3 LATHE

3.1 INTRODUCTION

A lathe is one of the oldest and perhaps the most important machine tool ever developed. It is widely used metal cutting machine tool invented by Henry Maudslay in the year 1797. *Lathe is a machine tool which removes undesired material from a rotating workpiece in the form of chips with help of a tool which is traversed across the work and can be fed deep into the work.* The lathes are also used for facing, recessing, thread cutting and parting- off operations.

Lathe was actually the first machine tool which came into existence as a useful machine tool for metal cutting. Thus, it forms the basis of production of all the other machine tools which are the results of later developments.

A large number of machine tools are available in market, most of them automatic too, still the lathe maintains its existence as an indispensable machine tool even today. Engine lathes are the most versatile machines of the lathe group. These are called so because in early lathes, power was used to obtain from engines.

3.2 PRINCIPLE OF TURNING

In lathe, work is held between two rigid and strong supports called centres or in a chuck or in a face plate. The chuck or face plate is mounted on the spindle of the lathe. The cutting tool is held in a tool post and is fed against the rotating workpiece. The tool can move parallel and perpendicular to the axis of rotating work piece. It can also move at an inclination with the axis to cut the desired material. Fig. 3.1 shows the basic elements involved in metal removal process.

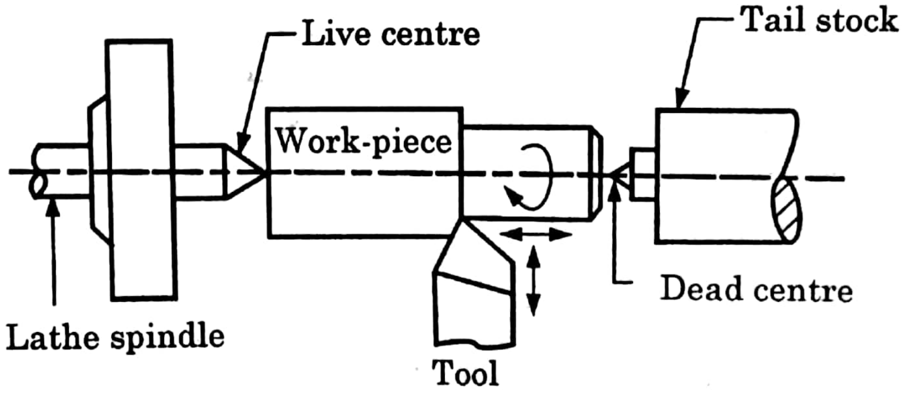


Fig. 3.1 : Principle of Turning on Lathe

3.3 REQUIREMENTS OF LATHE MACHINE TO REMOVE METAL

The followings are the requirements of lathe machine to remove metal :

1. Tool must have sharp cutting edge.
2. Both tool and workpiece should be held rigidly.
3. Tool must be made of harder material than workpiece.
4. There must be relative motion between job and tool.

3.4 CLASSIFICATION OF LATHE MACHINES

The followings are the important types of lathes :

1. Speed lathe,
2. Engine or centre lathe,
3. Bench lathe,
4. Tool room lathe,
5. Capstan and turret lathe,
6. Automatic lathe,
7. Special purpose lathe.

1. Speed Lathe : Speed lathe is simplest among all types of lathes. It is driven by power and consists of a bed, a headstock, a tail stock and an adjustable slide for supporting the tool. These lathes may be of bench types or they may have the supporting legs cast and fitted to the bed. Speed lathe normally does not possess gearbox, carriage and lead screw. The tool is mounted on the adjustable slide and is fed into the work by hand only. Spindle speeds usually from 1200 to 3600 r.p.m. can be obtained easily. The speed lathe is used mainly for the following purposes :

(*i*) Wood working,
(*ii*) Centering,
(*iii*) Metal spinning,
(*iv*) Polishing.

2. Engine or Centre Lathe : It is a general purpose lathe and is widely used in workshops. It is called engine lathe because in early times, power was used to obtain from the engines. Although, it practically resembles a speed lathe in most of its features, but its construction is relatively more robust. It differs from the speed lathe as it has additional mechanism for controlling the spindle speed and controlling the feed of the fixed cutting tool. In this, cutting tool may be fed in both directions, longitudinal and cross, with reference to the lathe axis with the help of a carriage. The engine lathe, depending upon the power transmission, may be classified as follow :

(*i*) Geared head lathe,

(*ii*) Motor driven lathe,

(*iii*) Belt driven lathe.

