

Theory of metal cutting

* INTRODUCTION

Metals are shaped into usable forms through various processes. Of these, some are called non cutting shaping processes. Those in which no chip formation takes place, and the metal is shaped under the action of heat, pressure or both. This category includes operations like forging, drawing, spinning, rolling, extruding, etc.. Against this, there are other processes in which the components are brought to the desired shape and size by removing the unwanted material from the parent metal in the form of chips through machining. This is termed as cutting shaping. A few of the important machining processes falling in this category are: turning, boring, milling, drilling, shaping, planing, broaching, etc.

In this context, it is obviously of a vital importance to understand and practice the principles of metal machining very thoroughly in order to achieve the following basic objectives of efficient and economical machining practice.

- * Quick metal removal,
- * Economy in tool cost,
- * High class surface finish
- * Economy in the cost of replacement & sharpening of tools,
- * Minimum idle time of machine tools.

* Geometry of single point cutting tool

Tool geometry refers to the tool angles, shape of the tool face and form of the cutting edges. Unless the cutting tool is ground to the correct shape with correct angles and smooth cutting edge, accuracy will be impossible and a poor finish will result. The optimum tool geometry depends upon the following factors.

- 1 Workpiece material
- 2 Machining variables
 - a) cutting speed
 - b) Feed
 - c) Depth of cut
- 3 Material of the tool point
- 4 Type of cutting.

For general purpose work, the tool used in a lathe is a single point tool, but for special operations multi point tools may be used

A typical single point tool. The most important features are the cutting edges and adjacent surfaces

