n}{25.4 \times 5/_5} = \frac{5\,p\,n}{127}$$

$$\text{Since pitch} = \frac{1}{\text{number of threads per inch}} \qquad \text{and 1 inch} = 25.4\text{ mm}$$

Example 2.3: The lead screw has 4 threads per inch, and the pitch of the thread to be cut is 7 mm. For this condition the change gear ratio is as follows;

$$\frac{\text{Driver teeth}}{\text{Driven teeth}} = \frac{5\,p\,n}{127} = \frac{5 \times 7 \times 4}{127} = \frac{140}{127} = \frac{70 \times 2}{127} = \frac{70 \times 2 \times 20}{127 \times 20} = \frac{70 \times 40}{127 \times 20}$$

Therefore the driver gears will have 70 teeth & 40 teeth and the driven gears will have 127 teeth & 20 teeth. This is effect by compound gear train.

British or English standard thread on English lead screw

Calculation for change gear ratio for cutting British or English standard thread on a centre lathe with an English lead screw is as follows;

$$\frac{\text{Driver teeth}}{\text{Driven teeth}} = \frac{{}^{1}/_{\text{number of threads per inch to be cut}}}{{}^{1}/_{\text{number of threads per inch on the lead screw}}} = \frac{\text{Pitch of the thread to be cut}}{\text{Pitch of the lead screw}}$$

Example 2.4: The lead screw has 4 threads per inch, and the screw thread to be cut has 26 threads per inch. For this condition the change gear ratio is as follows;

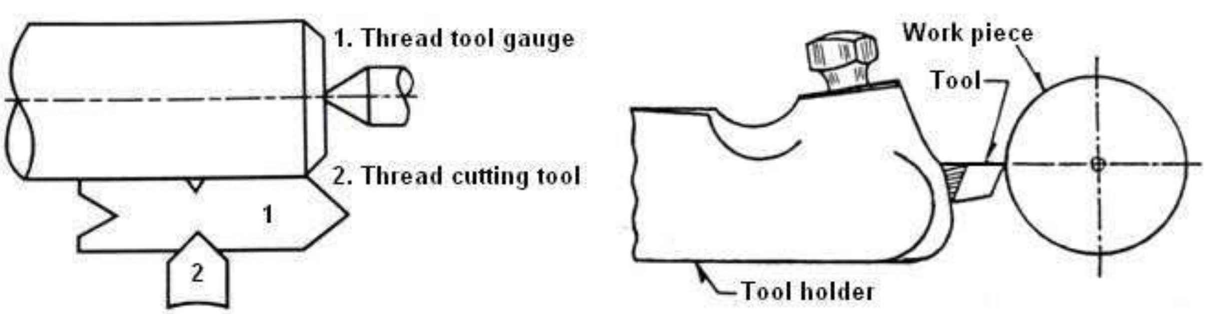
$$\frac{\text{Driver teeth}}{\text{Driven teeth}} = \frac{{}^{1}/_{\text{number of threads per inch to be cut}}}{{}^{1}/_{\text{number of threads per inch on the lead screw}}} = \frac{{}^{1}/_{26}}{{}^{1}/_{4}} = \frac{4}{26} = \frac{4 \times 5}{26 \times 5} = \frac{4 \times 5}{13 \times 10}$$

$$= \frac{4 \times 5}{13 \times 5} \times \frac{5 \times 10}{10 \times 10} = \frac{20 \times 50}{65 \times 100}$$

Therefore the driver gears will have 20 teeth & 50 teeth and the driven gears will have 65 teeth &100 teeth. This is effect by compound gear train.

Thread cutting procedure

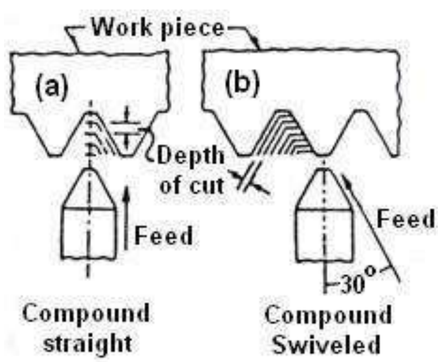
1. The work piece should be rotated in anticlockwise direction when viewed from the tail stock end.
2. The excess material is removed from the workpiece to make its diameter equal to the major diameter of the screw thread to be generated.
3. Change gears of correct size are fitted to the end of the bed between the spindle and the lead screw.
4. The thread cutting tool is selected such that the shape or form of the cutting edge is of the same form as the thread to be generated. In a metric thread, the included angle of the cutting edge should be ground exactly 60^0.
5. A thread tool gauge or a centre gauge is used against the turned surface of the workpiece to check the form of the cutting edge so that each face may be equally inclined to the centre line of the workpiece. This is illustrated in Fig. 2.38.

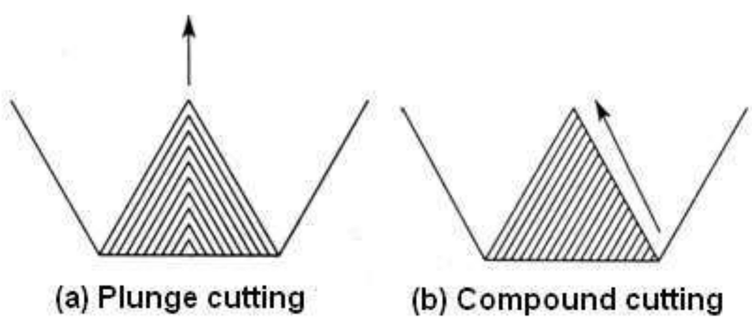


6. Then the tool is mounted in the tool post such that the top of the tool nose is horizontal and is in line with the axis of rotation of the workpiece. This is illustrated in Fig. 2.39.
7. The speed of the spindle is reduced by ½ to ¼ of the speed required for turning according to the type of material being machined.
8. The tool is fed inward until it first scratches the surface of the workpiece. The graduated dial on the cross slide is noted or set to zero. Then the split nut or half nut is engaged and the tool moves along helical path over the desired length.
9. At the end of tool travel, it is quickly withdrawn by means of cross slide. The split nut is disengaged and the carriage is returned to the starting position, for the next cut. These successive cuts are continued until the thread reaches its desired depth (checked on the dial of cross slide).
10. For cutting left hand threads the carriage is moved from left to right (i.e. towards tail stock) and for cutting right hand threads it is moved from right to left (i.e. towards headstock).

Depth of cut in thread cutting

The depth of first cut is usually 0.2 to 0.4 mm. This is gradually decreased for the successive cuts until for the final finishing cut; it is usually 0.025 to 0.075 mm. The depth of cut is applied by advancing the tool either radially (called as plunge cutting) or at an angle equal to half angle of the thread (called as compound cutting) (300 in case of metric threads) by swiveling the compound rest. Fig. 2.40 schematically shows the method of applying plunge cut and compound cut.





Plunge cutting: In this the absence of side and back rake will not produce proper cutting except on brass and cast iron. Cutting takes place along a longer length of the tool. This gives rise to difficulties in machining in terms of higher cutting forces and consequently chattering. This result in poor surface finish and lower tool life, thus this method is not generally preferred. This method is used for taking very light finishing cuts and for cutting square, acme and worm threads.

Compound cutting: Compound cutting is superior to the plunge cutting as it:

Permits the tool to have a top rake.

Permits cutting to take place on one edge of the tool only.

Allows the chips to slide easily across the face of the tool without crowding. Reduces cutting strain that acts on the tool.

Reduces the tendency to cause the tool to 'dig-in'.

So compound cutting is more preferred compared with plunge cutting.

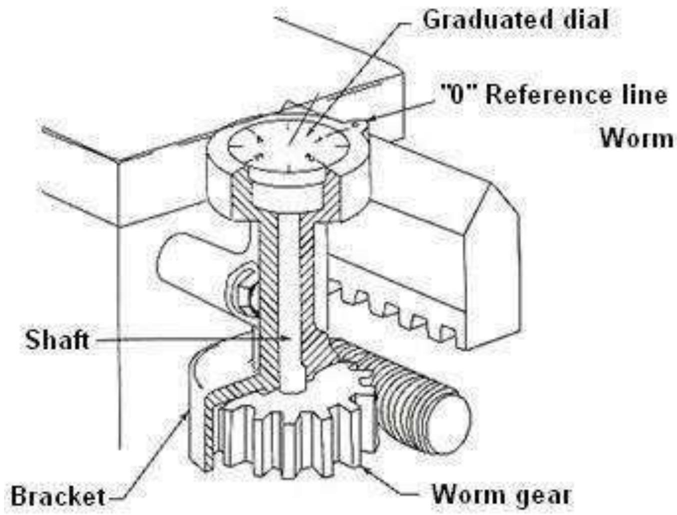
Picking up the thread

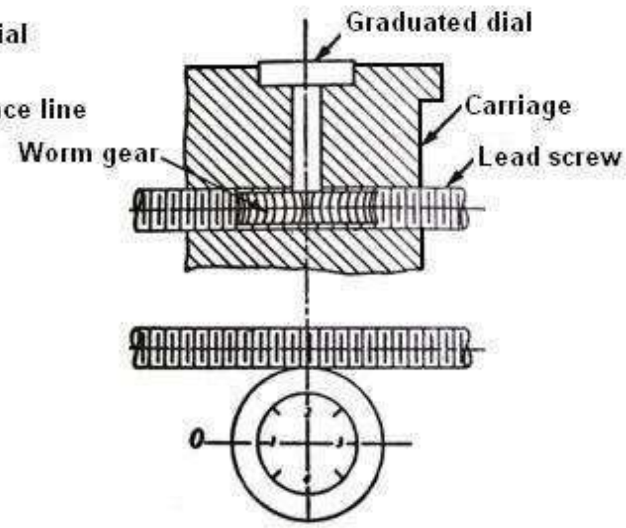
Several cuts are necessary before the full depth of thread is reached. It is essential that the tool tip should always follow the same thread profile generated in the first cut; otherwise the workpiece will be spoiled. This is termed as picking up the thread. The different methods of picking up the thread are:

Reversing the machine: After the end of one cut the machine is reversed while keeping the half nut permanently engaged and retaining the engagement between the tool and the workpiece. The spindle reversal would bring the cutting tool to the starting point of the thread following the same path in reverse. After giving a further depth of cut the spindle is again reversed and the thread cutting is continued in the normal way. This is easy to work and is somewhat more time consuming due to the idle time involved in stopping and reversing of the spindle at the end of each stroke.

Marking the lathe parts: The procedure is to mark the lead screw and its bracket, the large gear and the head stock casting, and the starting position of the carriage on the lathe bed. The aim is to bring each of the markings on the lead screw and gear opposite the markings on the stationary portions of the lathe, and have the carriage at the starting position before attempting to engage the split nut.

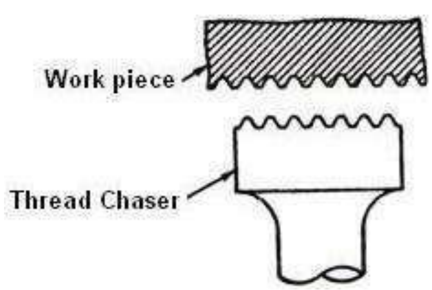
Using a chasing dial: Fig. 2.41 shows the basic configuration of a chasing dial. This is also called as thread indicator. This is a special attachment used in modern lathes for accurate "picking up" of the thread. This dial indicates when to close the split or half nuts. This is mounted on the right end of the apron. It consists of a vertical shaft with a worm gear engaged with the lead screw. The top of the vertical shaft has a revolving dial marked with lines and numbers to indicate equal divisions of the circumference. The dial turns with the lead screw so long the half nut is not engaged. If the half nut is closed and the carriage moves along, the dial stands still.

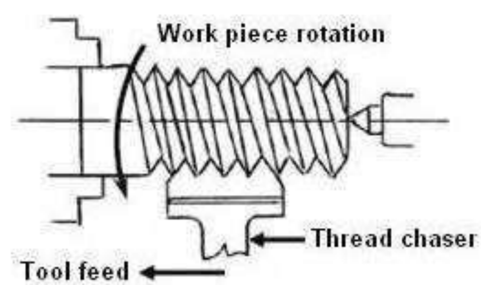




As the dial turns, the graduations pass a fixed reference line. The half-nut is closed for all even threads when any line on the dial coincides with the reference line. For all odd threads, the half-nut is closed at any numbered line on the dial coincides with the reference line. The corresponding number is determined from the charts. If the pitch of the thread to be cut is an exact multiple of the pitch of the lead screw, the thread is called even thread; otherwise the thread is called odd thread.

Thread chaser: A chaser is a multipoint threading tool having the same form and pitch of the thread to be chased. An external thread chaser is shown in Fig. 2.42 (a). A chaser is used to finish a partly cut thread to the size and shape required. Fig. 2.42 (b) shows finishing of a partly cut thread by a thread chaser. Thread chasing is done at about ½ of the speed of turning





2.6.3Other methods for cutting external threads

2.6.3.1 External thread cutting by dies

Machine screws, bolts or studs are quickly made by different types of dies which look and apparently behave like nuts but made of hardened tool steel or HSS and having sharp internal cutting edges. The dies are coaxially rotated around the premachined rod like blank with the help of handle, die stock or die holder. First the proper die is selected according to the thread to be cut. A die holder is selected and the die is inserted in the holder. Then the die holder with die is placed in the tail stock spindle. The work piece is held in a chuck or a collet and rotated at a very slow speed. The tail stock is turned in to cut the threads. The machine is stopped as soon as the correct length of the thread is machined. The threads can also be cut by screwing the die (held in a die holder) on the work piece held and rotated between centres.

Different types of dies used for cutting external threads are:

(a) Solid die: It is used for making threads of usually small pitch and diameter in one pass.

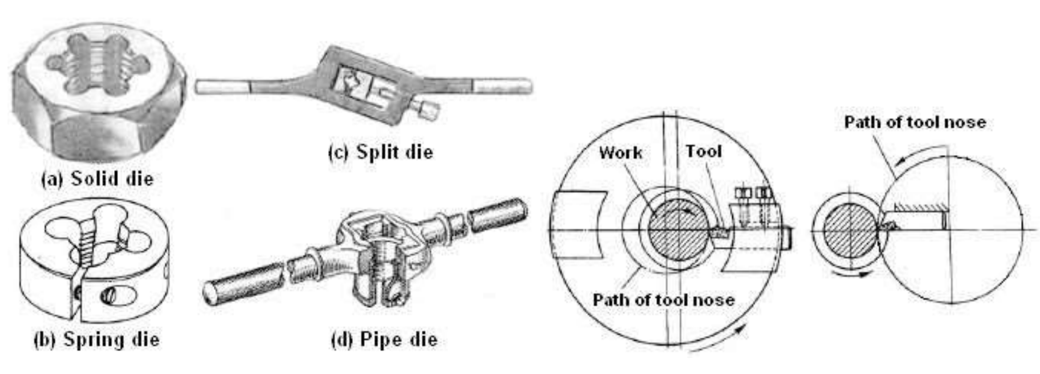
(b) Spring die: The die ring is provided with a slit, the width of the slit is adjustable by a screw to enable elastically slight reduction in the bore and thus cut the thread in number of passes with lesser force on hands.

(c) Split die: The die is made in two pieces, one fixed and one movable (adjustable) within the cavity of the handle or wrench to enable cut relatively larger threads or fine threads on harder blanks easily in number of passes, the die pieces can be replaced by another pair for cutting different threads within small range of variation in size and pitch.

(d) Pipe die: Pipe threads of large diameter but smaller pitch are cut by manually rotating the large wrench (stock) in which the die is fitted through a guide bush.

However the quality of the threads will depend upon the perfection of the dies and skill of the operator.

Fig. 2.43 shows the hand operated dies of common use.



2.6.3.2 External thread cutting by rotating tools

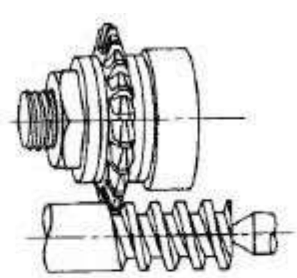
Often it becomes necessary to machine large threads on one or very few pieces of heavy blanks of irregular size and shape like heavy castings or forgings. In such cases, the blank is mounted on face plate in a centre lathe with proper alignment. The deep and wide threads are produced by intermittent cutting action by a rotating tool. A separate attachment carrying the rotating tool is mounted on the saddle and fed as usual by the lead screw of the centre lathe. Fig. 2.44 schematically shows the principles of thread cutting by rotating tool. The tool is rotated fast but the blank much slowly. This intermittent cut enables more effective lubrication and cooling of the tool.

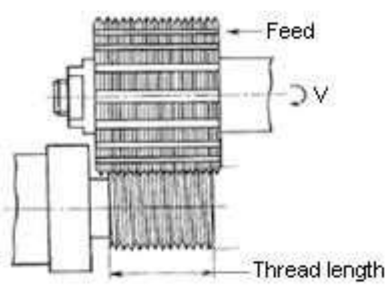
2.6.3.3 External thread cutting by milling cutters

This process gives quite fast production by using suitable thread milling cutters in centre lathes. The milling attachment is mounted on the saddle of the lathe. Thread milling is of two types:

Long thread milling: Long and large diameter screws like machine lead screws are reasonably accurately made by using a large disc type form milling cutter as illustrated in Fig. 2.45 (a).

Short thread milling: Threads of shorter length and fine pitch are machined at high production rate by using a HSS milling cutter having a number of annular threads with axial grooves cut on it for generating cutting edges. Each job requires only around 1.25 revolution of the blank and very short axial (1.25 pitch) and radial (1.5 pitch) travel of the rotating tool. This is illustrated in Fig. 2.45 (b).





2.6 Constructional features of speed gear box and feed gear box

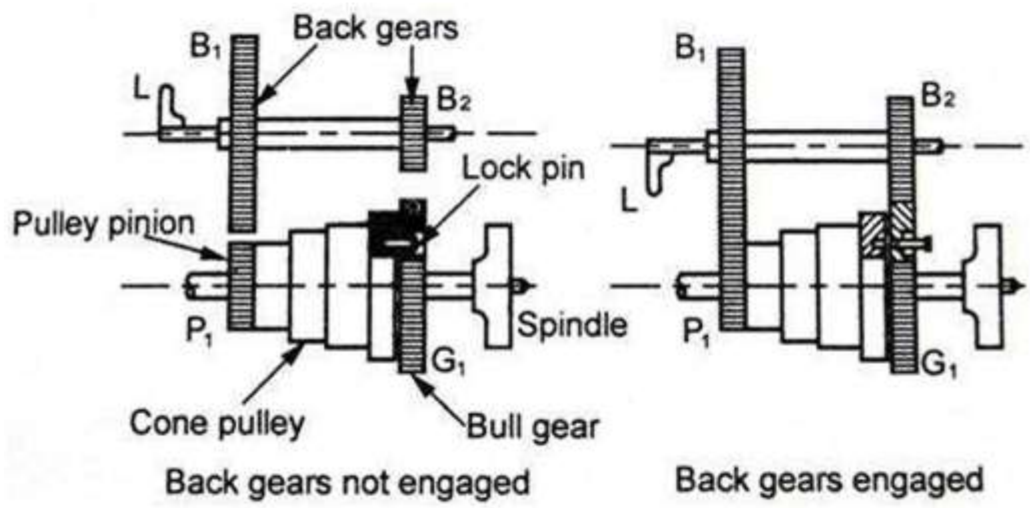
Headstock driving mechanisms

There are two types of headstock driving mechanisms as follows:

1. Back geared headstock.
2. All geared headstock.

Back geared headstock

Back gear arrangement is used for reducing the spindle speed, which is necessary for thread cutting and knurling. The back gear arrangement is shown in Fig.2.3.