3. **Bench Lathe :** It is a small lathe with bed upto about 1.8 m long and swing upto about 30 cm and is commonly set on bench. In most cases, it is as complete as larger lathe, but is smaller and lighter. It is used for small and precision work.

4. **Tool Room Lathe :** This lathe looks like a conventional engine lathe, but is built more accurately, has more speeds and feeds and is equipped with all the accessories and attachments. It costs more and is mainly used for the manufacture of small tools, dies, gauges, fixtures and precision parts of all kinds. It may either be a pedestal or a bench type.

5. **Capstan and Turret Lathe :** Turret lathe is similar to standard lathe with one modification. In this, tailstock has been replaced by a hexagonal head known as turret. This turret is capable of being rotated so that various tools mounted on this turret can be brought to the job as and when required.

Capstan lathe is similar to turret lathe, but it is lighter and used for lighter work and secondly, it has got square head.

6. **Automatic Lathe :** It is a special purpose lathe whose movements are controlled automatically. In this, the operator has to load and unload the job and rest of the work is performed by lathe itself. It is very widely used for the production of bolts etc.

7. **Special Purpose Lathe :** Special purpose lathes are designed to perform the specific operations, which cannot be performed efficiently by the standard lathes. Some special purpose lathes are as follow :

(*i*) **Gap Bed Lathe :** It has a special sliding bed making it possible to accomodate the large diameter work.

(*ii*) **Wheel Lathe :** It is used for duplicating the shape of certain object.

(*iii*) **Screw Cutting Lathe :** It is used for the mass production of the screwed parts.

(*iv*) **Duplication Lathe :** It is used for duplicating the shape of a certain object.

3.5 PRINCIPAL PARTS OF A LATHE AND THEIR FUNCTIONS

Fig. 3.2 shows the main parts of a centre lathe. The principal parts of lathe are as follow :

1. Bed,
2. Head stock,
3. Tailstock,
4. Carriage,
5. Feed mechanisms.

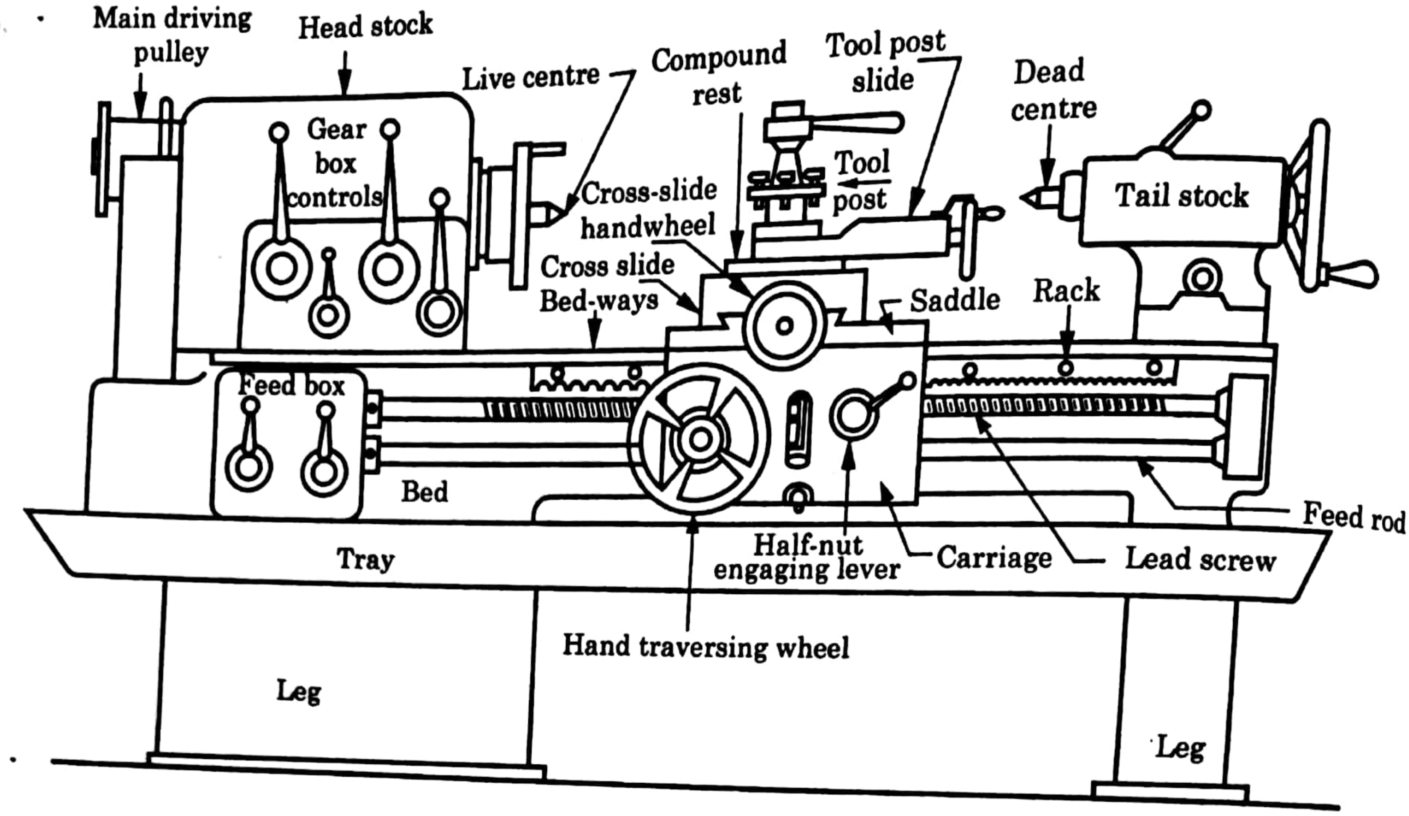
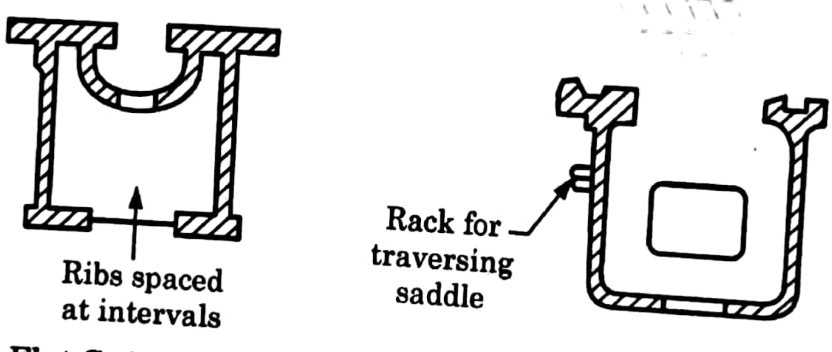