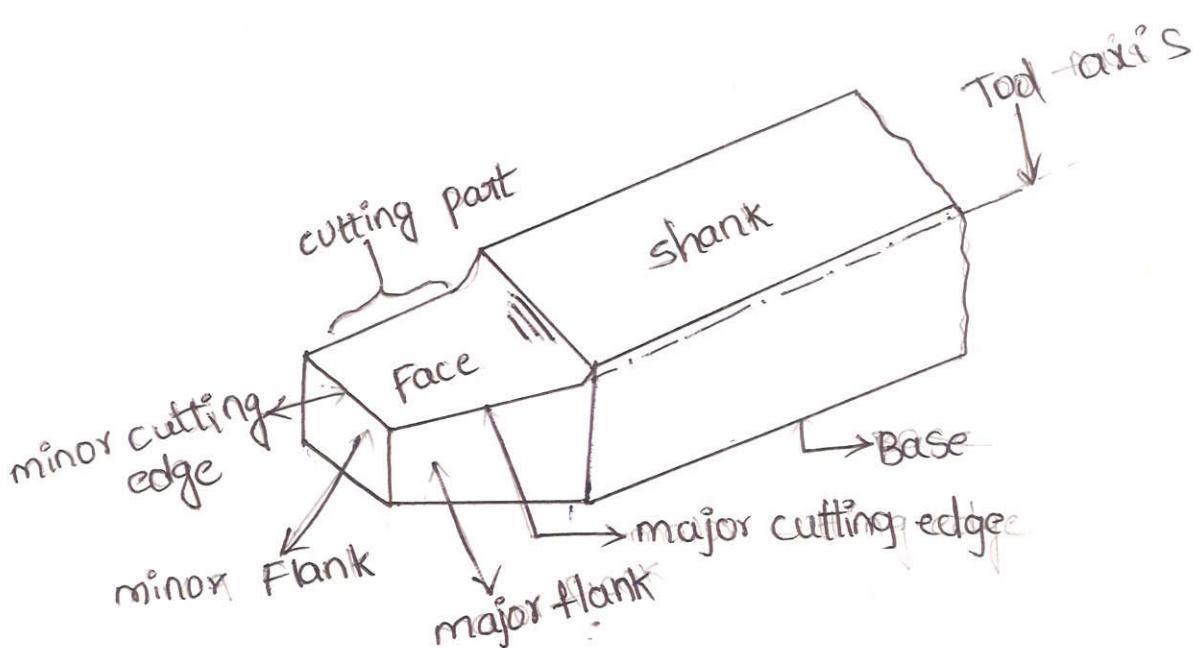


fig :- single point cutting tool

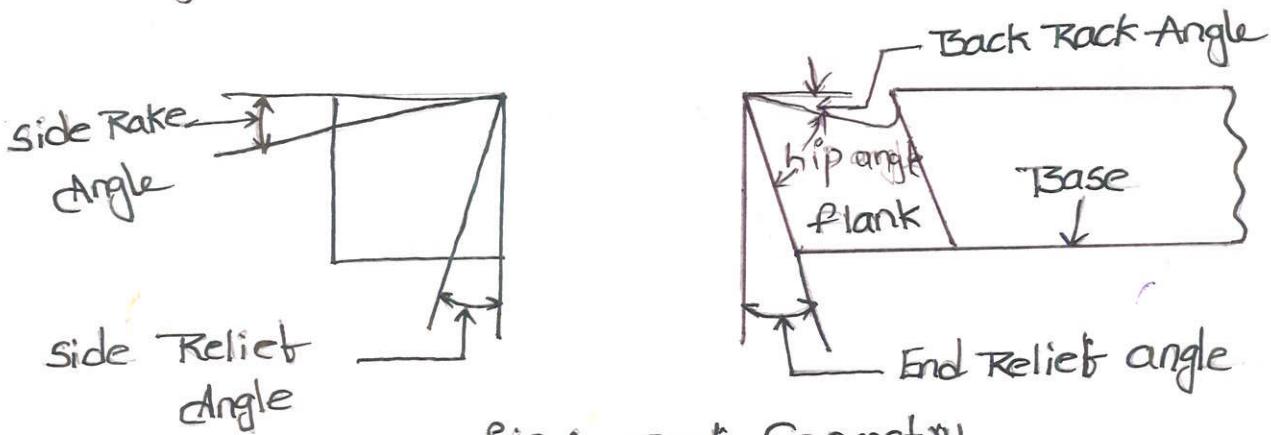
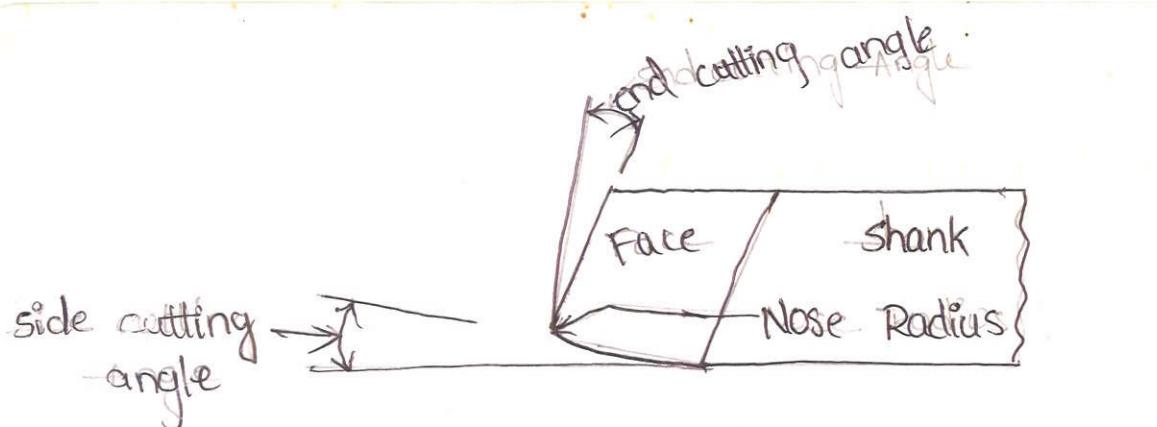


fig : Tool Geometry.

In lathe work, different operations require different types of tools. The tool bits are shaped for various lathe operations such as straight turning, boring, cutting-off, threading and knurling. Furthermore more the cutter bits may be shaped for either rough turning or finish turning, or they may be shaped as round-nose turning tools, right or left hand turning tools, and right or left hand facing tools.

* important terms

* shank

it forms the main body of a solid tool and it is this part of the tool which is gripped in the tool holder.

* Face

it is the top surface of the tool between the shank and the point of the tool. In the cutting action, the chips flow along this surface only.

* point

it is wedge shaped portion where the face and flank of the tool meet.

it is the cutting part of the tool. it is also called nose, particularly in case of round nose tools.

* Flank

portion of the tool which faces the work is termed as flank. it is the surface adjacent to and below the cutting edge when the tool lies in a horizontal position

* Base

it is actually the bearing surface of the tool on which it is held in a tool holder or clamped directly in a tool post.

* Heel

it is the curved portion at the bottom of the tool where the base and flank of the tool meet.