There is one stepped cone pulley in the lathe spindle. This pulley can freely rotate on the spindle. A pinion gear P_1 is connected to small end of the cone pulley. P_1 will rotate when cone pulley rotates. Bull gear G_1 is keyed to lathe spindle such that the spindle will rotate when Gear G_1 rotates. Speed changes can be obtained by changing the flat belt on the steps. A bull gear G_1 may be locked or unlocked with this cone pulley by a lock pin.

There are two back gears B_1 and B_2 on a back shaft. It is operated by means of hand lever L; back gears B_1 and B_2 can be engaged or disengaged with G_1 and P_1. For getting direct speed, back gear is not engaged. The step cone pulley is locked with the main spindle by using the lock pin. The flat belt is changed for different steps. Thus three or four ranges of speed can be obtained directly

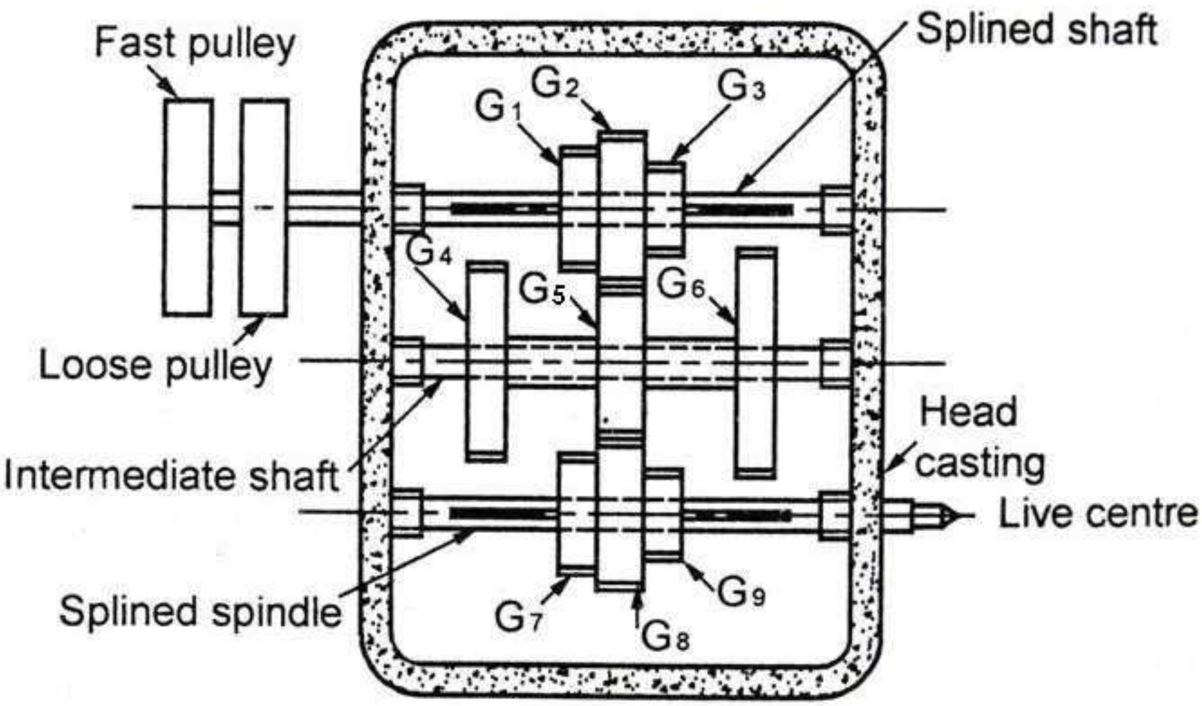
For getting slow or indirect speeds, back gear is engaged by lever L and lock pin is disengaged. Now, power will flow from P_1 to B_1. B_1 to B_2 (same shaft), B_2 to G_1 to spindle. As gear B_1 is larger than P_1, the speed will further be reduced at B_1. B_1 and B_2 will have the same speeds. The speed will further be reduced at G_1 because gear G_1 is larger than B_2. So, the speed of spindle is reduced by engaging the back gear.

All geared headstock

All geared headstock is commonly used in modern lathes because of the following advantages:

- It gives wider range of spindle speeds.
- It is more efficient and compact than cone pulley mechanism.
- Power available at the tool is almost constant for all spindle speeds. Belt shifting is eliminated.
- The vibration of the spindle is reduced. More power can be transmitted.

The all geared headstock is shown in Fig 2.4.



The power from the constant speed motor is delivered to the spindle through a belt drive. Speed changing is made by levers. The different spindle speeds are obtained by shifting the levers into different positions to obtain different gear combinations. This mechanism has a splined spindle, intermediate shaft and a splined shaft. The splined shaft receives power from motor through a belt drive.

This shaft has 3 gears namely G_1, G_2 and G_3. These gears can be shifted with the help of lever along the shaft. Gears G_4, G_5 and G_6 are mounted on intermediate shaft and cannot be moved axially. Gears G_7, G_8 and G_9 are mounted on splined headstock spindle and can be moved axially be levers. Gears G_1, G_2 and G_3 can be meshed with the gears G_4, G_5 and G_6 individually. Similarly, gears G_7, G_8, G_9 can be meshed with gear G_4, G_5 and G_6 individually. Thus, it provides nine different speeds.

Feed mechanisms

The feed mechanism is used to transmit power from the spindle to the carriage. Therefore, it converts rotary motion of the spindle into linear motion of the carriage. The feed can be given either by hand or automatically. For automatic feeding, the following feed mechanisms are used:

Tumbler gear reversing mechanism.

Quick-change gearbox.

Tumbler gear quick-change gearbox. Apron mechanism.

Bevel gear feed reversing mechanism.

2.2.4.1Tumbler gear reversing mechanism

Tumbler gear mechanism is used to change the direction of lead screw and feed rod. By engaging tumbler gear, the carriage can be moved along the lathe axis in either direction during thread cutting or automatic machining. Fig. 2.5 shows the schematic arrangement of tumbler gear reversing mechanism.

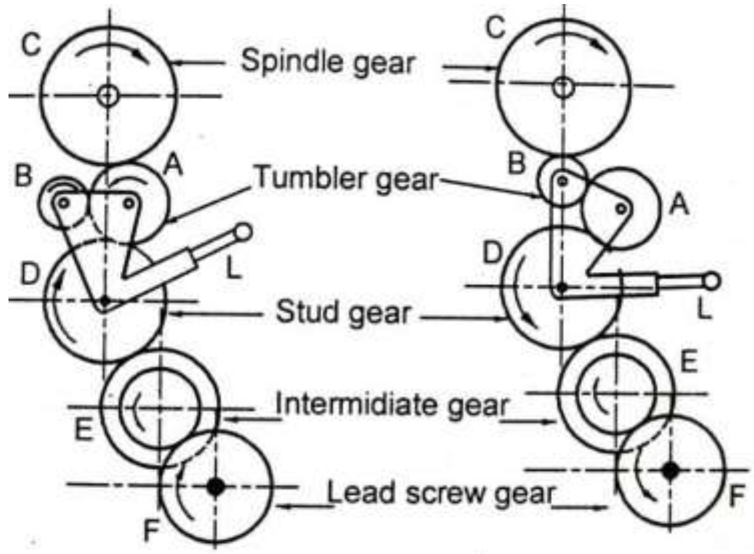


Fig. 2.5 Tumbler gear reversing mechanism

The tumbler gear unit has two pinions (A and B) of same size and is mounted on a bracket. The bracket is pivoted at a point and can be moved up and down by a lever L. The bracket may be placed in three positions i.e., upward, downward and neutral. Gear 'C' is a spindle gear attached to the lathe spindle. Gear 'D' is the stud gear. The stud gear is connected to the lead screw gear through a set of intermediate gears.

When the lever is shifted upward position, the gear 'A' is engaged with spindle gear 'C' and the power is transmitted through C-A-D-E-F. During this position, lead screw will rotate in the same direction as spindle rotates (i.e. both anticlockwise). Now, the carriage moves towards the headstock. When the lever is shifted downward, the gear 'B' is engaged with spindle gear 'C' and the power is transmitted through C-B-A-D-E-F. Hence, the lead screw will rotate in the opposite direction of the spindle. Now, the carriage moves towards tailstock.

When the bracket is in neutral position, the engagement of tumbler gears is disconnected with the spindle gear. Hence, there is no power transmission to lead screw.

2.2.4.2Quick-change gear box

Quick-change gearbox is used to get various power feeds in the lathe. Fig. 2.6 shows the schematic arrangement of quick-change gear box.

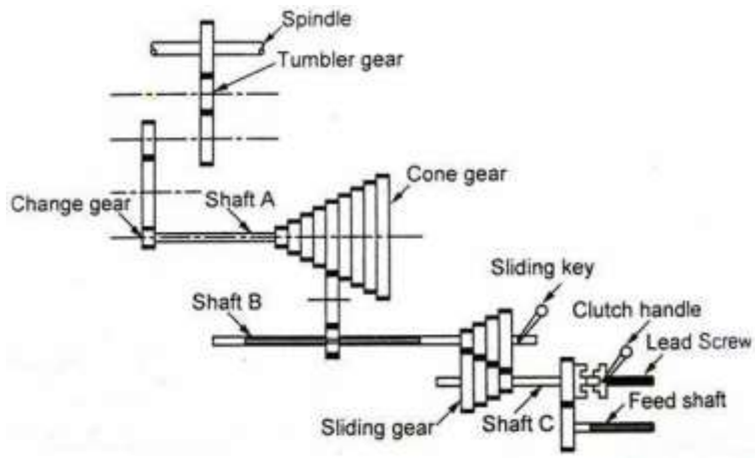


Fig. 2.6 quick-change gear box

Power from the lathe spindle is transmitted to feed shaft through tumbler gear, change gear train and quick-change gearbox. Shaft A (Cone gear shaft) contains 9 different sizes of gears keyed with it. Shaft B (Sliding gear shaft) has a gear and it receives 9 different speeds from shaft A by the use of sliding gear. Shaft B is connected to shaft C (Driven shaft) through 4 cone years. Therefore, Shaft C can get 9 X 4 = 36 different speeds. The shaft C is connected to lead screw by a clutch and feed rod by a gear train. Lead screw is used for thread cutting and feed rod is used for automatic feeds.

2.2.4.3Tumbler gear quick-change gear box

The different speed of the driving shaft is obtained by a tumbler gear and cone gear arrangement. Fig. 2.7 shows the schematic arrangement of tumbler gear quick-change gear box.

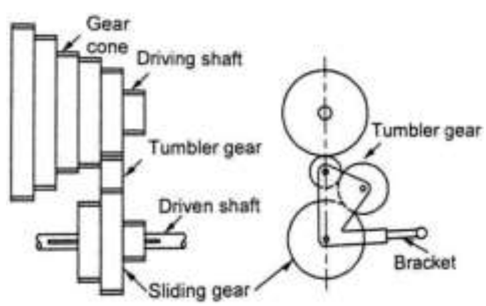


Fig. 2.7 Tumbler gear quick-change gearbox

It is simpler than quick-change gearbox. A tumbler gear and a sliding gear are attached to the bracket as shown in Fig. 2.7. Driving shaft has a cone gear made up of different sizes of gears. The sliding gear is keyed to the driven shaft which is connected by the lead screw or feed rod. The sliding gear can be made to slide and engaged at any desired position. By sliding the sliding gear to various positions and engaging the tumbler gear, various speeds can be obtained.

2.2.4.4Apron mechanism

Fig. 2.8 shows the schematic arrangement of apron mechanism.

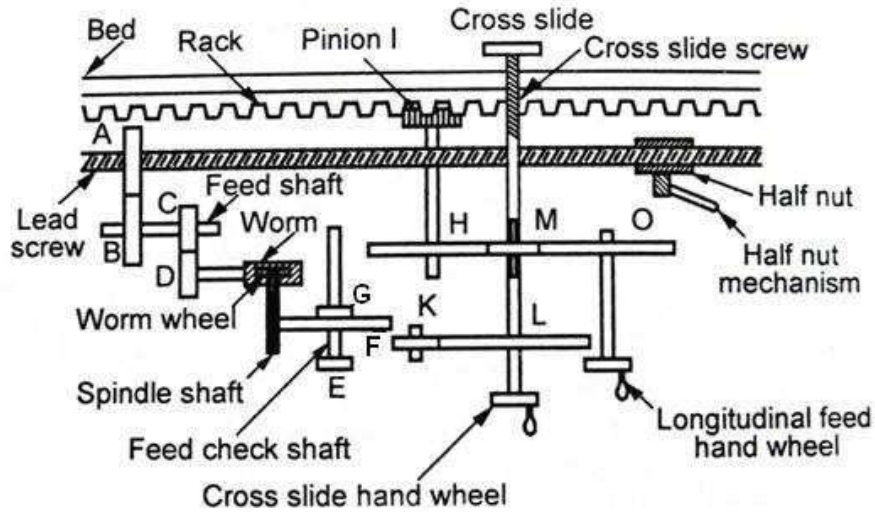


Fig. 2.8 Apron mechanism

Lead screw and feed rod is getting power from spindle gear through tumbler gears. Power is transmitted from feed rod to the worm wheel through gears A, B, C, D and worm.

A splined shaft is attached with worm wheel. The splined shaft is always engaged with the gears F and G which are keyed to the feed check shaft. A knob ‘E’ is fitted with feed check shaft. Feed check knob ‘E’ can be placed in three positions such as neutral, push-in and pull-out.

When the feed check knob ‘E’ is in neutral position, power is not transmitted either to cross feed screw or to the carriage since gears F and G have no connection with H and K. Therefore, hand feed is given as follows. When the longitudinal feed hand wheel rotates, pinion I will also be rotated through I and H. pinion I will move on rack for taking longitudinal feed. For getting cross feed, cross slide screw will be rotated by using cross slide hand wheel.

When the feed check knob ‘E’ is push-in, rotating gear G will be engaged to H. then the power will be transmitted to pinion I. pinion I will rotate on rack. So, automatic longitudinal feed takes place. When the feed check knob ‘E’ is pulled-out, the rotating gear F will be engaged to K. Hence, the power will be transmitted to cross feed screws through L. This leads to automatic cross feed.

For thread cutting, half nut is engaged by half nut lever after putting knob ‘E’ neutral position. Half nut is firmly attached with the carriage. As the lead screw rotates, the carriage will automatically move along the axis of the lathe. Both longitudinal and cross feed can be reversed by operating the tumbler gear mechanism.

2.2.4.5Bevel gear feed reversing mechanism

The tumbler gear mechanism being a non-rigid construction cannot be used in a modern heavy duty lathe. The clutch operated bevel gear feed reversing mechanism incorporated below the head stock or in apron provides sufficient rigidity in construction. Fig. 2.9 shows the schematic arrangement of bevel gear feed reversing mechanism.

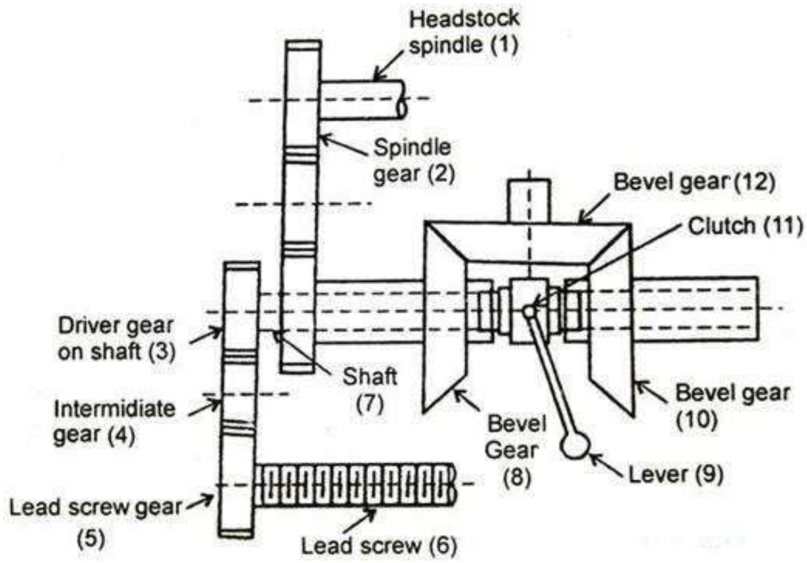


Fig. 2.9 Bevel gear feed reversing mechanism

The motion is communicated from the spindle gear 2 to the gear on the stud shaft through the intermediate gear. The bevel gear 8 is attached to the gear on the stud shaft and both of them can freely rotate on shaft 7. The bevel gear 8 meshes with bevel gear 12 and 12 mesh with 10. 12, 10 and 8 are having equal number of teeth. The bevel gear 10 can also rotate freely on shaft 7.

A clutch 11 is keyed to the shaft 7 by a feather key and may be shifted to left or right, by the lever 9 to be engaged with the gear 8 or 10 or it remains in the neutral position. When the clutch engages with bevel gear 8, gear 3 which is keyed to the shaft 7 and the lead screw, rotates in the same direction as the gear 2. The direction of rotation is reversed when the clutch 11 engages with gear 10.

2.7 Turret and capstan lathes

CAPSTAN AND TURRET LATHES

Capstan and turret lathes are production lathes used to manufacture any number of identical pieces in the minimum time. These lathes are development of centre lathes. The capstan lathe was first developed in the year 1860 by Pratt and Whitney of USA.

In contrast to centre lathes, capstan and turret lathes:

- Are relatively costlier.
- Are requires less skilled operator.
- Possess an axially movable indexable turret (mostly hexagonal) in place of tailstock.
- Holds large number of cutting tools; up to four in indexable tool post on the front slide, one in the rear slide and up to six in the turret (if hexagonal) as indicated in the schematic diagrams.

- Are more productive for quick engagement and overlapped functioning of the tools in addition to faster mounting and feeding of the job and rapid speed change.
- Enable repetitive production of same job requiring less involvement, effort and attention of the operator for pre-setting of work-speed and feed rate and length of travel of the cutting tools.
- Are suitable and economically viable for batch production or small lot production.
- Capable of taking multiple cuts and combined cuts at the same time.