Fig. 3.2 : Centre Lathe

1. **Bed :** The bed is the base or foundation of the lathe. It is a heavy and rigid casting made in one piece to resist deflection and vibrations. *It holds or supports all other parts i.e. head stock, tailstock, carriage etc.* On the top of the bed, there are two sets of guide ways: Outer-ways and inner-ways. Outer-ways are for the carriage and the inner-ways for the tailstock. The guide ways are of two types *i.e* wide flat guide ways as shown in fig. 3.3(*a*) or inverted vee guide ways. Generally, the combination of both the flat and inverted vee guide ways is used as shown in fig. 3.3(*b*).



(*a*) Flat Guide Ways

(*b*) Flat and Inverted Vee Guide Ways

Fig. 3.3: Bed

2. **Headstock :** The headstock assembly is permanently fastened to the left hand end of the lathe. *It serves to support the spindle and driving arrangements.* The spindle revolves in bearings, one at each end of the headstock.

The spindle is hollow to take long bar stock. The front end of the hole is taper for holding centres and other tools having a standard morse taper shank. A taper sleeve fits into the taper spindle hole. The nose of spindle may be of flanged type or threaded, but the latter is mostly used on lathes.

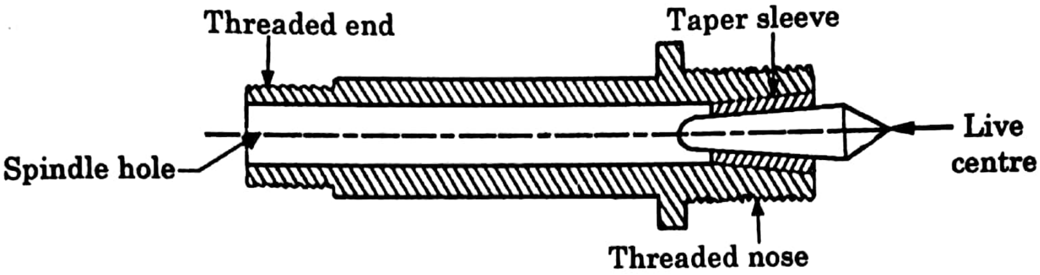


Fig. 3.4 : Headstock Spindle

3. **Tailstock :** It is an important part of lathe made of cast iron or mild steel. It is located on the innerways of lathe bed at the right hand end of the bed. It has the following main uses :

(*i*) *It helps in performing taper turning operation.*

(*ii*) *It holds a tool for performing operations such as reaming, drilling, tapping etc.*

(*iii*) *It supports the other end of the work when it is being machined between centres.*

A tailstock is illustrated in fig. 3.5.