* Nose radius

if the cutting tip (nose) of a single point tool carries a sharp cutting point, the cutting tip is weak. it is, therefore, highly stressed during the operation, may fail or lose its cutting ability soon and produce marks on the machined surface. in order to prevent

* Rake angle

it is the angle formed between the face of the tool and a plane parallel to its base. if this inclination is towards the shank, it is known as "back Rake" or "Top Rake". when it is measured towards the side of the tool, it is called "side rake".

* Lip angle

The angle between the face and the flank of the tool is known as lip angle. it is also sometimes called the angle of keenness of the tool.

* clearance angle

it is angle formed by the front or side surfaces of the tool which are adjacent and below the cutting edge when the tool is held in a horizontal position. it is the angle between one of these surfaces and a plane normal to the base of the tool.

* Relief angle.

It is the angle formed between the flank of the tool and a perpendicular line drawn from the cutting point to the base of the tool.

* cutting angle.

The total cutting angle of the tool is the angle formed between the tool face and a line through the point, which is a tangent to the machined surface of the work at that point.

* chip formation

It is a schematic representation of a shaping operation, in which the workpiece remains stationary and the tool advances into the workpiece towards the left. Thus, the metal in front of the tool gets compressed very severely, causing shear stress. This stress is maximum along a plane, called shear plane. If the material of the workpiece is ductile, the material flows plastically along the shear plane, forming the chip, which flows upwards along the face of the tool.

The complete plastic deformation of the metal does not take place entirely along the shear plane only but it actually occurs over a definite area, represented by PQRS. The metal structure starts getting elongated along the line PQ below the shear plane and continues up to the line RS above the shear plane,

where its deformation is complete the complete area represented by PQRS, within which the metal deformation occurs, is known as shear zone. For the sake of clarity in explanation, the lines PQ and RS are shown as exactly parallel in the diagram, but actually they may not be so. They will actually be inclined to each other such that the shear zone contained between them will be of wedge shape with its thicker portion near the tool and the thinner one opposite to it.

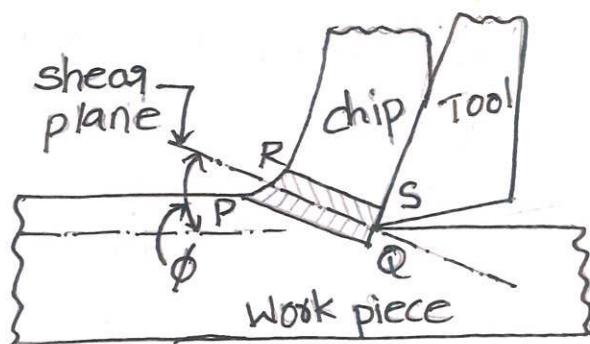


fig :- shear zone.

This shape of the shear zone is one of the reasons due to which the chip curls. The produced chip is very hot and its safe disposal is very necessary. The various devices used for its disposal are discussed in the latter chapters.

* Types of chips

The chips produced during machining of various metals can be broadly classified into the following three types. The production of any particular type will largely depend upon the type of material being machined and the cutting conditions.

* continuous chip

- * discontinuous chip or segmental chip
- * continuous chip with built-up edge

* continuous chip

As is evident from the name, the presence of separated segmental elements is totally eliminated in this case. This type of chip is produced while machining a ductile material, like mild steel, under favourable cutting conditions, such as high cutting speed and minimum friction between the chip and the tool face. If otherwise, it will break and form the segmental chip.

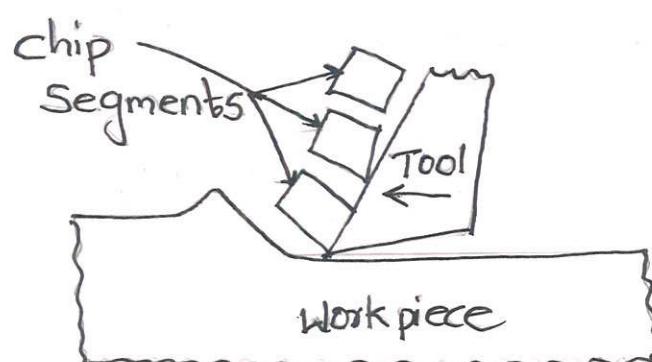


fig :- Discontinuous chip

* Discontinuous or segmental chips

This type of chips are produced during machining of brittle materials like cast iron and bronze. These chips are produced in the form of small segments. In machining of such materials, as the tool advances forward, the shear-plane angle gradually reduces until the value of compression stress acting on the shear plane becomes too low to prevent rapture. At this stage, any further advancement of the tool results in the fracture of the metal ahead of it, thus producing a segment of the chip. With further advancement of the tool, the processes of metal fracture and production of chip segments go on being repeated, and this is how the discontinuous chips are produced. Such chips are also sometimes produced in the machining of ductile materials when low cutting speeds are used and adequate lubrication is not provided.