Major parts of capstan and turret lathes

Capstan and turret lathes are very similar in construction, working, application and specification. Fig. 2.60 schematically shows the basic configuration of a capstan lathe and Fig. 2.61 shows that of a turret lathe. The major parts are:

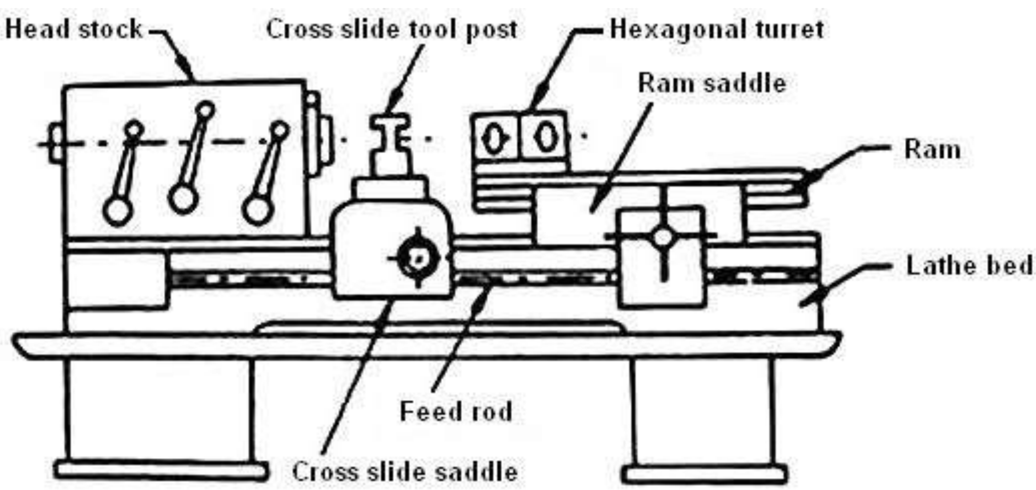


Fig. 2.60 Basic configuration of a Capstan lathe

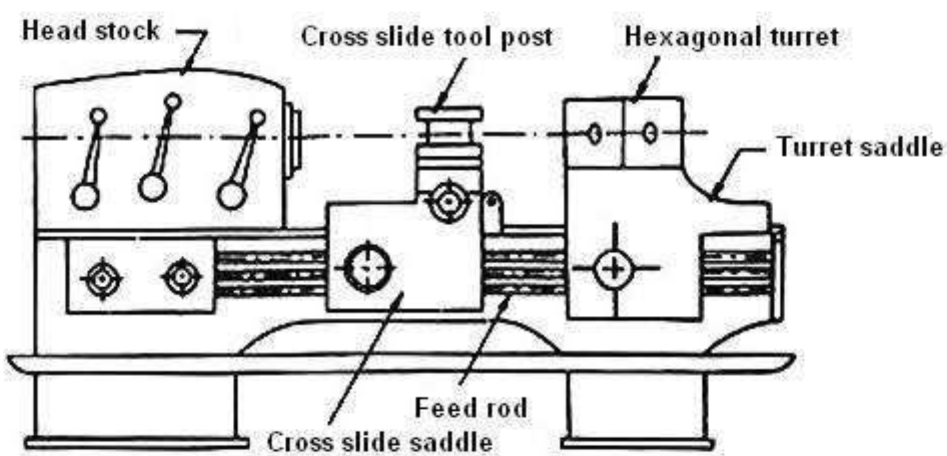


Fig. 2.61 Basic configuration of a Turret lathe

Bed: The bed is a long box like casting provided with accurate guide ways upon which the carriage and turret saddle are mounted. The bed is designed to ensure strength, rigidity and permanency of alignment under heavy duty services.

Headstock: The head stock is a large casting located at the left hand end of the bed. The headstock of capstan and turret lathes may be of the following types:

- Step cone pulley driven headstock.
- Direct electric motor driven headstock. All geared headstock.
- Pre-optive or pre-selective headstock.

Step cone pulley driven headstock: This is the simplest type of headstock and is fitted with small capstan lathes where the lathe is engaged in machining small and almost constant diameter of workpiece. Only three or four steps of pulley can cater to the needs of the machine. The machine requires special countershaft unlike that of an engine lathe, where starting, stopping and reversing of the machine spindle can be effected by simply pressing a foot pedal.

Electric motor driven headstock: In this type of headstock the spindle of the machine and the armature shaft of the motor are one and the same. Any speed variation or reversal is effected by simply controlling the motor. Three of four speeds are available and the machine is suitable for smaller diameter of work pieces rotated at high speeds.

All geared headstock: Onthelargerlathes,theheadstocksare geared and different mechanisms are employed for speed changing by actuating levers. The speed changing may be performed without stopping the machine.

Pre-optive or pre-selective headstock: It is an all geared headstock with provisions for rapid stopping, starting and speed changing for different operations by simply pushing a button or pulling a lever. The required speed for next operation is selected beforehand and the speed changing lever is placed at the selected position. After the first operation is complete, a button or a lever is simply actuated and the spindle starts rotating at the selected speed required for the second operation without stopping the machine. This novel mechanism is effect by the friction clutches.

Cross slide and saddle: In small capstan lathes, hand operated cross slide and saddle are used. They are clamped on the lathe bed at the required position. The larger capstan lathes and heavy duty turret lathes are equipped with usually two designs of carriage.

Conventional type carriage.

Side hung type carriage.

Conventional type carriage: This type of carriage bridges the gap between the front and rear bed ways and is equipped with four station type tool post at the front, and one rear tool post at the back of the cross slide. This is simple in construction.

Side hung type carriage: The side-hung type carriage is generally fitted with heavy duty turret lathes where the saddle rides on the top and bottom guide ways on the front of the lathe bed. The design facilitates swinging of larger diameter of work pieces without being interfered by the cross-slide. The saddle and the cross-slide may be fed longitudinally or crosswise by hand or power. The longitudinal movement of each tool may be regulated by using stop bars or shafts set against the stop fitted on the bed and carriage. The tools are mounted on the tool post and correct heights are adjusted by using rocking or packing pieces.

Ram saddle: In a capstan lathe, the ram saddle bridges the gap between two bed ways, and the top face is accurately machined to provide bearing surface for the ram or auxiliary slide. The saddle may be adjusted on lathe bed ways and clamped at the desired position. The hexagonal turret is mounted on the ram or auxiliary slide.

Turret saddle: In a turret lathe, the hexagonal turret is directly mounted on the top of the turret saddle and any movement of the turret is effected by the movement of the saddle. The movement of the turret may be effected by hand or power.

Turret: The turret is a hexagonal-shaped tool holder intended for holding six or more tools. Each face of the turret is accurately machined. Through the centre of each face accurately bored holes are provided for accommodating shanks of different tool holders. The centre line of each hole coincides with the axis of the lathe when aligned with the headstock spindle. In addition to these holes, there are four tapped holes on each face of the turret for securing different tool holding attachments. The photographic view of a hexagonal turret is shown in Fig. 2.62.

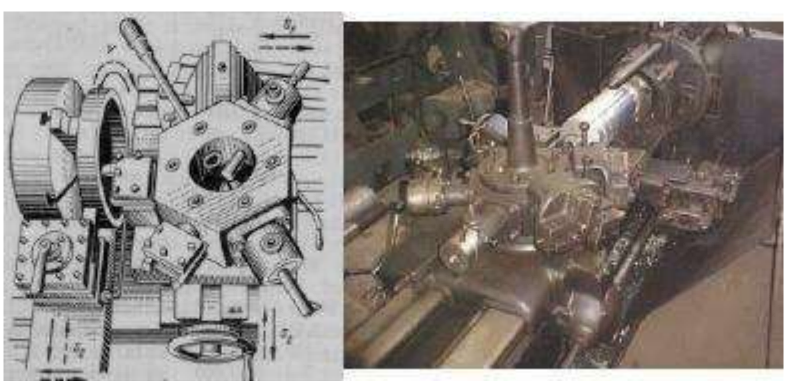


Fig. 2.62 Photographic view of a hexagonal turret

Working principle of capstan and turret lathes

The work pieces are held in collets or chucks. In turret lathes, large work pieces are held by means of jaw chucks. These chucks may be hydraulically or pneumatically operated. In a capstan lathe, bar stock is held in collet chucks. A bar feeding mechanism is used for automatic feeding of bar stock. At least eleven tools can be set at a time in turret and capstan lathes. Six tools are held on the turret faces, four tools in front square tool post and one parting off tool at the rear tool post. While machining, the turret head moves forward towards the job. After each operation, the turret head goes back. The turret head is indexed automatically and the next tool comes into machining position. The indexing is done by an indexing mechanism. The longitudinal movement of the turret corresponding to each of the turret position can be controlled independently.

By holding different tools in the turret faces, the operations like drilling, boring, reaming, counter boring, turning and threading can be done on the component. Four tools held on the front tool post are used for different operations like necking, chamfering, form turning and knurling. The parting off tool in the rear tool post is used for cutting off the workpiece. The cross wise movements of the rear and front tool posts are controlled by pre-stops.

Bar feeding mechanisms

The capstan and turret lathes while working on bar work require some mechanism for bar feeding. The long bars which protrude out of the headstock spindle require to be fed through the spindle up to the bar stop after the first piece is completed and the collet chuck is opened. In simple cases, the bar may be pushed by hand. But this process unnecessarily increases the total production time by stopping, setting, and starting the machine. Therefore, various types of bar feeding mechanisms have been designed which push the bar forward immediately after the collet releases the work without stopping the machine, enabling the setting time to be reduced to the minimum.

Type 1: This mechanism is shown in Fig. 2.63. After the work piece is complete and part off, the collet is opened by moving the lever manually in the rightward direction. Further movement of the lever in the same direction causes forward push of the bar with the help of ratchet - pawl system. After the projection of the bar from the collet face to the desired length controlled by a preset bar stop generally held in one face of the turret, the lever is moved in the leftward direction to close the collet. Just before closing the collet, the leftward movement of the lever pushes the ratchet bar to its initial position.

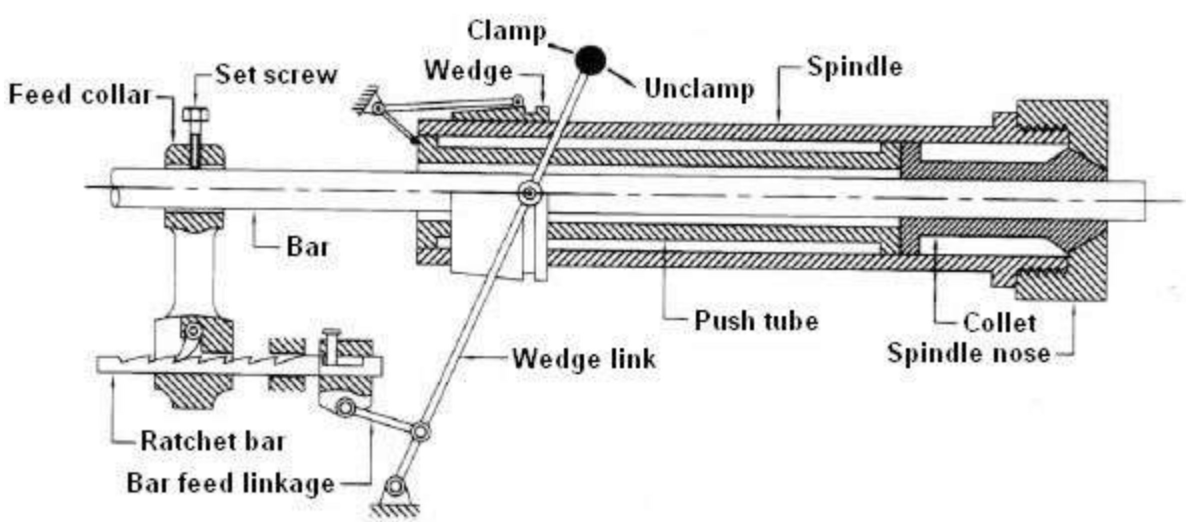


Fig. 2.63 Bar feeding mechanism

Type 2: This mechanism is shown in Fig. 2.64. The bar is passed through the bar chuck, spindle of the machine and then through the collet chuck. The bar chuck rotates in the sliding bracket body which is mounted on a long sliding bar. The bar chucks grips the bar centrally by two set screws and rotates with the bar in the sliding bracket body. One end of the chain is connected to the pin fitted on the sliding bracket and the other end supports a weight. The chain running over two fixed pulleys mounted on the sliding bar. The weight constantly exerts end thrust on the bar chuck while it revolves on the sliding bracket and forces the bar through the spindle at the moment the collet chuck is released. Thus bar feeding may be accomplished without stopping the machine.

In this way the bar is fed without stopping the machine. After a number of such feedings, the bar chuck will approach the rear end of the head stock. Now the bar chuck is released from the bar and brought to the left extreme position. Then it is screwed on to the bar.

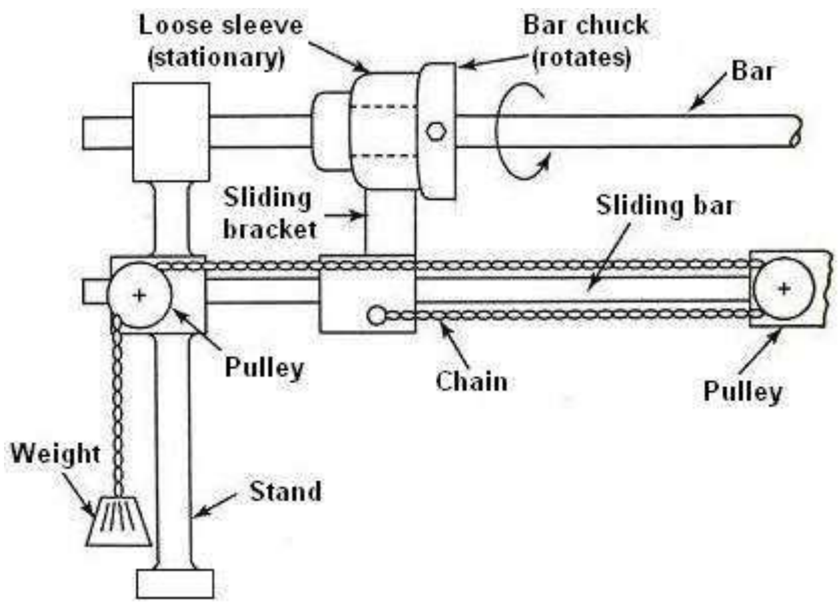


Fig. 2.64 Bar feeding mechanism

2.10.4 Turret indexing mechanism

Construction: Fig. 2.65 shows the schematic view of the turret indexing mechanism. It illustrates an inverted plan of the turret assembly. This mechanism is also called as Geneva mechanism. There is a small vertical spindle fixed on the turret saddle. At the top of the spindle, the turret head is mounted. Just below the turret head on the same spindle, a circular index plate having six slots, a bevel gear and a ratchet are mounted. There is a spring actuated plunger mounted on the saddle which locks the index plate this prevents the rotation of turret during the machining operation. A pin fitted on the plunger projects out of the housing. An actuating cam and an indexing pawl are fitted to the lathe bed at the required position. Both cam and pawl are spring loaded.

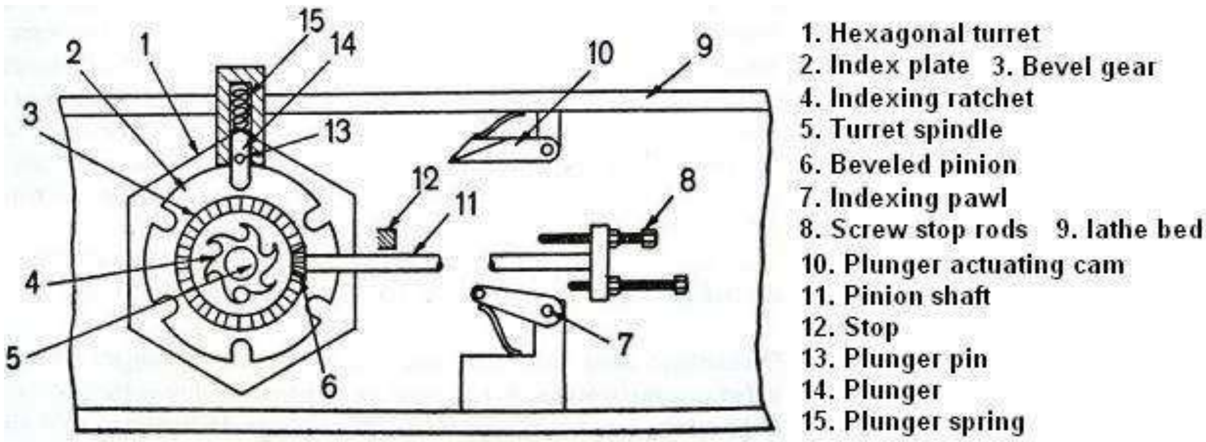


Fig. 2.65 Turret indexing mechanism

Working principle: When the turret reaches the backward position (after machining) the projecting pin of the plunger rides over the sloping surface of the cam. So the plunger is released from the groove of the index plate. Now the spring loaded pawl engages the ratchet groove and rotates it. The index plate and the turret spindle rotate through 1/6 of a revolution. The pin and the plunger drop out of the cam and hence the plunger locks the index plate at the next groove. The turret is thus indexed and again locked into the new position automatically. The turret holding the next tool is now fed forward and the pawl is released from the ratchet plate by the spring pressure.

The corresponding movement of the stop rods with the indexing of the turret can also be understood from the Fig. 2.65. The pinion shaft has a bevel pinion at one end. The bevel pinion meshes with the bevel gear mounted on the turret spindle. At its other end, a circular plate is connected. Six adjustable stop rods are fitted to this circular plate. When the turret rotates, the bevel pinion will also rotate. And hence the circular stop plate is also indexed by 1/6 of a revolution. The ratio of the teeth between the pinion and the gear is chosen according to this rotation.

2.8 Collet chucks - other work holders

2.10.5 Work holding devices used in capstan and turret lathes

The standard practice of holding the work piece between two centres in a centre lathe finds no place in a capstan lathe or turret lathe as there is no dead centre to support the work piece at the other end. Therefore, the work piece is held at the spindle end by the help of chucks and fixtures. The usual methods of holding the work piece in a capstan and turret lathes are:

1. Jaw chucks

The jaw chucks are used in capstan lathes having two, three or four jaws depending upon the shape of the work piece. The jaw chucks are used to support odd sized jobs or jobs having larger diameter which cannot be introduced through the headstock spindle and gripped by collet chucks.

2-jaw chuck self centering chuck

It is used for bar work. The two jaws hold the irregular work more readily since the clamping is at two points which are diametrically opposite. It is available in size from about 125 mm to 250 mm outside diameter to hold bar stock of diameter from about 20 mm to 45 mm.