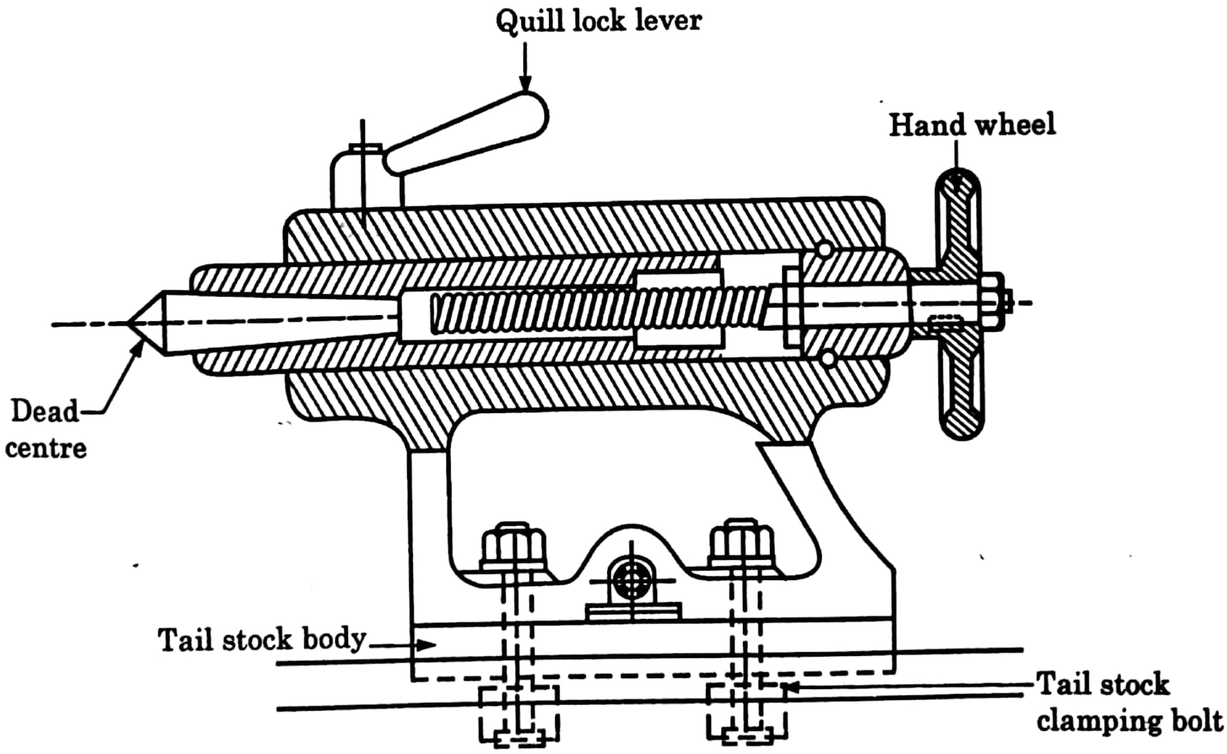


Fig. 3.5 : Tailstock

The tailstock spindle is a hollow taper shaft (left side end). It can be used to hold the dead centre or other tools having the same tapers such as drills and reamers. The tailstock hand wheel is used to move the tailstock spindle in or out of the tailstock casting and a spindle clamping lever or lock handle is used to hold the tailstock spindle in a fixed position.

4. Carriage : It is placed between the headstock and the tailstock. *It controls and supports the cutting tool.* It is movable on the bed ways and its purpose is to hold the cutting tool and to impart to it either longitudinal or cross feed. It has five major parts as shown in fig. 3.6.