3-jaw chuck self centering chuck

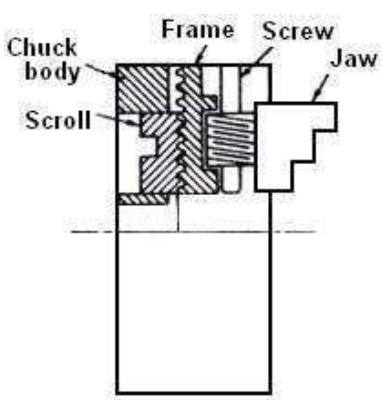
It is used for holding round or hexagonal bar stock or other symmetrical work. It is suitable for gripping larger diameter bars, circular castings, forgings etc. It is available in size from about 100 mm to 750 mm outside diameter and they can hold work up to about 650 mm diameter. The 3-jaw chuck has been described in Article 2.2.5.1, Page 57 and illustrated in Fig. 2.10 (a).

4-jaw independent chuck

It is used occasionally for gripping irregular shaped workpiece, where the number of articles required does not justify the manufacture of special fixtures. It is used for holding rough castings and square or octagonal work. Each jaw can be operated independently and is reversible. It is available in sizes up to about 1000 mm diameter. The 4-jaw chuck has been described in Article 2.2.5.1, Page 57 and illustrated in Fig. 2.10 (b).

Combination chuck

The combination chuck is shown in Fig. 2.66. As the name implies, a combination chuck may be used both as a self centering and an independent chuck to take advantage of both the types. The jaws may be operated individually by separate screws or simultaneously by the scroll disc. The screws mounted on the frame have teeth cut on its underside which meshes with the scroll and all the jaws together with the screws move radially when the scroll is made to rotate by a pinion.



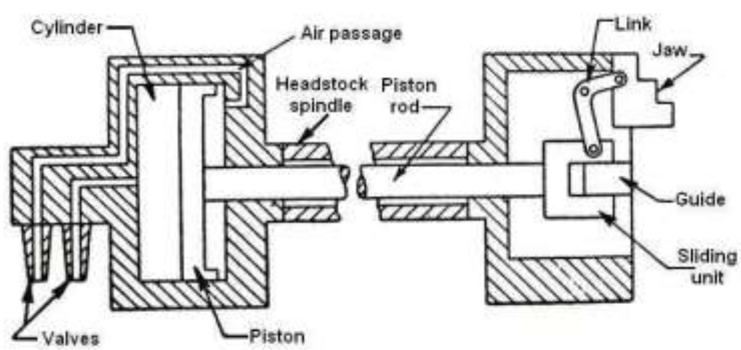


Fig. 2.66 Combination chuck Fig. 2.67 Air operated chuck

Air operated chuck

The air operated chuck is shown in Fig. 2.67. Heavy duty turret lathes and capstan lathes engaged in mass production work are equipped with air operated chucks for certain distinct advantages. The chuck grips the work piece quickly and is capable of taking powerful grip with least manual exertion. The chucks are operated by air at a pressure of 5.5 kg/cm2 to 7 kg/cm2.

The mechanism incorporates an air cylinder mounted at the back end of the headstock spindle and rotates with it. Fluid pressure may be communicated to the cylinder by operating a valve with a lever and the piston will slide within the cylinder. The movement of the piston is transmitted to the jaws by means of connecting rod and links. A guide is provided for the movement of the connecting rod.

To clamp the work piece, compressed air is admitted to the cylinder at the right side of the piston. The piston slides to the left side and the jaws grip the work piece securely. To release the work piece, the air is admitted to the left side of the piston. Then the piston slides to the right side and the jaws unclamp the work piece.

2. Collet chucks

Collet chucks or collets are used mainly to hold bar stock, especially in the smaller sizes. A collet is a circular steel shell having three or four equally spaced slits extending the greater part of its length. These slits impart springing action to the collet. That is why, collets are also known as “spring collets”. The collet nose is made thicker to form the jaws. The outside surface of the nose fits in the taper hole of the hood. The inside of the collet is made according to the shape of the work to be held.

Collets are much more suitable than a self centering chuck in mass production work due to its quickness in action and accurate setting. The collets may be operated by hand or by power. The collets are classified by the methods used to close the jaws on the work.

Push out type Collet chuck

The push out type collet chuck is shown in Fig. 2.68 (a). In this type the taper of the collet nose and hood converge towards the right. To grip the work, the tapered portion of the spring collet is pushed into the mating taper of the hood. There is a tendency of the bar to be pushed slightly outward when the collet is pushed for gripping. If the bar is fed against a stop bar fitted on the turret head, this slight outward movement of the bar ensures accurate setting of the length for machining.

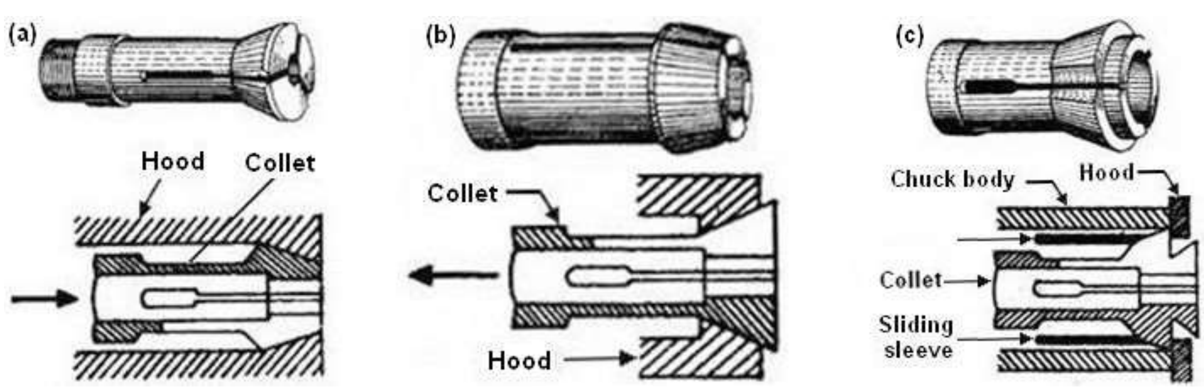


Fig. 2.68 Collet chucks (a) Push out type (b) draw back type (c) Dead length type

Draw back or Draw in type Collet chuck

The drawback type collet chuck is shown in Fig. 2.68 (b). In this type the taper of the collet nose and hood converge towards the left. To grip the work, the tapered portion of the spring collet is pulled back into the mating taper of the hood which causes the split end of the collet to close in and grip the bar. The machining length of the bar in this type of chuck cannot be accurately set as the collet while closing will draw the bar slightly inward towards the spindle.

Dead length type Collet chuck

The dead length type collet chuck is shown in Fig. 2.68 (c). For accurate positioning of the bar, both the push out and draw in type collet present some error due to the movement of the bar along with the collet while gripping. This difficulty is removed by using a stationary collet on the bar. In this type the taper of the collet nose converge towards the left. A sliding sleeve is placed between the collet and the hood. This sliding sleeve has a tapered edge which fits on the taper of the collet nose. To grip the work, the sliding sleeve is pushed towards the right. This makes the collet to close in and grip the bar. The end movement of the collet is prevented by the shoulder stop.

3. Fixtures

A fixture may be described as a special chuck built for the purpose of holding, locating and machining a large number of identical pieces which cannot be easily held by conventional gripping devices. Fixtures also serve the purpose of accurately locating the machining surface.

The main functions of a fixture are as follows:

- It accurately locates the work.
- It grips the work properly, preventing it from bending or slipping during machining operations. It permits rapid loading and unloading of workpiece.

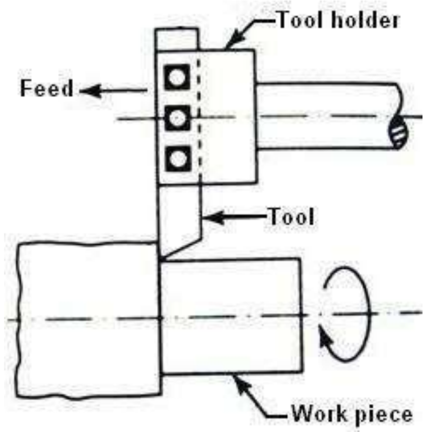
2.9 Tool holding devices

2.10.6 Tool holding devices used in capstan and turret lathes

The wide variety of work performed in a capstan or turret lathe in mass production necessitated designing of many different types of tool holders for holding tools for typical operations. The tool holders may be mounted on turret faces or on cross-slide tool post and may be used for holding tools for bar and chuck work. Certain tool holders are used for holding tools for both bar and chuck work while box tools are particularly adapted in bar work.

Straight cutter holder

This is a simple tool holder constructed to take standard section tool bits. The shank of the holder can be mounted directly into the hole of the turret face or into a hole of a multiple turning head. In this type of holder, the tool is held perpendicular to the shank axis. The tool is gripped in the holder by three set screws. Different operations like turning, facing, boring, counter boring, chamfering, etc. can be performed by holding suitable tools in the holder. Fig.2.69 illustrates a straight cutter holder.



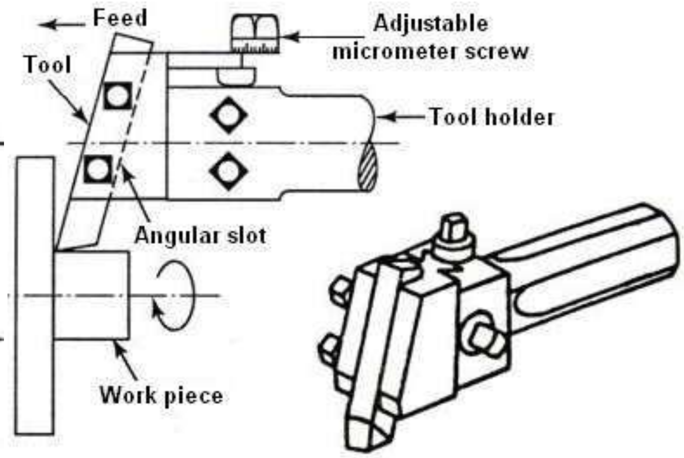


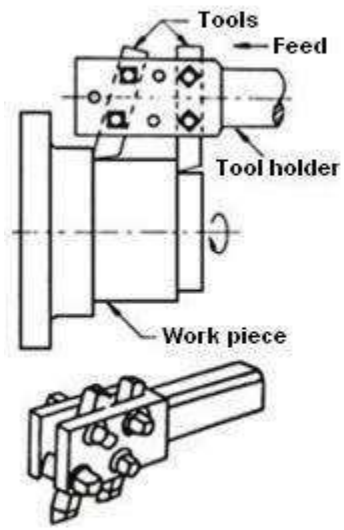
Fig. 2.69 straight cutter holder   Fig. 2.70 Adjustable angle cutter holder

Plain or adjustable angle cutter holder

It is similar as that of a straight cutter holder but having an angular slot. The tool is fitted in this slot by means of setscrews. The inclination of the tool helps in turning or boring operations close to the chuck jaws or up to the shoulder of the work piece without any interference. In plain type of holder, the setting of the cutting edge relative to the work is effect by opening the set screws and then adjusting the tool by hand. In adjustable type of holder, the accurate setting of the tool can be effect by rotating a micrometer screw. Fig.2.70 illustrates an adjustable angle cutter holder.

Multiple cutter holders

This holder can accommodate two or more tools in its body. This feature enables turning of two different diameters simultaneously. This will reduce the time of machining. Turning and boring tools can also be set in the holder to perform two operations at a time. Fig.2.71 illustrates a multiple cutter holder.



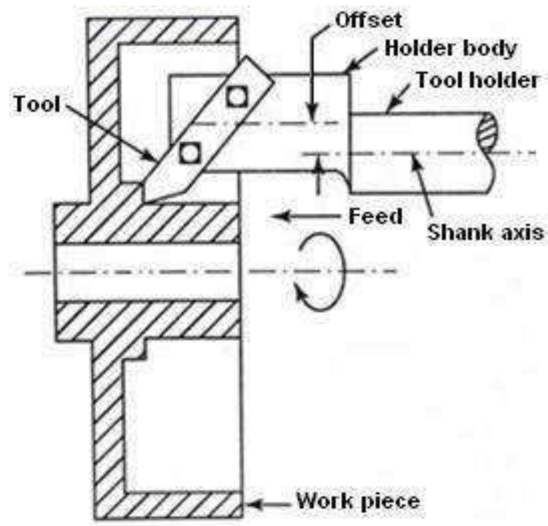


Fig. 2.71 Multiple cutter holder Fig. 2.72 Offset cutter holder

Offset cutter holder

In this type, the holder body is made offset with the shank axis. Larger diameter work can be turned or bored by this type of holder. Fig.2.72 illustrates an offset cutter holder.

Combination tool holder or multiple turning head

It is used for holding straight, angular, multiple or offset cutter holders, boring bars, etc. for various turning and boring operations, so that it may be possible to undertake a number of operations simultaneously. The tools are set at different positions on the work surface by inserting the shank of tool holders in different holes of the multiple head body, and they are secured to it by tightening separate set screws. A boring bar is held at the central hole of the head which is aligned with the axis of the supporting flange. The head is supported on the turret face by tightening four bolts passing through the holes of the flange. The tool holder has a guide bush. The pilot bar projecting from the head stock of the machine; slides inside the guide bush. This gives additional support to the tool while cutting and prevents any vibration or deflection. Fig.2.73 illustrates a combination tool holder.

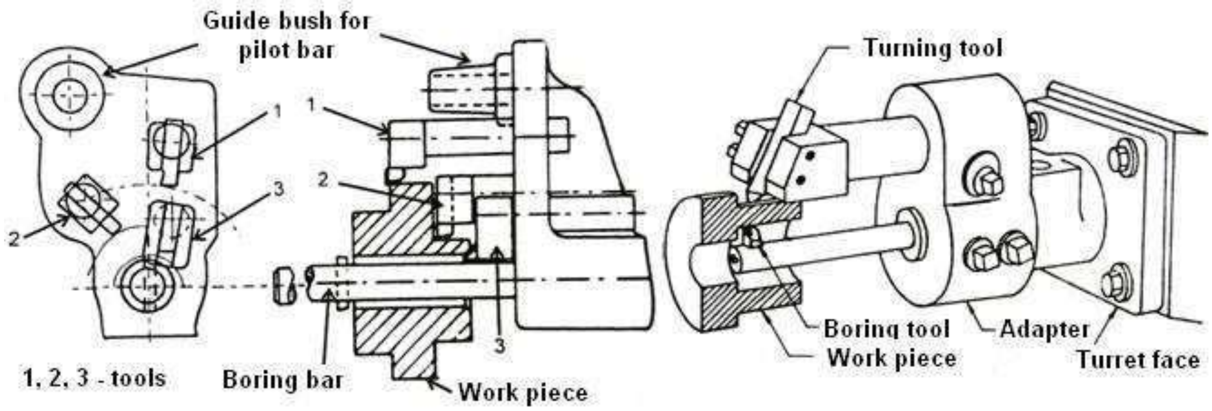
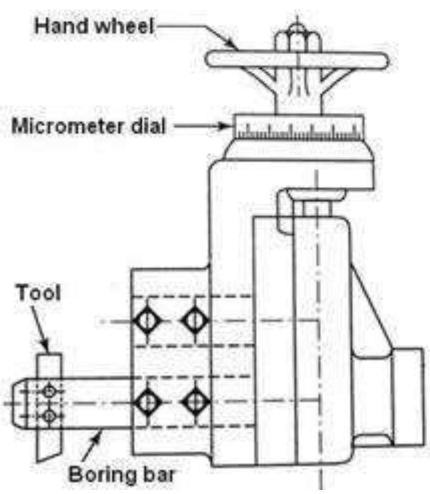


Fig. 2.73 Combination tool holder

Sliding tool holder

It is useful for rough and finish boring, recessing, grooving, facing, etc. The holder consists of a vertical base on which a slide is fitted. The slide may be adjusted up or down accurately by rotating a hand wheel provided with a micrometer dial. Two holes are provided on the sliding unit for holding tools. The lower hole which is aligned with the lathe axis is used for holding boring bars, drills, reamers, etc. The upper hole accommodates a turning tool holder. After necessary adjustments the slide is clamped to the base by a clamping lever for turning or boring operations. For facing or recessing operations, the crosswise movement of the tool is obtained in the vertical plane. The slide is equipped with two adjustable stops for facing or similar operations in order to be able to duplicate the workpiece. The holder base is clamped directly on the turret face by studs. Fig.2.74 illustrates a sliding tool holder.



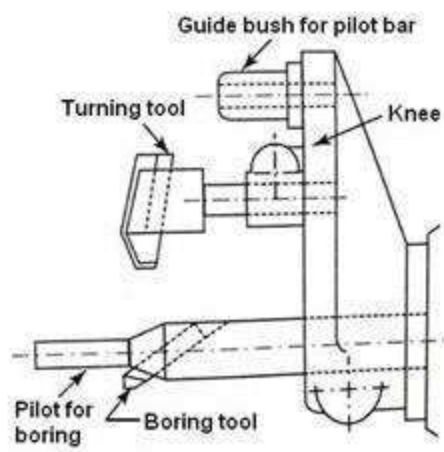


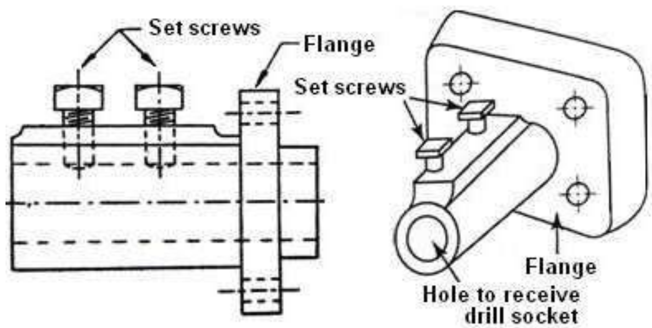
Fig. 2.74 sliding tool holder   Fig. 2.75 Knee tool holder

Knee tool holder

It is useful for simultaneous turning and boring or turning and drilling operations. The knee holder is bolted directly on the turret face. The axis of the lower hole coincides with the lathe axis and is used for holding boring bars, drills, etc. The turning tool holder is fitted in to the centre hole. A guide bush is provided at the top of the holder for running of pilot bar. Fig.2.75 illustrates a knee tool holder.

Flange tool holder

This holder is also called as extension holder, drill holder or boring bar holder. These holders are intended for holding drills, reamers, boring bars, etc. The twist drills having Morse taper shanks are usually held in a socket which is parallel outside and tapered inside. The socket is introduced in the hole of the flange tool holder and clamped to it by set screws. The flanged end of the holder is bolted directly to the face of the turret and is accurately centered. Fig.2.76 illustrates a flange tool holder.



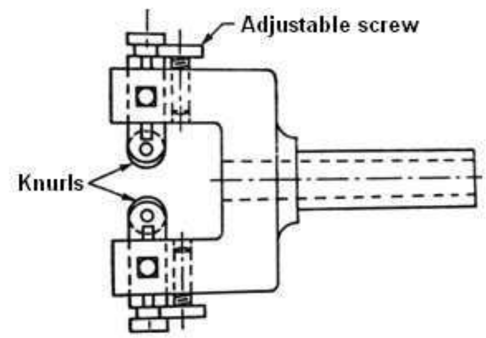


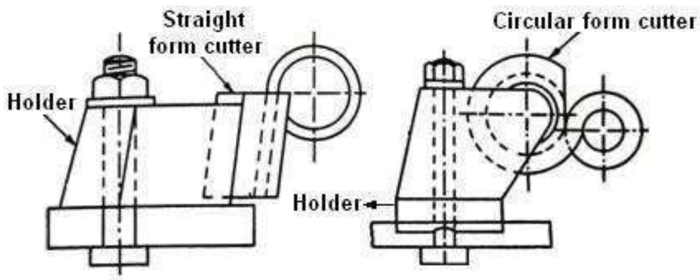
Fig. 2.76 Flange tool holder Fig. 2.77 Knurling tool holder

Knurling tool holder

It may be mounted on the turret face or on the tool posts of the cross-slide. The holders with knurls mounted on the cross-slide can perform knurling operation on any diameter work. Fig 2.77 illustrates a knurling tool holder which is fitted on the turret face. The position of knurls can be adjusted in a vertical plane to accommodate different diameters of work, while the relative angle between them can also be varied to produce different patterns of knurled surface.

Form tool holder

Two sets of form tool holders have been designed for holding straight and circular form cutters. The usual procedure of holding a form tool holder is on the cross-slide. In the straight form tool holder, the tool is mounted on a dovetail slide and the height of the cutting edge may be adjusted by moving the tool within the slide. The height of the circular form tool may be adjusted by rotating the circular cutter. Fig.2.78 illustrates a form tool holder.



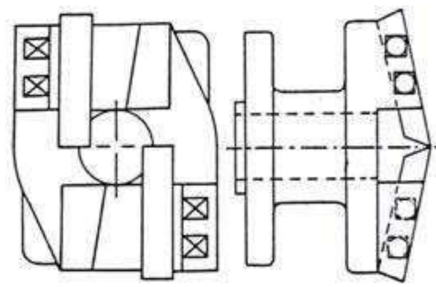


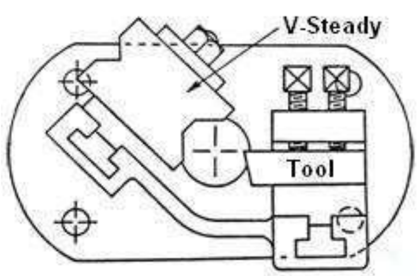
Fig. 2.78 Form tool holder Fig. 2.79 Balanced tool holder

Balanced tool holder

Its name is derived from the fact that the tools mounted on the holder are so arranged that the cutting thrust exerted by one of the tools on the work is balanced by the cutting thrust developed by the other tool fitted on the holder. This prevents any bending of the work and obviates the use of any other work support. Fig.2.79 illustrates a balanced tool holder.

V-Steady tool holder

The V-steady box tool holders are used for lending support to the workpiece while cutting action progresses from the end of a bar stock. Both the tool and V-steady are mounted on the adjustable slide in order to set the required diameter of the machined part and to position the tool relative to the V-steady. The V-steady tool holder is mainly used in brass work. Fig.2.80 illustrates a V-Steady tool holder.



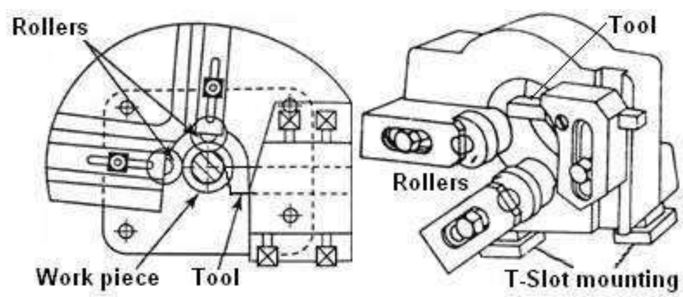


Fig. 2.80 V-Steady tool holder Fig. 2.81 Roller steady box tool holder

Roller steady box tool holder

It is commonly used in bar work for turning steel rods. In construction, it replaces V-steady and in its place two rollers are used to provide support to the work. The tool and the rollers can be adjusted in the holder for proper setting. A high class finish is obtained on the work surface due to burnishing action of the rollers on the work. The rollers acting against the cutting pressure remove the feed marks on the workpiece. Fig.2.81 illustrates a roller steady box tool holder.

2.10.7 Comparison of capstan and turret lathes

Sl . No.	Capstan lathe	Turret lathe
1	Turret head is mounted on a ram which slidesover the saddle.	Turret head is directly mounted on saddle. But it slides on the bed.

2	The turret movement is limited.	The turret moves on the entire length ofthe bed without any restriction.
3	Hence shorter work piece can be machined.	Longer work piece can be machined.
4	Its construction does not provide rigidity dueto overhanging of ram beyond the bed.	It provides rigidity and strong.
5	It is suitable for light duty applications.	It is suitable for heavy duty applications.
6	Turret head can be moved manually.	Turret head cannot be moved manually.
7	The maximum size of 60 mm diameter workcan be accommodated.	It can accommodate only from 125 to 200mm.
8	No cross-wise movement to turret.	Facing and turning are usually done bycross-wise movement of turret.
9	Overhung type of cross-slide is not used.	Overhung type of cross-slide is providedfor some specific operations.

2.10.8 Specifications of capstan and turret lathes

The main sizes to be specified in any capstan and turret lathes are:

- Maximum diameter of the workpiece that can be machined.
- Swing over cross slide.
- Swing over bed.

E.g. 100-200-250 refers to the maximum diameter that can be machined by using this size of lathe is 100 mm, the size of swing over cross slide is 200 mm and the size of swing over bed is 250 mm.

In addition to the above sizes, the following details are also needed to specify the full description about the machine:

- Power of the main drive motor.
- Range of spindle speeds.
- Range of feeds for the carriage.
- Range of feeds for the turret or saddle. Total weight of the machine.
- Floor space required.

2.10 Principal features of automatic lathes

AUTOMATIC LATHES

Highly automated machine tools especially of the lathe family are ordinarily classified as semi automatics and automatics. Automatics as their name implies are machine tools with a fully automatic work cycle. Semi automatics are machine tools in which the actual machining operations are performed automatically in the same manner as on automatics. In this case however, the operator loads the blank into the machine, starts the machine, checks the work size and removes the completed piece by hand.

Work holding devices used in automatic lathes

Automation is incorporated in machine tool systems to enable faster and consistently accurate processing operations for increasing productivity and reducing manufacturing cost in batch and mass production. Therefore, in semiautomatic and automatic machine tools mounting and feeding of the work piece or blank is done much faster but properly.

Mostly collet chucks are used for holding the work pieces. Collet chucks inherently work at high speed with accurate location and strong grip. The chucks are actuated manually or semi automatically in semi automatic lathes and automatically in automatic lathes. The collet chucks has been described in Article 2.10.5, Page 87 and illustrated in Fig. 2.68 (a, b and c).

2.11 Classification of Automats

The automats can be classified as follows:

According to the type of work materials used:

Bar stock machine.

Chucking machine.

According to the number of spindles:

Single spindle machine.

Multi spindle machine.

According to the position of spindles:

Horizontal spindle type.

Vertical spindle type.

According to the use:

General purpose machine.

Single purpose machine.

According to the feed control:

Single cam shaft rotating at constant speed.Single cam shaft with two speeds.

Two cam shafts.

Advantages of automats over conventional lathes

Mass production of identical parts.

High accuracy is maintained.

Time of production is minimized.

Less floor space is required.

Unskilled labor is enough. It minimizes the labor cost.

Constant flow of production.

One operator can be utilized to operate more than one machine.

The bar stock is fed automatically.

Scrap loss is reduced by eliminating operator error.

Comparison of automats and semiautomatics

Sl . No.	Automats	Semi automatics
1	Loading and unloading of work piece are done automatically by the	Loading and unloading are done manually.
2	Feeding of bar stock and bringing the tools to correct machining	These are done manually.
3	A single operator can attend a number of machines	An operator can attend to only one or two machines at a line.
4	Production time and cost less.	Not so less.
5	Best suitable for production of small size components.	Suitable for large size components.
6	Initial cost of machine is high.	Initial cost is lower than that of automatic lathe.

2.12 Single spindle and multi-spindle automatic lathes

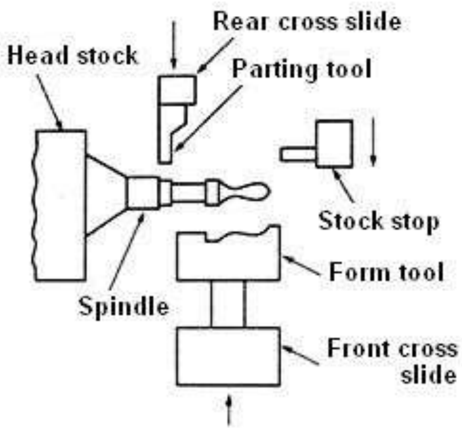
SINGLE SPINDLE AUTOMATS

These machines have only one spindle. So, one component can be machined at a time. These are modified form of turret lathe. These machines have maximum of 4 cross slides in addition to a 6 stations or 8 station turrets. These cross slides are operated by disc cams which draws the power from the main spindle through cycle time change gears. The single spindle automats are of the following types:

SINGLE SPINDLE AUTOMATIC CUTTING OFF MACHINE

This machine produces large quantities of workpiece of smaller diameter and shorter lengths. Components with simple form are produced in this machine by means of cross sliding tools.

Construction: This machine is simple in design. The head stock with the spindle is mounted on the bed. Two cross slides are located on the bed at the front end of the spindle. The front cross slides are used for turning and forming operations. The rear tool slide is used for facing, chamfering, recessing, under cutting and cutting off operations. Cams on a camshaft actuate the movements of the cross slides through a system of levers.



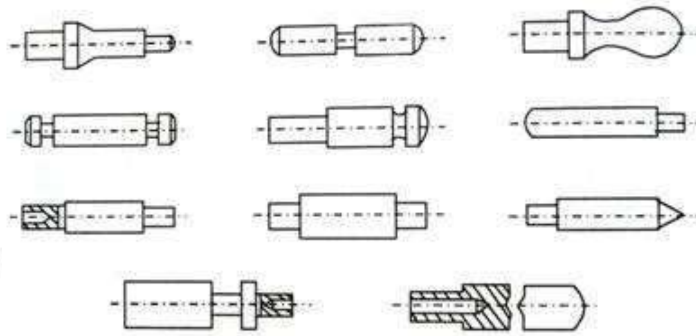


Fig. 2.82 Arrangement of tool slide Fig. 2.83 Simple parts produced on cutting off machine

Working principle: Typical arrangement of tool slide in an automatic cutting off machine is illustrated in Fig. 2.82. The required length of work piece (stock) is fed out with a cam mechanism, up to the stock stop which is automatically advanced in line with the spindle axis, at the end of each cycle. The stock is held in the collect chuck of the rotating spindle. The machining is done by tools held in cross slides operating only in the crosswise direction. The form tool held in the front tool slide produces the required shape of the component. The parting off tool in the rear tool slide is used to cut off the component after machining. Special attachments can be employed if holes or threads are required on the simple parts.

This machine has a single cam shaft which controls the working and idle motions of the tools. The cam shaft runs at constant speed. Therefore working motions and idle motions takes place at the same speed. Hence the cycle time is more. Typical simple parts (from 3 mm to 20 mm in diameter) produced on this machine are shown in Fig. 2.83.

2.16 SWISS TYPE AUTOMATIC SCREW MACHINE

This machine was designed and developed in Switzerland. So it is often called as Swiss auto lathe. This machine is also known as ‘Sliding head screw machine’, or ‘Movable headstock machine’, because the head stock is movable and the tools are fixed. This machine is used for machining long accurate parts of small diameter (2 mm to 25 mm).

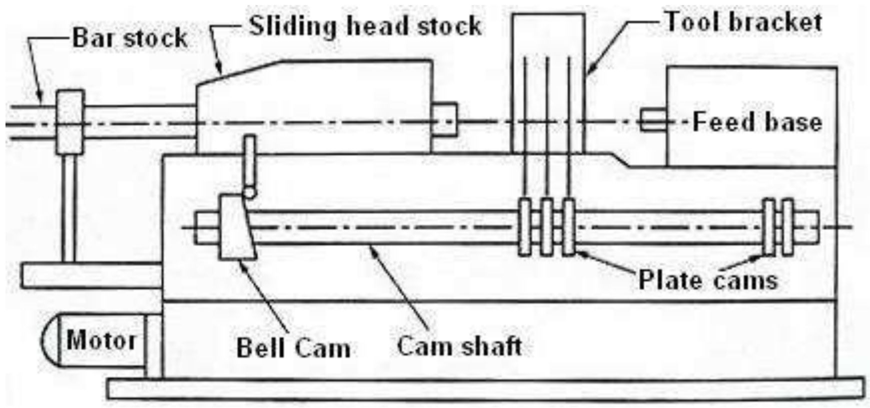


Fig. 2.84 Swiss type automatic screw machine

A wide variety of formed surfaces may be obtained on the workpiece by synchronized alternating or simultaneous travel of the headstock (longitudinal feed) and the cross slide (approach to the depth of cut). The bar stock used in these machines has to be highly accurate and is first ground on centre less grinding machines to ensure high accuracy. Parts produced on this machine are shown in Fig. 2.87.

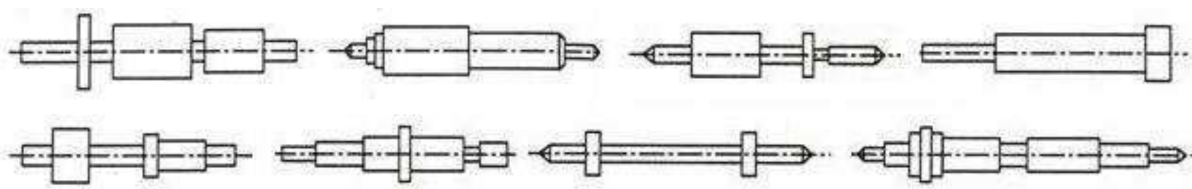


Fig. 2.87 Simple parts produced on Swiss auto lathe

Advantages

- It is used to precision turning of small parts. Wide range of speeds is available.
- It is rigid in construction.
- Micrometer tool setting is possible.
- Interchange ability of cams is possible.
- Tolerance of 0.005 mm to 0.0125 mm is obtained.

2.17 SINGLE SPINDLE AUTOMATIC SCREW TYPE MACHINE

This is essentially wholly automatic bar type turret lathe. This is very similar to capstan and turret lathes with reference to tool layout, but all the tool movements are cam controlled, such that full automation in manufacturing is achieved. This is designed for machining complex external and internal surfaces on parts made of bar stock or of separate blanks. These machines are made in several sizes for bar work from 12.7 mm to 60 mm diameter.

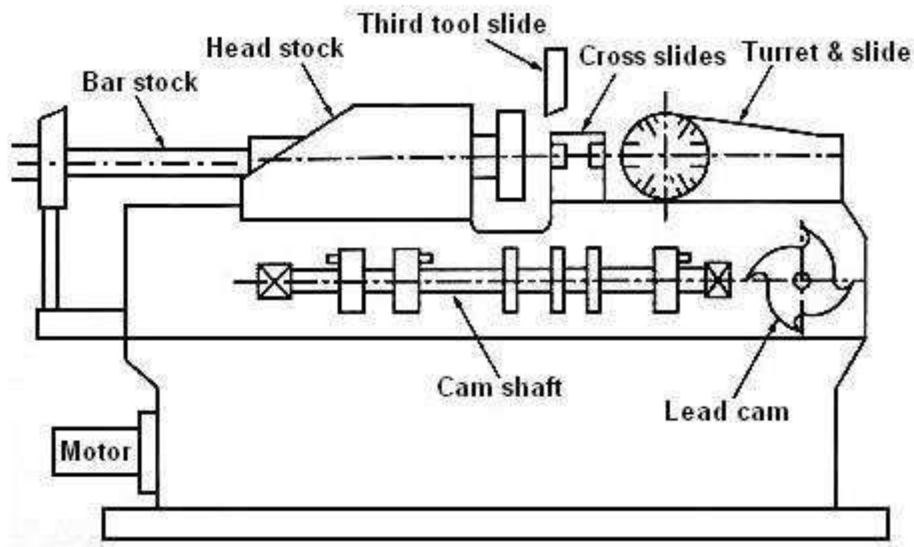


Fig. 2.88 Single spindle automatic screw cutting machine

One revolution of camshaft produces one component. It is used for producing small jobs, screws, stepped pins, taper pins, bolts, etc. Typical parts produced on this machine are shown in Fig. 2.89.

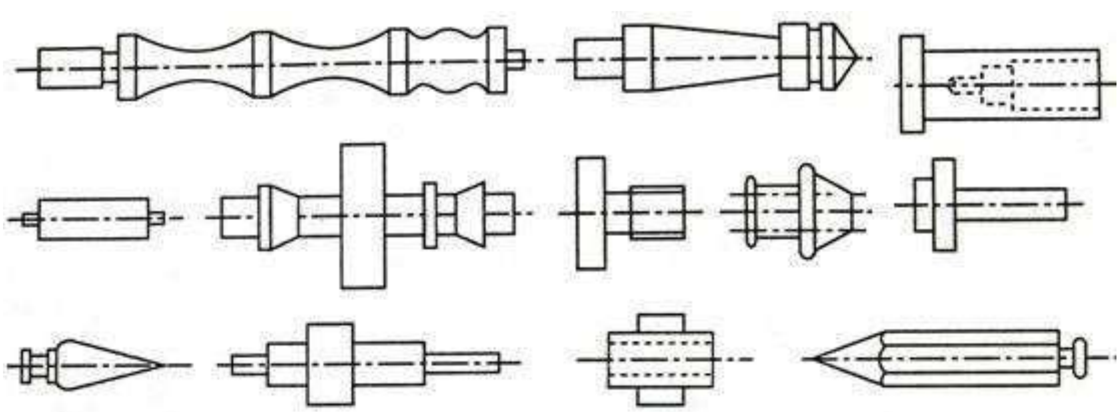


Fig. 2.89 Parts produced on single spindle automatic screw cutting machine

2.18 MULTI SPINDLE AUTOMATS

The multi spindle automats are the fastest type of production machines and are made in a variety of models with 2, 4, 5, 6 or 8 spindles. Each of the spindles is provided with its own set of tools for operation. As a result, more than one work piece can be machined simultaneously in these machines. In contrast to the single spindle automat, where one turret face at a time is working on one spindle, the multi spindle automat has all turret faces working on all spindles at the same time. The production rate of a multi spindle automat, however, is less than that of the corresponding number of single spindle automats. E.g. the production rate of a 4 spindle automat is not four times but only 2½ to 3 times more than that of a single spindle automat.