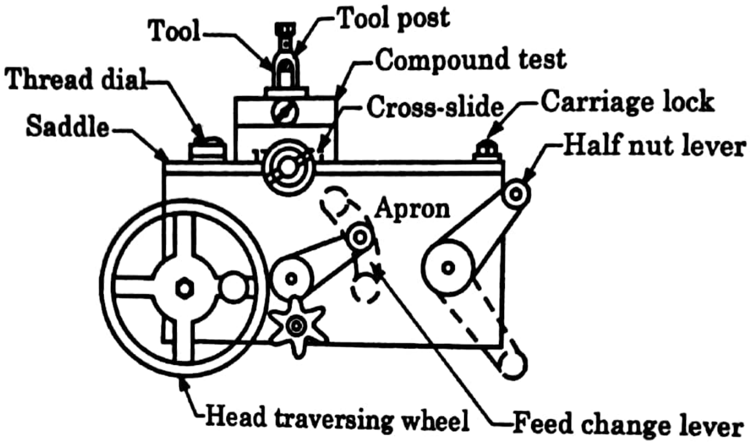


Fig. 3.6 : Carriage

(i) Saddle : Saddle is a H shaped casting mounted on the top of the lathe ways. So it slides along the ways between the headstock and tailstock. *It serves as the base for the cross slide.*

(ii) Cross Slide : The cross slide is mounted on the saddle. *It provides cutting tool motion which is perpendicular to the cente line of the lathe itself.* The cross feed movement may be controlled by manual or by power feed.

(iii) Compound Rest : It is mounted on top of the cross-slide. The compound rest has a graduated base and can be swivelled around a vertical axis. In this way, its slide can be set at any angle with the axis of the work piece. It can be clamped to remain at any angular setting.

(iv) Tool Post : It is mounted above the compound rest. A T-slot is machined in the compound rest to accomodate the tool post. *It serves to rigidly clamp the cutting tool or tool holder in a desired position.* A tool post is shown in fig. 3.7.

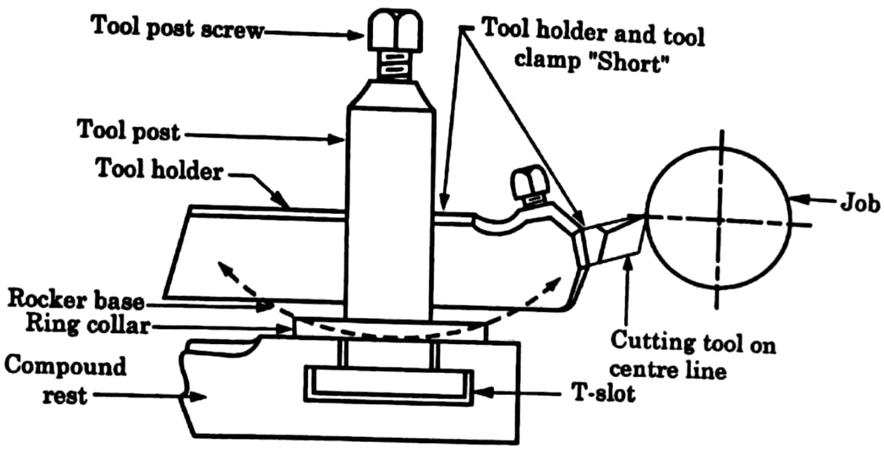


Fig. 3.7 : Tool Post

(*v*) **Apron :** It is fastened to the saddle and hangs over the front of the bed. It contains the gears, clutches and levers for operating the carriage by hand and power feeds. The apron hand wheel can be turned to move the carriage longitudinally by hand. This wheel is further attached to a pinion that meshes with the rack under the front of the fed. The apron also contains friction clutches for automatic feeds and a split nut or half nut.

5. **Feed Mechanism :** *The movement of tool relative to work is termed as feed.* A lathe tool may have three types of feeds: Longitudinal, cross and angular.

(*i*) **Longitudinal Feed :** *When the tool moves parallel to the work i.e. towards or away from the headstock, it is called longitudinal feed.*

(*ii*) **Cross feed :** *When the tool moves perpendicular to the work i.e. towards or away from the operator, it is called cross feed.*

(*iii*) **Angular feed :** *When the tool moves at an angle to the work, it is called angular feed.* It is obtained by swivelling the compound slide.

The three types of feeds are shown in fig. 3.8.

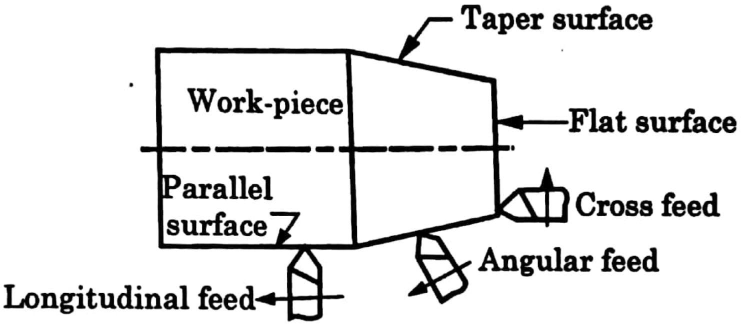


Fig. 3.8 : Longitudinal, Cross and Angular Feeds

Both cross feed and longitudinal feed are manual, but angular feed can be automated. The other parts of feed mechanism are as follow :

(*a*) End of bed gearing,
(*b*) Feed gear box,
(*c*) Feed rod and lead screw,
(*d*) Apron mechanism.