2.18.1 Classification of multi spindle automats

The multi spindle automats can be classified as follows:

According to the type of stock used:

Bar stock machine.

Chucking type machine.

According to the position of spindles:

Horizontal spindle type.

Vertical spindle type.

According to the principle of operation:

Parallel action type.

Progressive action type.

2.18.2 Comparison of single spindle automat and multi spindle automat

Sl . No.	Single spindle automat	Multi spindle automat
1	There is only one spindle.	There are 2,4,5,6 or 8 spindles.
2	Only one work piece can be machined at a time.	More number of work pieces can be machined at a time.
3	The rate of production is low.	The rate of production is high.
4	Machining accuracy is higher.	Machining accuracy is lower.
5	Tool setting time is less.	Tool setting time is more.
6	Tooling cost is less.	Tooling cost is more.
7	Economical for shorter as well as longer runs.	Economical for longer runs only.
8	The time required to produce one job is the sum of all turret operation times.	The time required to produce one job is the time of the longest cut in any one spindle.
9	Tools in turret are indexed.	Work pieces held in spindles are indexed(Progressive action machine)

2.19 PARALLEL ACTION MULTI SPINDLE AUTOMATION

These machines are usually automatic cutting off bar type machines. This is also called as ‘multiple-flow’ machine. In this machine, the same operation is performed on each spindle and a workpiece is finished in each spindle in one working cycle. The rate of production is very high, but the machine can be employed to machine simple parts only since all the machining processes are done at one position. Fig. 2.90 shows the basic configuration of a parallel action multi spindle automat.

They are used to perform the same work as single spindle automatic cutting off machines. Centering or a single drilling operation can also be performed on certain models. The machine consists of a frame with a head stock. The horizontal work spindles which are arranged in a line, one above the other, are housed in this headstock. Cross slides are located at the right and left hand sides of the spindles and carry the cross feeding tools. All the working and the auxiliary motions of the machine units are obtained from the cam mounted on the cam shaft.

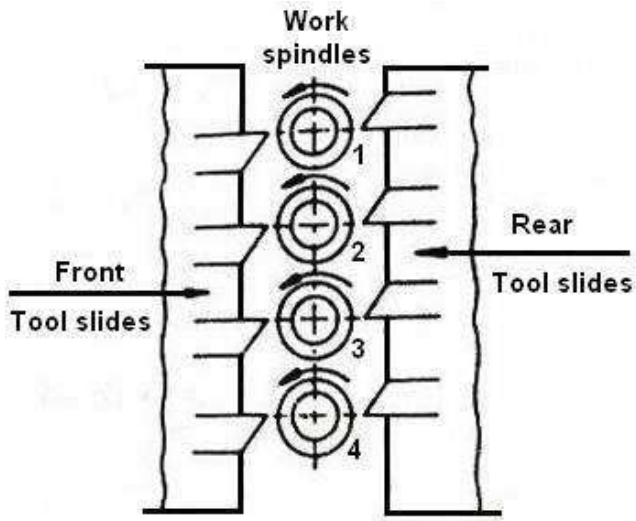


Fig. 2.90 Parallel action multi spindle automat

2.20 PROGRESSIVE ACTION MULTI SPINDLE AUTOMAT

In this machine the blanks clamped in each spindle are machined progressively in station after station.

Construction Fig. 2.91 shows the basic configuration of a six-spindle progressive action automat. The headstock is mounted at the left end of the base of the machine. It contains a spindle carrier which periodically indexes through a definite angle (3600 divided by the number of spindles) about a horizontal axis through the centre of the machine at each tool retraction. The main tool slide (end tool slide), which accommodates tooling for all of the spindles, travels on the spindle carrier stem. The number of tool slides or faces is equal to the number of spindles.

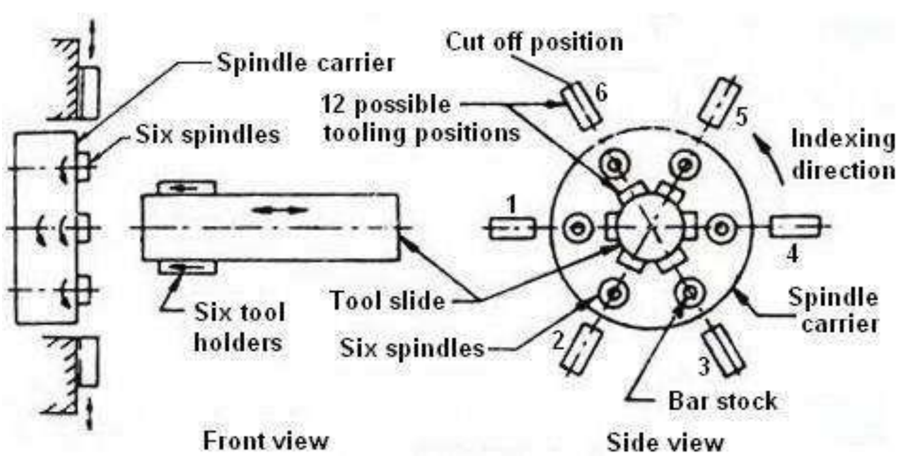


Fig. 2.91 Six-spindle progressive action automat

2.20.1 Comparison of parallel action and progressive action multi spindle automat

Sl . No.	**Parallel action multi spindle automat**	**Progressive action multi spindle automat**
1	Same operation is done on all jobs in all the spindles.	Different operations are done on jobs at each station one after
2	In one cycle the number of components produced imultaneously is equal to the number of spindles.	It is not so. (i.e.) The number of components produced in one cycle is not equal to the number of spindles. For every indexing of component (spindle) one component is produced.
3	Rate of production is very high	Rate of production is moderate.
4	If anything goes wrong in one station, the production in that particular station only is affected.	Ifanythinggoeswronginonestation ,theproductioniscompletelyaffect edinallthestations.
5	Small parts of simple shapes are produced.	Parts of complicate shapes can be produced.

SHAPING MACHINES

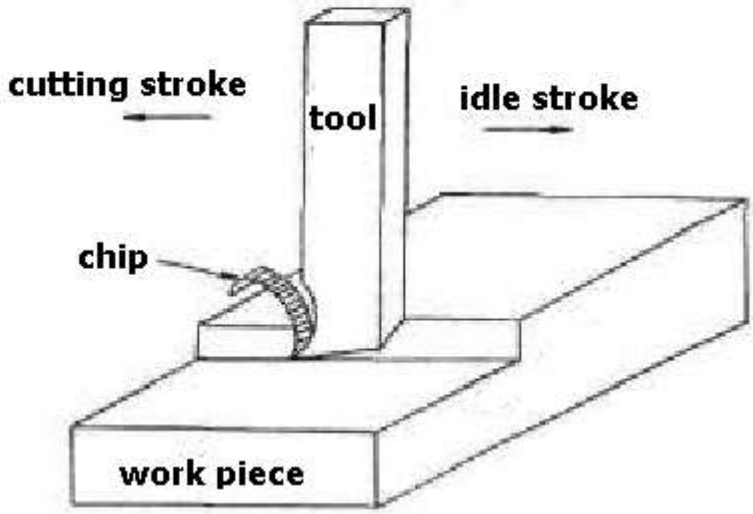
3.1 Shaping Machines

Introduction

The shaper is a machine tool having a reciprocating cutting tool of the lathe type, which takes a straight line cut. It is primarily intended to produce flat surfaces. These surfaces may be horizontal, vertical or inclined. The main significance of this machine lies in its greater flexibility on account of ease in work holding, quick adjustment and use of tools of relatively simple design. In the light of above fact it is almost an indispensable machine in tool rooms die making shops and general repair shops for the production of a few identical shapes of jobs. It can also be adopted for producing curved and irregular surfaces.

3.2 Working Principle

The working principle of a shaper is illustrated in the Fig.



On a shaper the job is usually fixed in a vice on the machine table. The tool is held in the tool post, mounted on the ram of the machine. As the ram reciprocates to and for the cutting tool cuts the material in forward stroke only except in case of draw cuts shaper, in which the tool cuts in backward stroke of the ram. The other stroke in both the cases remains idle, as there is no cutting action in this stroke and hence termed as idle strokes.

Types of Shapers

Shapers are classified in a number of ways depending upon the general features of design or the purpose for which they are intended. Shapers are classified under the following headings.

1) According to the type of mechanism used for giving reciprocating motion to the ram

(a) Crank type (b) Geared type (c) Hydraulic type

2) According to the position and travel of ram

(a) Horizontal type (b) Vertical type (c) Traveling head type

3) According to the type of design of the table:

(a) Standard shaper (b) universal shaper

4) According to the type of cutting stroke

(a) Push type (b) Draw type

Crank Shaper

This is the most common type of shaper in which a single point cutting tool is given' a reciprocating motion equal to the length of the stroke desired while the work is clamped in position on an adjustable table. In construction, the crank shaper employs a crank mechanism to change circular motion of a large gear called "bull gear" incorporated in the machine to reciprocating motion of the ram. The bull gear receives power either from an individual motor or from an overhead line shaft if it is a belt driven shaper.

Geared type

The reciprocating motion of the ram in some type of shaper is affected by means of a rack and pinion. The rack teeth, which are cut directly below the ram, mesh with a spur gear. The pinion meshing with the rack is driven by a gear train. The speed and the direction in which the machine will traverse depend on the number of gears in the gear train. This type of shaper is not very widely used.

Hydraulic Shaper

In a hydraulic shaper reciprocating movement of the ram is obtained by hydraulic power. Oil under high pressure is pumped in to the operating cylinder fitted with a piston. The end of the piston rod is connected to the ram. The high-pressure oil first acts on one side of the piston and then on the other causing the piston to reciprocate and the motion is transmitted to the ram. The piston speed is changed by varying the amount of liquid delivered by the pump. One of the most important advantages of this type of shaper is that the cutting speed and force of the ram drive are constant from the very beginning to the end of the cut. It also offers great flexibility up of motion when the cutting tool is overloaded. Protecting the parts or the tools from breakage. Another advantages is that the machine does not make any noise and operates very quietly.

Horizontal Shaper

In a horizontal shaper, the ram holding the tool reciprocates in a horizontal axis. Horizontal shapers are mainly used to produce flat surfaces.

Vertical Shaper

In a vertical shaper, the ram holding the tool reciprocates in a vertical axis. In some of the vertical machines provision is made to allow adjustment of the ram to an angle of about 10 degrees from the vertical position. Vertical shapers may be crank driven, rack driven, screw driver or hydraulic power driven. The work table of a vertical shaper can be given cross, longitudinal, and rotary movement. The tool used on a vertical shaper is entirely different from that used on a horizontal shaper. Vertical shapers are very convenient for machining internal surfaces, keyways, slots or grooves; large internal and external gears may also be machined by indexing arrangement of the rotary table. There are vertical shapers, which are specially designed for machining internal keyways. They are then called keys eaters.

Travelling Head Shaper

In a travelling head shaper, the ram carrying the tool while it reciprocates moves crosswise to give the required feed. Heavy and un widely jobs, which are very difficult to hold on the table of standard shaper and fed past the tool are, held static on the basement of the machine while the ram reciprocates and supplies the feeding movements.

Standard or Plain Shaper

A shaper is termed as standard or plain when the table has only two movements, vertical and horizontal, to give the feed. The table may or may not be supported at the outer end.

Universal Shaper

In a universal shaper in addition to the two movements provided on the table of a standard shaper, the table can be swivelled about an axis parallel to the ram ways, and the upper portion of the table can be tilted about a second horizontal axis perpendicular to the first axis. As the work mounted on the table can be adjusted in different planes, the machine is most suitable for different types of work and is given the name "universal". A universal shaper is mostly used in tool room work.

Push Type Shaper

This is the most general type of shaper used in common practice. The metal is removed when the ram moves away from the column, i.e., pushes the work.

Draw Type Shaper

In a draw shaper, the metal is removed when the ram moves towards the column of the machine, i.e., draws the work towards the machine. The tool is set in a reversed direction to that of a standard shaper. The ram is generally supported by an overhead arm which ensures rigidity and eliminates deflection of the tool. In this shaper the cutting pressure acts towards the column which relieves the cross rail and other bearings from excessive loading and allows to take deep cuts. Vibration in these machines is practically eliminated.

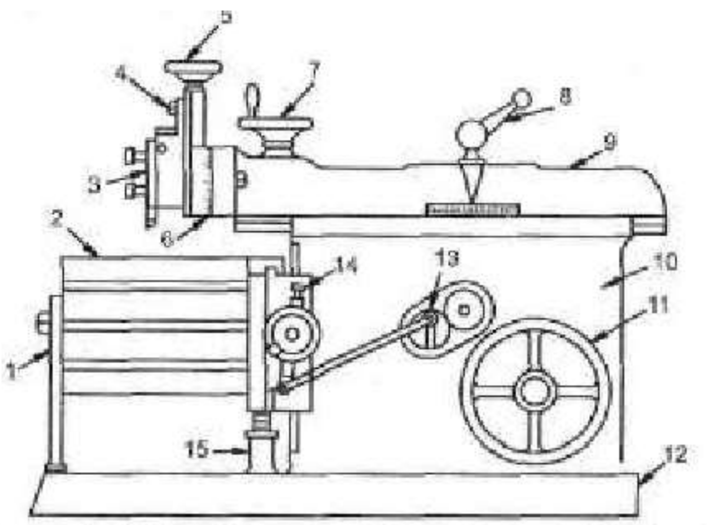
3.3 Principal parts

Base

The base is the necessary bed or support required for all machine tools. The base may be rigidly bolted to the floor of the shop or on the bench according to the size of the machine. It is so designed that it can take up the entire load of the machine and the forces set up by the cutting tool over the work. It is made of cast iron to resist vibration and take up high compressive load.

Column

The column is a box like casting mounted upon the base. It encloses the ram driving mechanism. Two accurately machined guide ways are provided on the top of the column on which the ram reciprocates. The front vertical face of the column contains levers, handles, etc, for operating the machine.



1) Table support 2) Table 3) Clapper box 4) Apron clamping blots 5) Down feed hand wheel 6) Swivel base degree graduations 7) Position of stroke adjustment hand wheel8) Ram block locking handle 9) Ram 10) Column 11) Driving pulley 12) Base 13) Feed disc 14) Pawl mechanism 15) Elevating screw.

Cross rail

The cross rail is mounted on the front vertical guide ways of the column. It has two parallel guide ways on its top in the vertical plane that is perpendicular to the ram axis. The table may be raised or lowered to accommodate different sizes of jobs by rotating an elevating screw which causes the cross rail to slide up and down on the vertical face of the column. A horizontal cross feed screw which is fitted within the cross rail and parallel to the top guide ways of the cross rail actuates the table to move in a crosswise direction.

Saddle

The saddle is mounted on the cross rail which holds the table firmly on its top. Crosswise movement of the saddle by rotating the cross feed screw by hand or power causes the table to move sideways.

Table

The table, which is bolted to the saddle, receives cross wise and vertical movements from the saddle and cross rail. It is a box like casting having T-slots both on the top and sides for clamping the work. In a universal shaper the table may be swivelled on a horizontal axis and the upper part of the table may be tilted up or down. In a heavier type shaper, the front face of the table is clamped with a table support to make it more rigid.

Ram

The ram is the reciprocating member of the shaper. This is semi-cylindrical in from and heavily ribbed inside to make it more rigid. It slides on the accurately machined dovetail guide ways on the top of the column and is connected to the reciprocating mechanism contained within the column. It houses a screwed shaft for altering the position of the ram with respect to the work and holds the tool head at the extreme forward end.

Tool head

The tool head of a shaper holds the tool rigidly provides vertical and angular feed movement of the tool and allows the tool to have an automatic relief during its return stroke. The vertical slide of the tool head has a swivel base, which is held on a circular seat on the ram. The swivel base is graduated in degrees, so that the vertical slide may be set perpendicular to the work surface or at any desired angle. By rotating the down feed screw handle, the vertical slide carrying the tool executes down feed or angular feed movement while machining vertical or angular surface. The amount of feed or depth of cut may be adjusted by a micrometer dial on the top of the down feed screw. Apron consisting of clapper box, clapper block and tool post is clamped upon the vertical slide by a screw. By releasing the clamping screw the apron may be swivelled upon the apron swivel pin either towards left or towards right with respect to the vertical slide. This arrangement is necessary to provide relief to the tool while making vertical or angular cuts. The two vertical walls on the apron called clapper box houses the clapper block, which is connected to it by means of a hinge pin. The tool post is mounted upon the clapper block on the forward cutting stroke the clapper block fits securely to the clapper box to make a rigid tool support on the return stroke a slight frictional drag of the tool on the work lifts the block out of the clapper box a sufficient amount preventing the tool cutting edge from dragging and consequent wear. The work surface is also prevented from any damage due to dragging. Fig.9.3 illustrates the tool head of a shaper.

1) Down feed screw micrometer dial 2) Down feed screw

3) Vertical slide 4) Apron 5) Apron clamping bolt

6) Clapper block 7) Tool post 8) Washer

9) Apron swivel pin 10) Swivel base.

Shaper Size and Specification

The size of shapers is classified according to the maximum length of stroke. Push-cut shapers can accept work sizes from 102-to 915 mm. Pull-cut shapers are made for work regiments up to 1.82 m. The maximum cross-feed distance is generally equivalent. The maximum ram stroke, distance. Therefore, a shaper with a 406mm maximum stroke, for example, is capable of machining a part with a plane surface that measures at least 406 mm x 406 mm square.

3.4 Specifications of a shaper

Maximum ram stroke 700mm

Maximum tool overhang 840 mm

Distance between table surface and ram Maximum 400mm

Minimum 80 mm

Dimensions of table working surface 700 mm x 450 mm

Maximum travel of table Horizontal 700 mm

Vertical 320 mm

Horizontal feed per double stroke 0.25-5 mm

Principal movement motor power 7 kW

Overall dimensions 2785 x 1750 x 1780 mm.

Shaper Driving Mechanism

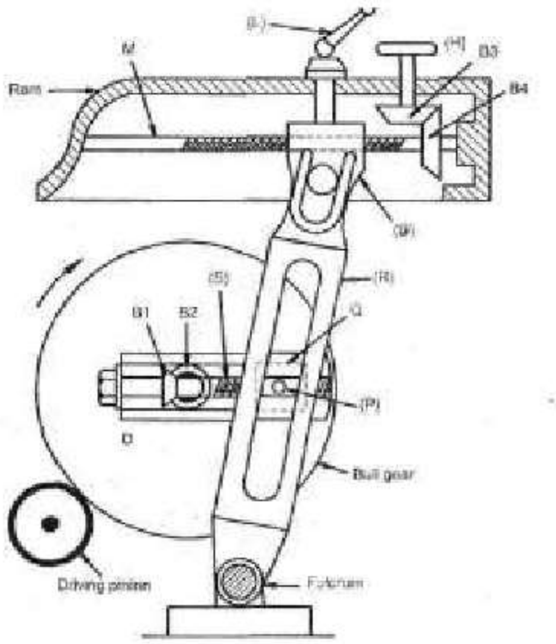
In a shaper, rotary movement of the drive is converted into reciprocating movement by the mechanism contained within the column of the machine. The ram holding the tool gets the reciprocating movement. In a standard shaper the metal is removed in the forward stroke and the return stroke is idle. The time taken by idle stroke is merely waste and should be minimised as far as possible. This can achieve by making the shaper to complete its return stroke quicker than the forward one. Thus the shaper mechanism should be so designed to perform the cutting stroke at a comparatively shower speed than the return stroke and this mechanism is known as quick return mechanism.