3.6 SIZE AND SPECIFICATION OF A LATHE

The size of a lathe is determined by

1. The maximum diameter of the work that can be accommodated in the gap for a gap bed lathe. This is shown by D_2 in fig. 3.9.
2. The height of the centres above the top of the bed. This is shown by H in fig. 3.9.
3. The maximum diameter of the work that can be rotated over the lathe saddle. This is shown by D_1.
4. The swing or the maximum diameter of the work that can be rotated over the ways of the bed. This is equal to twice the height of the centres. It is shown by D.
5. The maximum length of the work that can be accomodated between the lathe centres. This is shown by L.

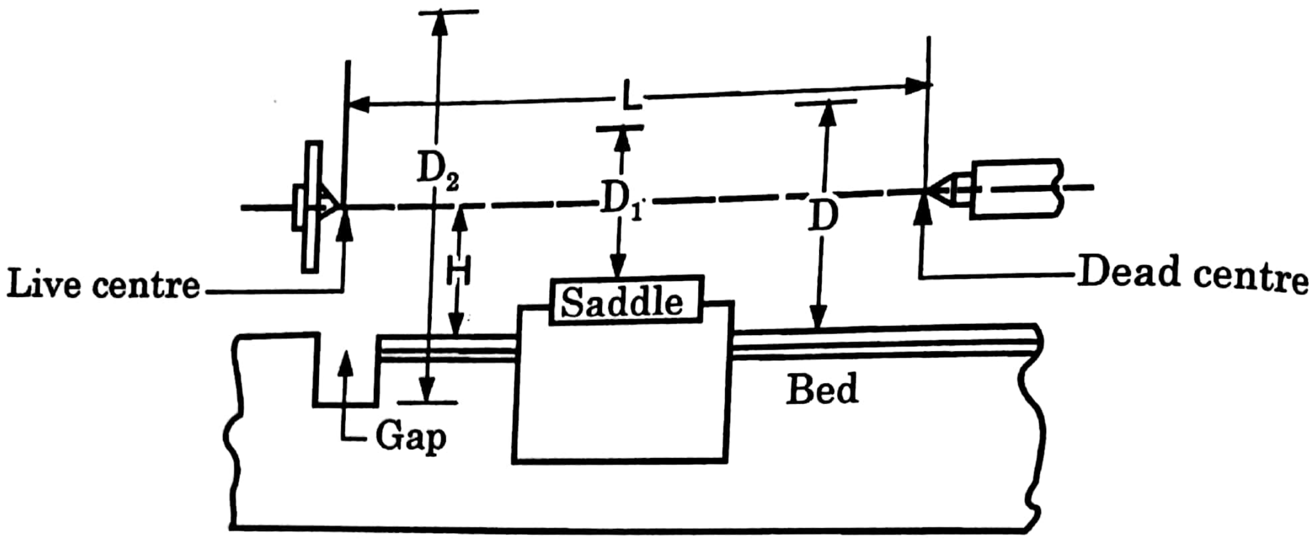


Fig. 3.9 : Lathe Specifications

The addition to the above, the following specifications are necessary to provide, while ordering a lathe :

1. The length, width and depth of bed.
2. The depth and width of the gap, if it is a gap bed lathe.
3. The swing over gap.
4. The power rating of electric motor.
5. The back gear ratio.
6. The tailstock spindle travel.
7. The lead screw diameter.
8. The number of feeds.
9. The tailstock spindle set over.

3.7 DRIVES AND TRANSMISSION

The following drives are used to obtain different speeds of lathe spindle:

1. Belt drive,
2. All gear drive.

1. Belt Drive: All belt driven lathes are provided with countershaft. A countershaft shown in fig. 3.10 is a short shaft having a set of fast and loose pulleys and a stepped cone pulley for each machine. The countershaft receives power from the main shaft which is driven at constant speed.

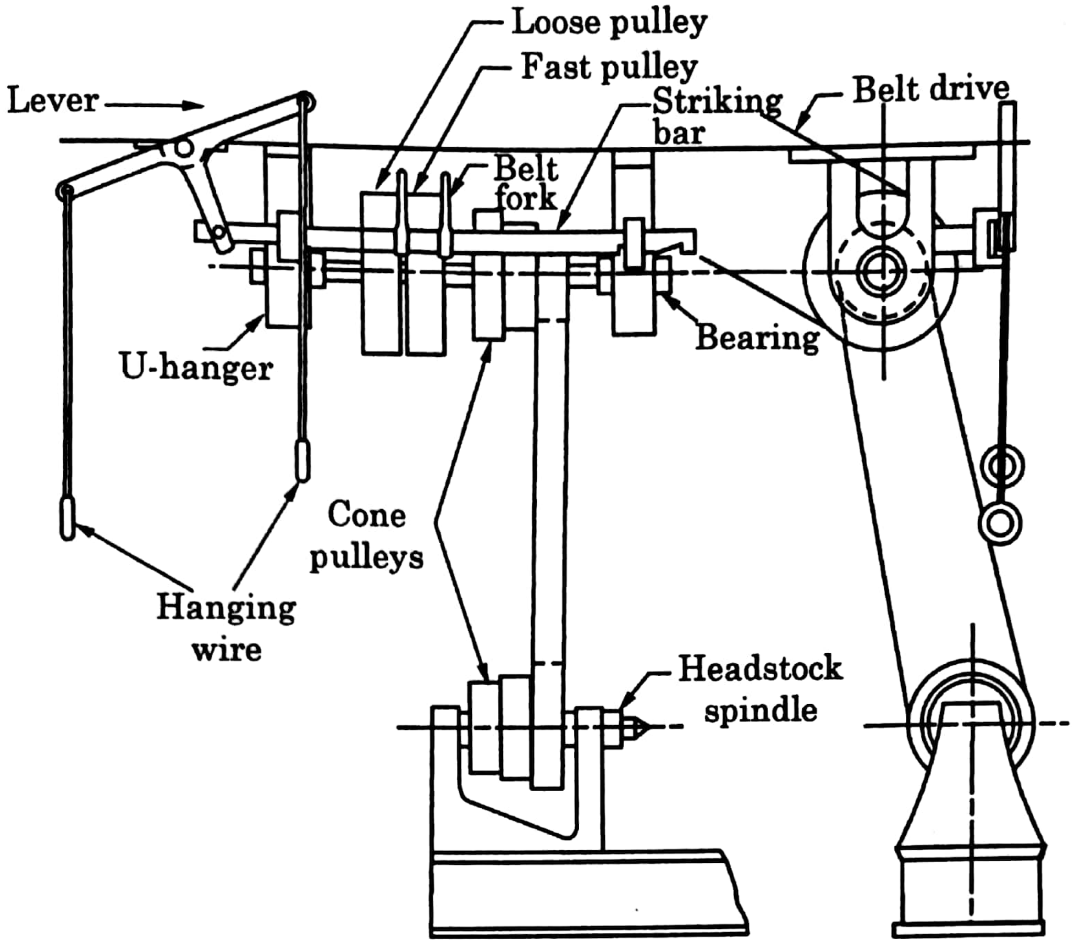


Fig. 3.10 : Counter Shaft Drive Arrangement

The stepped cone pulley on the countershaft is connected to the stepped cone pulley mounted on the headstock spindle with the help of a belt. Different speeds can be obtained when the position of belt on the stepped pulleys is changed. The spindle speed increases when the belt is shifted from a larger to a smaller step of the cone pulley mounted on headstock spindle. To stop the machine, the belt is shifted from the fast pulley to the loose pulley on the countershaft with the help of belt fork attached to the striking bar which is operated through a lever by simply pulling a cord.

2. All Gear Drive: Modern lathes are provided with all geared headstock to get large variation of spindle speeds. These lathes are driven by a constant speed motor.

Speed changes are obtained through a series of gear combinations. The different mechanisms which are commonly employed in all geared headstock are as follow:

(*i*) Sliding gear mechanism,

(*ii*) Sliding clutch mechanism,

(*iii*) Combination of above two.

In a lathe, the standard practice is to arrange the gears in such a way that spindle speed increases in geometrical progression *i.e.* each speed is multiplied by a constant called common ratio to give next higher speed. *e.g.* if N is the first speed and r is the constant, then second speed will be $N \times r$, third speed will be $N \times r \times r = Nr^2$ and so on. Now, if n is the number of speeds required and H and L are the highest and lowest speeds respectively, the constant r may be determined by using the following formula:

$$r = (n-1)\sqrt{\frac{H}{L}}$$

The international standard values of r are 1.12, 1.25, 1.40, 1.60 and 2.00. Thus, in a lathe gear box, there is a set of common ratio or preferred numbers to obtain series of output speeds of spindle.