The reciprocating movement of the ram and the quick return mechanism of the machine are usually obtained by any one of the following.

1) Crank and slotted lever mechanism
2) Whit-worth quick return mechanism
3) Hydraulic shaper mechanism

Crank and Slotted Lever Mechanism

The crank and slotted lever mechanism is shown in the Fig. It consists of slotted link called rocker arm. The rocker arm is pivoted at its bottom end which forms the fulcrum. At its upper it carries another short link which is attached to the ram block (B). The ram block (B) can be clamped at the desired position by hand lever (L). The rocker arm is provided with a sliding block (QJ in which the crank pin (P) revolves. The sliding block can freely slide in the slot provided in the rocker arm. At the back of the rocker arm a large gear wheel known as bull gear is provided. The motion of the power is transmitted to the bull gear through a pinion, which receives its motion from an individual motor or overhead line shaft through speed control mechanism. A slotted disc (D), carrying a T-slot is fitted to the bull gear at its front, the crank pin 'P' is fitted in this slot and can be moved to any desired piston along the slot by means of the bevel gears (BJ and (B2) and adjusting screw (S). The bevel gears (B2) is concentric with the bull gear and the other bevel gear (BJ is attached to the lead screw (S) at its one ends as shown in the Fig. The axes of bevel gears (BJ and (B2) are at right angles to each other and called as miter gears.

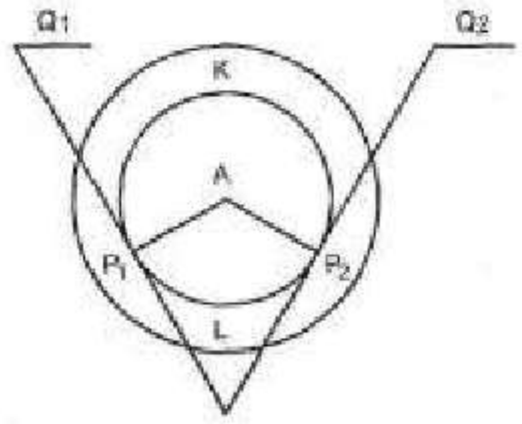


As the bull gear rotates causing the crank pin (P) to rotate, the sliding block (Q) fastened to the crank pin (P) will rotate on the crank pin circle and at the same time will move upand down the slot in the rocker arm giving it rocking movement which makes the rocked arm to swing about the fulcrum. Thus in turn the rocker arm moves the ram to and fro.

Principle of Quick Return Mechanism

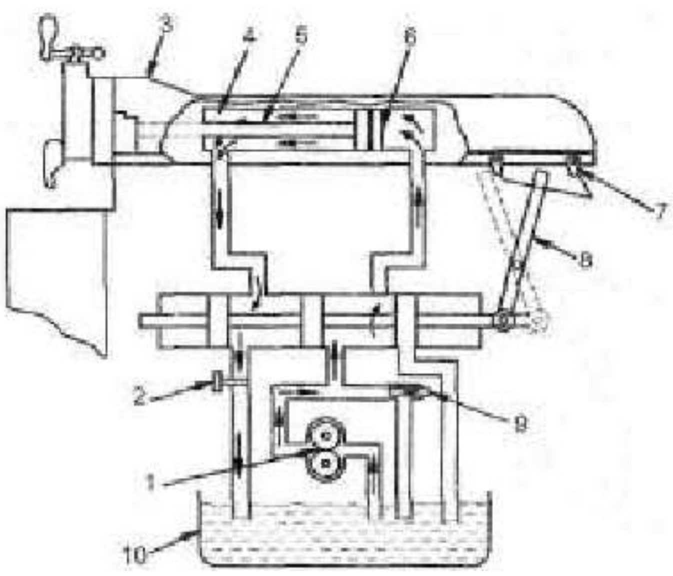
The principle of quick return mechanism is illustrated in Fig. When the link is in the position OQ2, the ram will be at the extreme backward position of the stroke and when it is at OQ2, it has reached the extreme forward position. Therefore the forward cutting stroke takes place when the crank rotates through the angle Pa, K P2, and the return stroke takes place when the crank rotates through the angle P2, L Pr

It is very clear that the angle P , KP2 made by the cutting stroke (forward stroke) is greater than the angle P2, LP] made by the return stroke. The angular velocity of the crank pin is constant. Therefore the return stroke is completed within a shorter time than the cutting stroke for which it is known as quick return motion. The ratio between these two angles, and hence between the corresponding times is approximately 3:2.



Hydraulic Mechanism

The simple mechanism of a hydraulic drive is shown in the Fig. In a hydraulic shaper the ram is moved forward and backward by a piston moving in a cylinder placed under the ram. The machine mainly consists of a constant discharged oil pump, a valve chamber, a cylinder and a piston. A constant speed motor drives the pump, which delivers oil at a constant pressure to the line. The regulating valves located in valve chamber, actuated by the machine and timed to the stroke; admit oil under pressure to each end of piston alternately and at the same time allowing oil from the opposite end of the piston to return to the reservoir. As the piston moves it. Although it is a constant pressure system under varying load condition the tool moves with different velocities. One end of the piston is having larger area and the other end has less area due to piston rod. Therefore it moves in one stroke at low speed (cutting stroke) and in opposite stroke (Return stroke) it moves at high speed. The velocity can also be controlled regulating the quantity of oil by feed handle as shown in Fig.



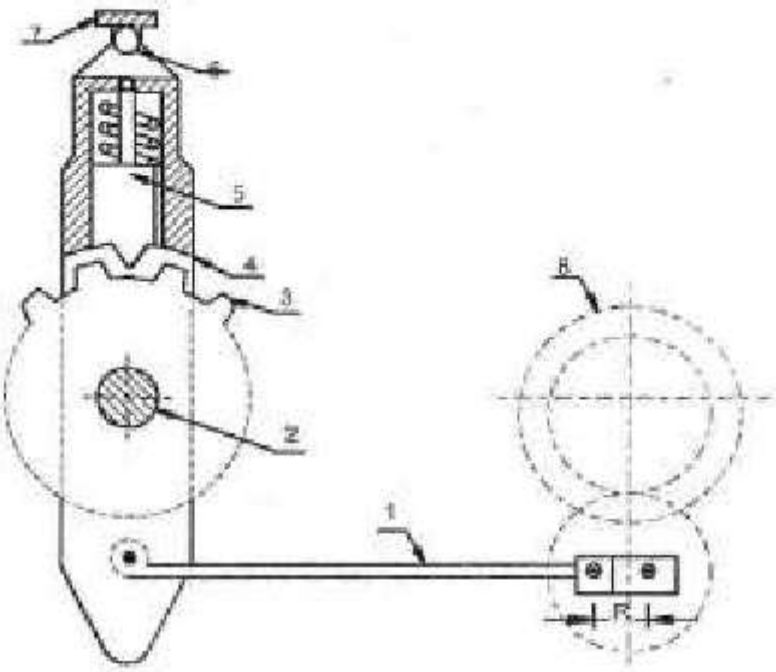
Advantages of Hydraulic Shaper over Mechanical Shaper

The hydraulic mechanisms are becoming popular because of the following advantages.

1) Ability to slip in case of over load
2) Smoother operation
3) Ability to withstand shock without damage to the tool or the machine
4) Infinite number of cutting speeds can be obtained from zero to the maximum value and the control easier.
5) Possibility of changing speed and feed during operation.

Table Feed Mechanism

The automatic cross feed mechanism incorporated to the shaper table is shown in the Fig. The cross feed of table may be obtained manually or by power. In the latter case the table cross feed screw is rotated through certain degrees with the help of a ratchet wheel mounted on the cross feed screw. The complete mechanism is as follows. In consists of a slotted disc which carries a T slot as shown in the Fig. In this slot an adjustable pin is fitted and to which the connecting rod is attached. The other end of the connecting rod is attached to the lower end of the rocker arm of the pawl mechanism. The rocker arm swings about the cross feed screw and at its upper end carries a spring loaded pawl. The adjustable pin is set eccentric with slotted link disc centre. The slotted disc at its back carries a spur gear, which is driven by the bull gear. As the disc rotates through gear the adjustable pin that is eccentric to the disc centre, causes the connecting rod to reciprocate. This in turn makes the pawl over one or more teeth and thus transmits an intermittent motion to the cross feed screw which moves the table. The lower end of the pawl is bevelled on one side. This facilitates the power feed to operate in either direction. The feed can be varied by varying the distance or between the disc centre and the centre of the adjustable pin. The larger the said distance, greater will be the feed and vice-versa.

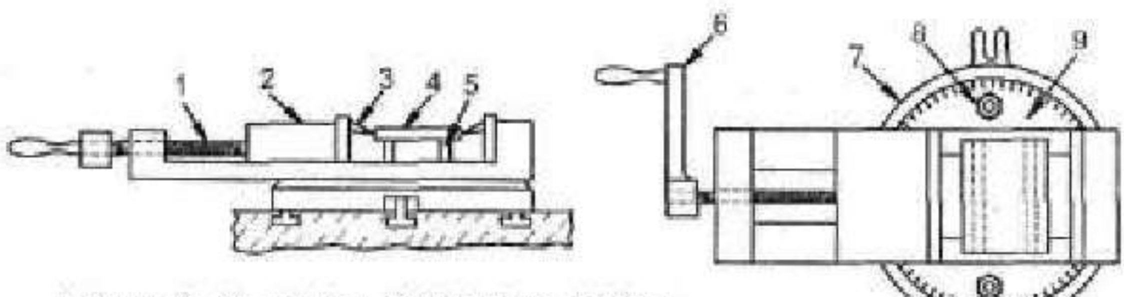


Work Holding Devices

The top and sides of the table of a shaper have T-slots for clamping the work. The work may be supported on the table by the following methods depending on the nature of the work-piece.

Shaper Vises

A vise is a quick method of holding and locating relatively small and regular shaped work-pieces. It consists of a base, table, screw, fixed and movable jaws. The base has a projection or tongue which fits in to the slot of the machine table. For properly securing it to the table lugs are provided for clamping the vise by T-bolts. The work is clamped between fixed and movable jaws by rotating the screw. Wherever possible the vise is so placed on the table that the tool while cutting exerts direct pressure upon the jaws. A machine vise may be classified under following headings.



1. Screw, 2. Movable jaw, 3. Hold down, 4. Work, 5. Parallels, 6. Handle, 7. Base, 8. Clamping bolt, 9. Swivelling base, 10. Lug.

1) Plain vise

a) Single screw

b) Double screw

2) Swivel vise

3) Universal vise.

Plain Vise

A plain vise is the most simple of all the types. The vise may have a single screw or double screws for actuating the movable jaw. The double screws add gripping strength while taking deeper cuts or handling heavier jobs.

Swivel Vise

In a swivel vise the base is graduated in degrees and the body of the vise may be swivelled at any designed angle on a horizontal plane. The swivelling arrangement is useful in bevelling the end of work-piece.

Universal Vise

A universal vise may be swivelled like a swivel vise. In addition to that, the body may be tilted in a vertical plane up to 90 degrees from the horizontal. An inclined surface may be machined by a universal vise.

Parallels

When the height of the job is less than the height of the jaws of the vise, parallels are used to raise and seat the work-piece above the vise jaws and parallel with the vise bottom. Parallels are square or rectangular bars of steel or cast iron, hardened and ground with opposites sides parallel. They are available in various sizes for seating work-pieces of different heights and are always used in pairs.

Hold Downs

Hold downs or grippers are used for holding thin pieces of work in a shaper vise. Hold downs are also used for holding work of smaller height than the vise jaws where suitable parallels are not available. The hold down is a hardened wedge shaped piece with its two working edges tapered at an angle of 5°. Hold downs are placed between two jaws of the vise and the work piece. When the screw is tightened the typical shaped of the hold down exerts down ward pressure on the work to hold it tight on the parallels or on the vise table.

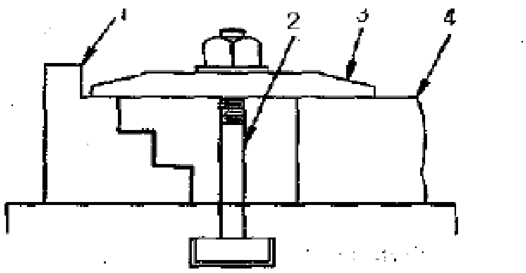
Clamping Work on the Table

When the work-piece is too large to be held in a vise it must be fastened directly on the shaper table. In holding work on the table, clamping bolts should not be unduly tightened to produce distortion of the work. The different methods employed to clamp different types of work on a shaper table are:

1) T-bolts and clamps
2) Stop pins
3) Stop pins and toe dogs
4) Strip and stop pins.

T-Bolts and Clamps

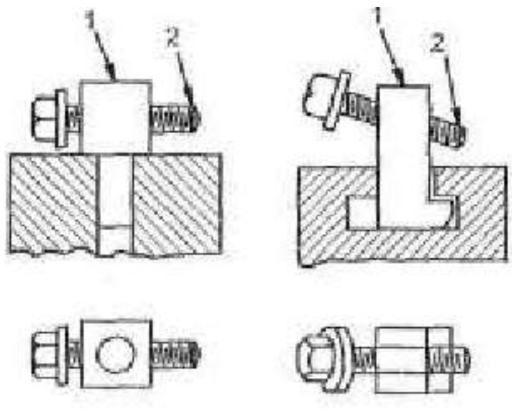
Fig. illustrates the use of T-bolts and clamps for holding the work. T-bolts having T-heads are fitted in the T-slots of the table. The length of the threaded portion is sufficiently long in order to accommodate different heights of work. The clamps are made of steel having slots at the centre for fitting the bolt. One end of the clamp rests on the side of the work while the other end rests on a fulcrum block. The fulcrum block should be of the same height as the part being clamped. The bolt is placed as near to the work as possible and the nut is then tightened. To hold a large work on the table a series of clamps and T-bots are used all round the work.



Step block, 2. T-Bolt, 3. Clamp, 4. Work.

Stop Pins

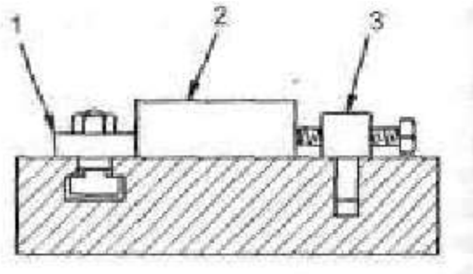
A stop pin is a one-leg screw clamp. As the tool moves forward to perform cutting stroke the work tends to be pushed out of its position under the pressure of the cutting tool. Stop pins are used to prevent the work from coming out of position. The body of the stop pin is fitted in the hole or slot on the table and the screw is tightened till it forces against the work.



1. Body, 2. Screw.

Strip and stop pins

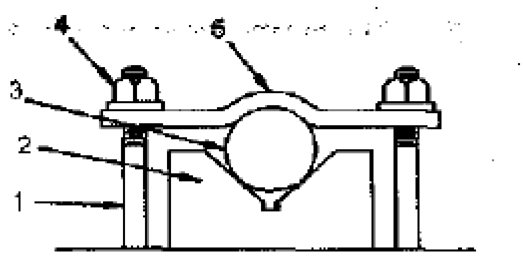
Fig. illustrates the working of strip and stop pins for holding the work. Work having sufficient thickness is held on the table by strip and stop pins. A strip is a long bar having a tongue with holes for fitting the T-bolts. The strip with bolts is fitted in the T-slot of the table, the tongue of the strip fitting within the slot. The nuts are then tightened so that thetrip plate may rest on one side of the work. The stop pin screws are then tightened endof the work so that the work may be clamped between stop pins and strip plate.



1. Strip, 2. Work, 3. Stop pin.

V-Block

Fig. illustrates the use of a V-block. For holding round rods V-block are used. Work may be supported on two V-blocks at its two ends and is clamped to the table by T-boltsand clamps. The tool may be made to reciprocate between the two clamps for cutting grooves or key ways. V-blocks are made of cast iron or steel and are accurately machined.



T-bolt, 2. V-block, 3. Work, 4. Nut, 5. Clamp

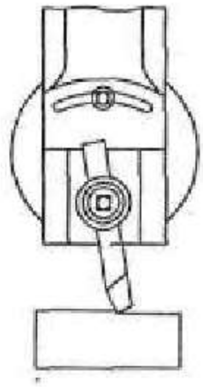
3.5 Operations performed on Shaper

A shaper is a versatile machine tool primarily designed to generate a flat surface by a single point cutting tool. But it may also be used to perform many other operations. The different operations, which a shaper can perform are as follows:

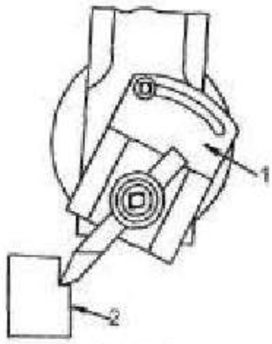
1) Machining horizontal surface
2) Machining vertical surface
3) Machining angular surface
4) Cutting slots, grooves, and key ways
5) Machining irregular surface
6) Machining splines or cutting gears.

Machining horizontal surface

Figillustrates machining horizontal surface on a workpiece. A shaper is mostly used to machine a flat, true surface on a work-piece held in a vise or other holding devices. After the work is properly held on the table, a planing tool is set in the tool post with minimum overhang. The table is raised till there is a clearance of 25 to 30 mm between the tool and the work-piece. The length and position of stroke are then adjusted. The length of stroke should be nearly 20mm longer than the work and the position of stroke is so adjusted that the tool begins to move from a distance of 12 to 15 mm before the begining of the cut and continues to move 5 to 8mm after the end of the cut proper cutting speed and feed is then adjusted. Short, strokes should be given with high speed while long strokes with slow speed. Both roughing and finishing cuts are performed to complete the job. For roughing cut speed is decreased but feed and depth of cut is increased. Depth of cut is adjusted by a micrometer dial. The depth of cut for roughing work usually ranges from 1.5 to 3mm, while for finishing work it ranges from 0.075 to 0.200 mm. Feed is adjusted about one half the width of the cutting edge of the tool so that each cut will over lap the last cut giving a smooth surface finish.