The simplest arrangement of obtaining multiple speeds in an all geared headstock is sliding gear mechanism. Various speed changes are obtained when a set of gears is made to slide on a splined shaft bringing them into mesh only one at a time with a cluster of gears mounted on second shaft.

Modern lathes are provided with both sliding gear and sliding clutch mechanism. Fig. 3.11 shows a 9-speed all geared headstock with sliding gear mechanism. Gears G_1, G_2 and G_3 are mounted on a splined shaft and get power from fast and loose pulley. Gears G_1, G_2 and G_3 may be made to mesh with gears G_4, G_5 and G_6 respectively by shifting with the levers. Gears G_4, G_5 and G_6 rotate freely on the intermediate shaft and do not move axially. Similarly, gears G_7, G_8 and G_9 may be made to slide with the help of second lever on the headstock spindle which is a splined one. Let T_1, T_2, T_3, ... etc. are the teeth on gears G_1, G_2, G_3 ... etc. The gears combination for nine different speeds are as follow:

1. $\frac{T_1}{T_4} \times \frac{T_4}{T_7}$ 2. $\frac{T_2}{T_5} \times \frac{T_4}{T_7}$ 3. $\frac{T_3}{T_6} \times \frac{T_4}{T_7}$
4. $\frac{T_1}{T_4} \times \frac{T_5}{T_8}$ 5. $\frac{T_2}{T_5} \times \frac{T_5}{T_8}$ 6. $\frac{T_3}{T_6} \times \frac{T_5}{T_8}$
7. $\frac{T_1}{T_4} \times \frac{T_6}{T_9}$ 8. $\frac{T_2}{T_5} \times \frac{T_6}{T_9}$ 9. $\frac{T_3}{T_6} \times \frac{T_6}{T_9}$

In gear selection, the rule is that the total number of teeth between any one pair of gears mounted on two shafts must be equal to the total number of teeth on the other pair.

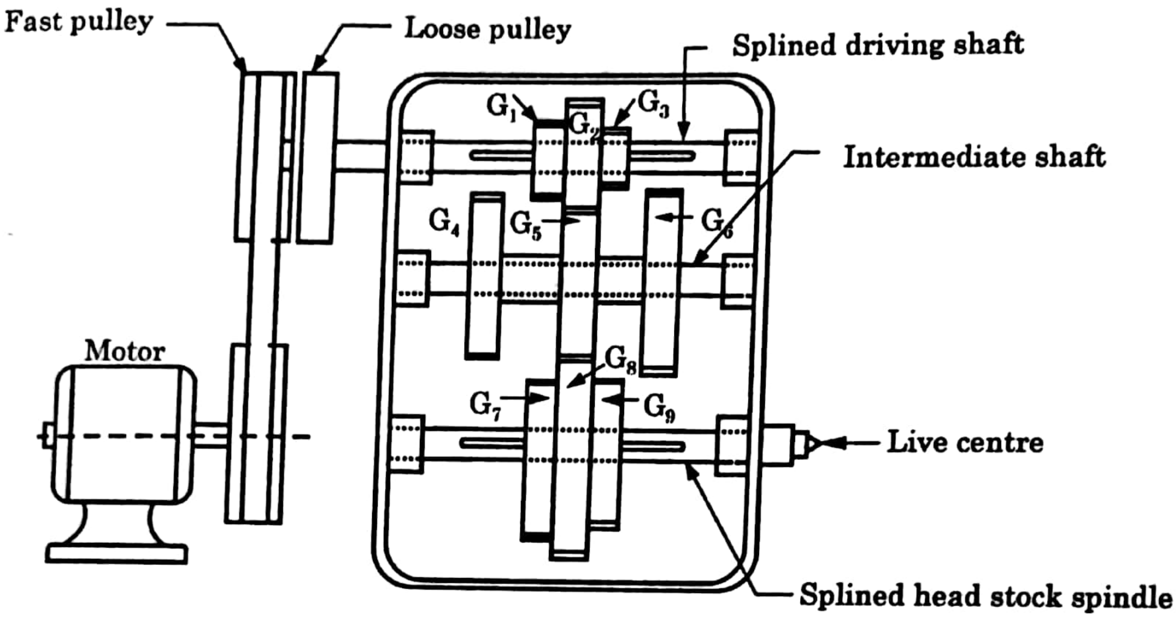


Fig. 3.11 : 9-Speed All-geared Headstock