Machining horizontal surface



1. Apron, 2. Work.

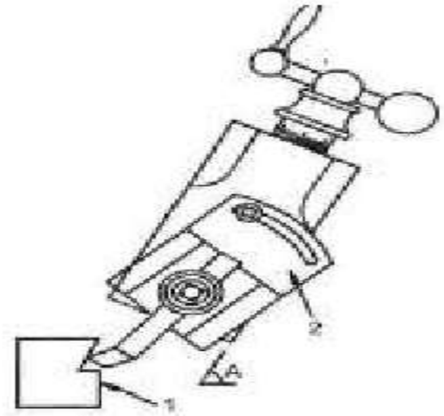
Machining vertical surface

Machining vertical surface

A vertical cut is made while machining the end of a work-piece, squaring up a block or cutting shoulder. The work is mounted in the vise or directly on the table and the surface to be machined is carefully aligned with the axis of the ram. A side-cutting tool is set on the tool post and the position and length of stroke is adjusted. The vertical slide is set exactly at zero position and the apron is swiveled in a direction away from the surface being cut. This is necessary to enable the tool to move upwards and away from the work during return stroke. This prevents the side of the tool from dragging on the planed vertical surface during return stroke. The down feed is given by rotating the down feed screw by hand. The feed is about 0.25mm given at the end of the each return stroke. Both roughing and finishing cuts are performed to complete the job.

Machining angular surface

An angular cut is made at any angle other than a right angle to the horizontal or to the vertical plane. The work is set on the table and the vertical slide of the tool head is swiveled to the required angle either towards left or towards right form the vertical position. The apron is then further swivelled away from the work so that the tool will clear the work during return stroke. The down feed is given by rotating the down feed screw. Angular surface can also be machined in a universal shaper by using a universal vise without swivelling the tool head.

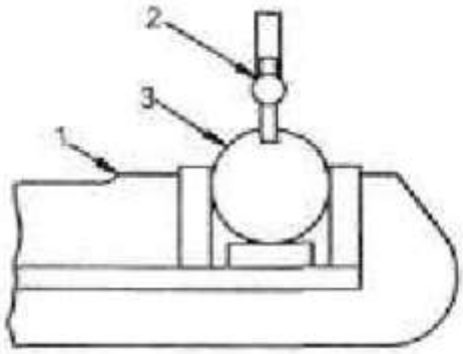


1. Work, 2. Apron, A. Swivelling angle of the vertical slide

Machining angular surface

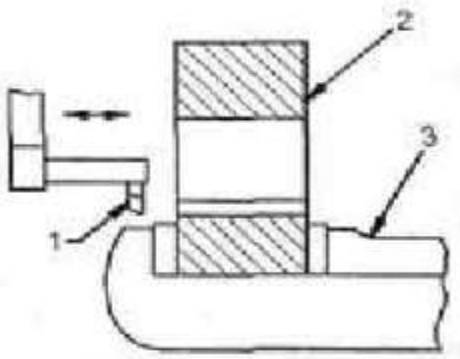
Cutting slots and keyways

With suitable tools a shaper can very conveniently machine slots or grooves on a work or cut external keyways on shafts and internal keyways on pulleys or gears. For cutting slots or keyways a square nose tool similar to a parting tool is selected. Fig.9.22 illustrates cutting of external keyways and Fig. shows cutting of internal keyways in a shaper. External keyways are cut on a shaft by first drilling a hole at the blind end of the keyway. The diameter of the holes should be 0.5 to 0.8mm over size than the width of the keyways and the depth should be about 1.55mm larger than the depth of keyway. This is necessary to leave a clearance on the tool at the end of the stroke. The length and position of stroke is carefully adjusted so that the stroke will terminate exactly at the clearance hole. The speed is reduced while cutting a keyway. Internal keyways are cut by holding the tool on a special tool holder so that the tool post will not hit against the work at the end of the stroke. The clapper block is locked in the clapper box to prevent the tool from lifting during return stroke. Lubrication is necessary on the work to prevent the cutting edge of the tool from wear due to dragging.



1. Vise, 2. Tool, 3. Work.

Cutting external keyway



1. Tool bit, 2. Work, 3. Vise.

Cutting internal keyway

Machining Irregular Surface

A shaper can also produce a contoured surface i.e. a convex or concave surface or a combination of any of the above surfaces. To produce a small contoured surface a forming tool is used. If the curve is sufficiently large power. Cross feed in conjunction with manual down feed is so adjusted that the tool will trace the required contour. If the contour has too many ups and downs both the feeds are operated by hand. A round nose tool is selected for machining irregular surfaces. For a shallow cut the apron may be set vertical but it the curve is quite sharp, the apron is swiveled towards right or left away from the surface to be cut. Fig. Shows machining of a concave surface using a round nose tool.

3.6 Machining time calculations

3.7 Slotting machines

Introduction

The slotting machine falls under the category of reciprocating type of machine tool similar to a shaper or a planer. It operates almost on the same principle as that of a shaper. The major difference between a slotter and shaper is that in a slotter the ram holding the tool reciprocates in a vertical axis, whereas in a shaper the ram holding the tool reciprocates in a horizontal axis. A vertical shaper and a sllotter are almost similar to each other as regards to their construction, operation, and use. The only difference being, in the case of a vertical shaper, the ram holding the tool may also reciprocate at an angle to the horizontal table in addition to the vertical stroke. The ram can be swivelled not more than 5° to the vertical. The slotter is used for cutting grooves, key ways and slots of various shapes, for making regular and irregular surfaces both internal and external, for handling large and awkward work pieces, for cutting internal or external gears and many other operations which cannot be conveniently machine in any other machined tool described before. The slotting machine was developed by Brunei in the year 1800 much earlier than a shaper was invented.

3.8 Principles of working

3.9 Principal parts of slotting machine

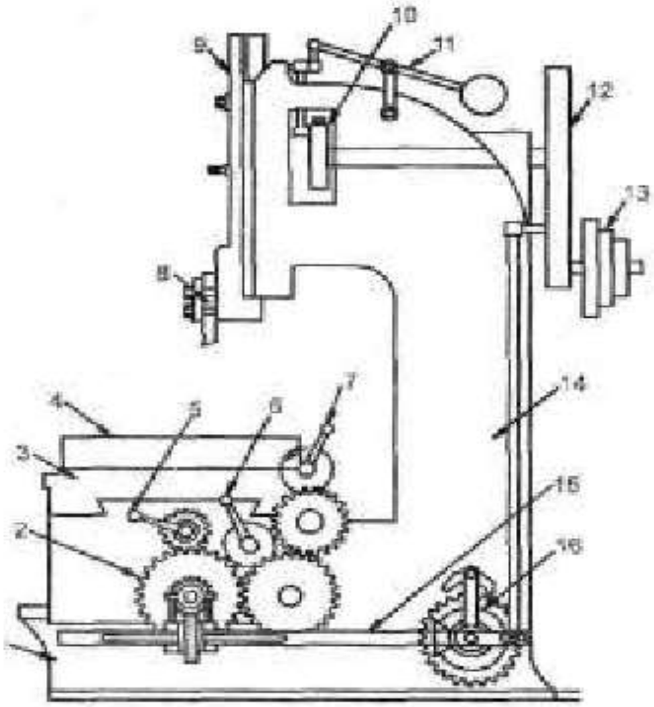


Fig. illustrates a slotting machine. The different parts of a slotting machine are:

1) Base
2) Column
3) Saddle
4) Cross-slide
5) Rotating table
6) Ram and tool head assembly
7) Ram drive mechanism
8) Feed mechanism

Base or Bed

The base is rigidly built to take up all the cutting forces and entire load of the machine. The top of the bed is accurately finished to provide guide ways on which the saddle is mounted. The guide ways are perpendicular to the column face. **Column** The column is the vertical member, which is cast integral with the base and houses driving mechanism of the ram and feeding mechanism. The front vertical face of the column is accurately finished for providing ways on which the ram reciprocates.

Saddle

The saddle is mounted upon the guideways and may be moved toward or away from the column either by power or manual control to supply longitudinal feed to the work. The top face of the saddle is accurately finished to provide guide ways for the cross-slide. These guide ways are perpendicular to the guide ways on thebase.

Cross-Slide

The cross-slide is mounted upon the guide ways of the saddle and may be moved parallel to the face of the column. The movement of the slide may be controlled either by hand or power to supply cross-feed.

Rotary Table

The rotary table is a circular table which is mounted on the top of the cross-slide. The table may be rotated by rotating a worm which meshes with a worm gear connected to the underside of the table. The rotation of the table may be effected either by hand or power. In some machines the table is graduated in degrees that enable the table to be rotated for indexing or dividing the periphery of a job in equal number of parts. T-slots are cut on the top face of the table for holding the work by different clamping devices. The rotary table enables a circular or contoured surface to be - generated on the work piece.

Ram and Tool head Assembly

The ram is the reciprocating member of the machine mounted on the guide-ways of the column. It supports the tool at its bottom end on a tool head. A slot is cut on the body of the ram for changing the position of stroke. In some machines, special type of tool holders is provided to relieve the tool during its return stroke.

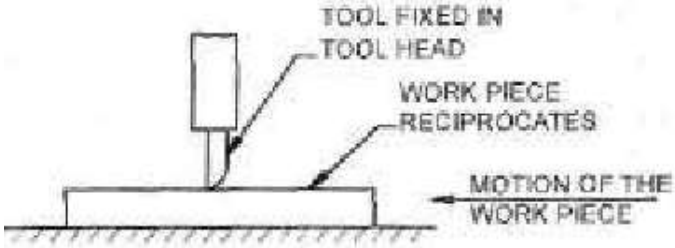
3.10 Specifications

3.11 Operations performed

3.12 PLANNING MACHINES &Principles of working

Introduction

A planer is a machine having reciprocating work and fixed tool. The work traverses the tool and feeds over at the end of each stroke the tool is clamped in the tool holder and the work on the table. Fig. shows the working principle of a planer. The type of work is very similar to that done on a shaper except that a plane is adapted to much large work. The cuts are all plain surfaces, but they may be horizontal, vertical or at any angle. Both the planer and shaper employ single-point cutting tools for machining. The planer is very heavy in construction and had long table travel. It can take multi-cuts at various places in a single stroke, because it can accommodate more than one tool holding stations. It is also possible to machine large number of smaller parts by setting them properly on the table usually, two tool heads are mounted on the overhead cross rail and one each on either of the column. Like all reciprocating machine tools, the planer is quipped with a clapper box to raise the tool on the return stroke.



Difference between Planer and shaper

Although both the planer and shaper employ single-point cutting tools for machining flat surfaces, they are not similar in their field of usefulness: they differ widely in construction and in method of operation when the two machines are compared in construction, operation and use, the following difference may be seen.

1) The planer is very heavy and robust machine in construction the shaper is smaller one.
2) On planer the work is moved against the stationary tool, on shaper the tool is moved against the stationary work.
3) On planner the feed is given to the tool, on shaper the feed is given to the work.
4) In planer the work table is drive either by gears or by hydraulic means. The shaper ram can also be driven in this manner, but in most cases the quick return mechanism is used.
5) Most planers differ from shapers in that they approach constant velocity cuts.
6) The planer is specially adopted to large work; the shaper can do only small work.
7) In a planer the tool is rigidly supported when the work moves on precision ways and maximum accuracy on the machined surface is assured. In a shaper, due to overhanging of the ram during the cutting stroke, and the machine being not very robust the accuracy cannot be expected up to the mark.
8) High rate of power consumption and overall rigidity in a planer enables it to take deep cuts and apply heavy feeds to rough finish a job quickly. A planer can consume up to 150 h.p. Whereas a shaper can consume 15 to 20 h.p.
9) A planer is not suitable for machining relatively small, and medium size work or few at a time that a shaper can do, but a planer is more economical and faster when large quantities are machined. A large number of jobs of identical shapers can be machined in one setting on a planer table.
10) Multiple tooling with double or four tool heads in a planer makes it possible to machine more than one surface together, thus reducing cutting time.
11) In a planning machine, work setting requires much of skill and takes along time, whereas in a shaper the work may be clamped easily and quickly.
12) Tools used in a planer are much more robust than that used in a shaper.
13) In modern planes wide range of cutting and return speeds are available and they may
1) be changed independently.
14) Planers are larger and costlier machines compared to shapers.
15) 11.3 Planer Size

The size of a planer is determined by the maximum length of material the tool can machine in one stroke. It includes the table size, (length and width) and its distance from the rail. Other details are also mentioned to complete the specifications like type of drive, type of speed reduction, power input, cutting to return stroke ratio etc.

3.13 Principal parts

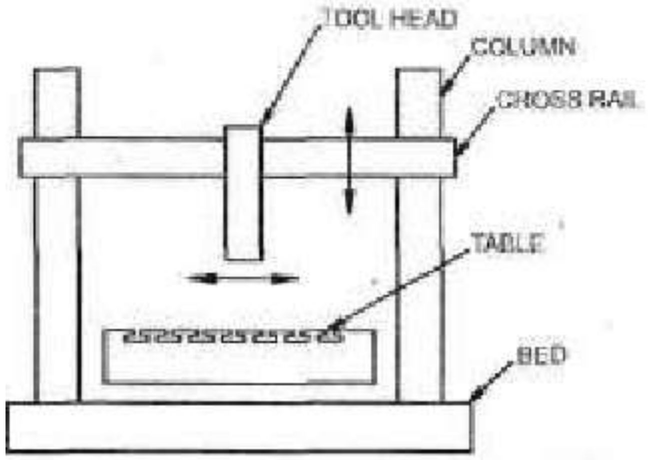
The principle parts of a planer are as follows:

Bed

It is a very strong and robust structure. It is made of cast iron. Cross ribs are provided to make it more strong and stable. The length of the bed is usually-twice the length of the table, so that the table may have complete stroke on the bed surface. For, supporting and permitting the table to reciprocate in constrained form, ways are provided on the top of the bed. Mechanisms for driving the table are accommodated inside the bed.

Table

The table is supported on the bed ways. T-slots are provided through out the length of the table for tightening the work-piece by T-bolts. A trough is provided at either end of the table to collet chips. Adjustable dogs are provided at aside of the table, which operate some mechanism for reversing the table automatically at the end of each the stroke. Some arrangements are also made to avoid the running away of the moving, loaded table. The table is usually cast in one piece; long table, may be cast in several pieces and bolted together.



Column or Uprights

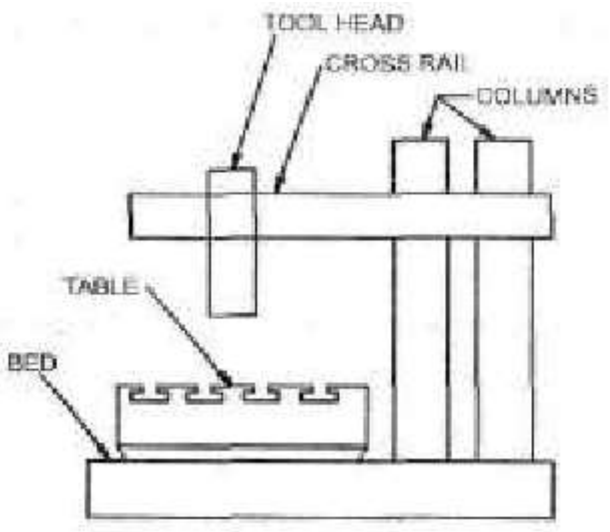
A planer has to columns one at each side of the bed at its centre and opposite to each other. The columns support a horizontal cross rail across the length of the bed. The cross rail may slide up or down on the columns and may be clamped in any position. Within the body of the columns, the vertical feed shaft, elevating screw for cross rail, end feed bar, etc. are accommodated within the body of the columns. The column may also support a tool head for side machining.

Cross-Rail

It is supported horizontally by the two vertical column at the centre of the bed and across it. The cross rail may be operated manually, hydraulically. It may be clamped horizontally in any position on the columns. It carries tool heads usually two in number. For feeding the tool, the feed screws are enclosed in the cross rail.

Tool Head

Usually two tool heads are mounted on the horizontal cross rail and one on each column. The tool head carries a tool post to hold the cutting tool. The tool post is hinged on the tool head for lifting the tool in the return stroke. The tool may be adjusted at an angle also, if desired.



Control

The controls for governing the various actions of different parts of a planer are provided in a centralised panel. From this central location the operator is able to obtain very close control of all cutting tools. These controls are start, stop, automatic cut, automatic return, speed reduce, etc.

Classification of Planer

According to the general construction the planers are of five types:

1) Double housing planer
2) Open-side planer
3) Universal planer
4) Pit type planer
5) Edge or plate planer.

Each of the above types may vary according to the method of drive as follows:

1) Gear drive
2) Hydraulic drive
3) Screw drive
4) Belt drive
5) Variable-speed motor drive
6) Crank drive.

Gear driven planers are generally used in the workshops. They have several times moreinertia force to over come than the hydraulic drive planers. Overcoming inertia consumes energy and with rapid short strokes, the difference is power consumption in noticeable hydraulic drives are highly satisfactory for planers. Advantages of hydraulic drives are uniform cutting pressure, quick table reversal, rapid means of varying the stroke and less noise in operation. Screw drive is employed principally on plate planers. Belt drive is the oldest system in which the power is taken from an overhead line shaft. Crank drive is found only on some small planers.

Double Housing Planer

It consists of a long heavy base on which the table or platen is reciprocated. The upright housing is located at the side of the base near the centre to support the cross rail. Thecross rail supports the tool heads. The tool maybe feed manually or by power in either a vertical or a crosswise direction. The motor drive usually at one side of the planer near the centre, and the drive mechanism is located under the table. The controls for operation are all at the upright housing The stroke length of the table is controlled by the adjustable dogs at the side of the bed. The accuracy of the planer depends upon the rigidity and the manner in which the bed ways are machined.

Open-Side Planer

The open side planer has housing on one side only. It is hydraulically driven and used to handle wide work. It can be equipped with duplicating attachments for machining irregular surfaces. On one side of the table, a master form is mounted so that as the tracer moves over the surface, the cutting tool is moved accordingly. Such device are usually hydraulically operated and are similar in operation to duplicating units used on other machine tools.

Pit-Type Planer

It is very heavy and huge in construction. If differs from an ordinary planer in that the bed is stationary and the tool is move over the work. The work piece up to 12 m long and 5m wide may easily be machined on this planer. The cross-rail is mounted with two ram-type hands equipped with double clapper block tool holders for two-way planing. Two reversing housing supporting the cross-rail, slide on ways and are screw- driven from an enclosed worm drive at one end of the bed. All feeds are automatic reversible, and can be operated at both ends of the planning stroke.

Plate or Edge Planer

It is special type of planer deviced for fabrication of heavy steel plates for pressure vessels armor plate. It may have the plate with capacity up to 15m. On one side of the housing the plate is clamped to the long bed. The carriage holding the cutting tool is supported on the heavy ways of the planer. The carriage carrying the tools and operator is moved along the work by the large screw drive. The size of the plates that can be edge-machined is limited by the width and height of the machine opening but there is no limit to the length, the plate may extended behind the machine.

3.14 Machining time calculations

3.15 DRILLING&BORINGMACHINES

DRILLING