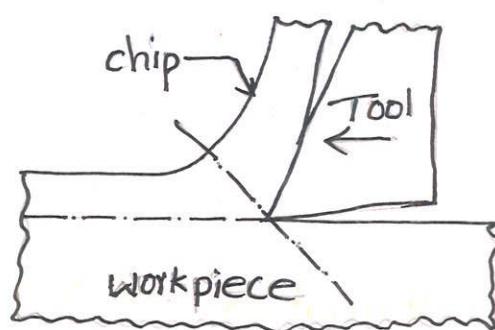


fig :- continuous chip

* continuous chip with built up edge.

such a chip is usually formed while machining ductile material, when high friction exists at the chip tool interface. The upward flowing chip exerts pressure on the tool face. The normal reaction NR of the chip on the tool face is quite high, and is maximum at the cutting edge or nose of the tool.

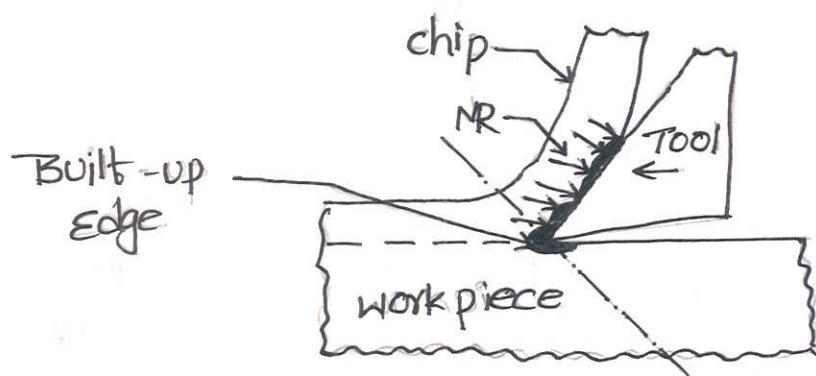


fig :- continuous chip with Built-up Edge

* Adverse effects of Built-up edge formation

1. Rough surface finish on the workpiece
2. fluctuating cutting force, causing vibrations in cutting tool.
3. chances of carrying away some material from the tool by the built-up surface, producing creases on the tool face and causing tool wear

* Avoiding the formation of Built-up edge the

following precautions are required.

1. The coefficient of friction at the chip tool interface should be minimised by means of polishing the tool face and adequate supply of coolant during the operation.

2. The Rake angle should be kept large.
3. High cutting speeds and low feeds should be employed, because at high speeds the strength of the weld becomes low. Similarly, at very high temperature also the strength of the weld becomes low.

* chip breakers

These chip breakers break the produced chips into the small pieces. The material of the chip makes the work of the chip breakers easy.

If the job requirements do not call for a very strict chip control, the common methods used for chip breaking are.

1 By control of tool Geometry, i.e., grinding proper Back Rake and side Rake according to the feeds and speeds to be used.

2 By obstruction method, i.e., by interposing a metallic obstruction in the path of the coil.

But, when a strict chip control is desired, some sort of a chip breaker has to be employed

The following types of chip breakers are commonly used.

- 1 Groove type
- 2 step type
- 3 Rake type
- 4 clamp type.

* Groove Type

it consists of grinding a groove on the face of the tool, behind the cutting edge, leaving a small land near the tip.

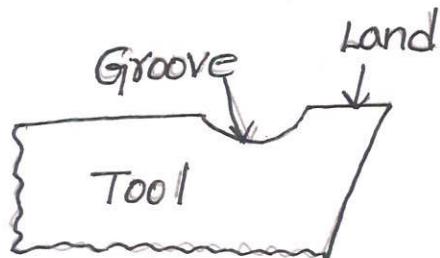


Fig :- Groove Type

* Step Type

it consists of grinding a step on the face of the tool, adjacent to the cutting edge, as shown in figure

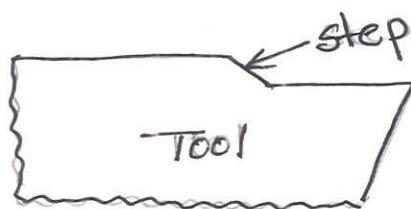


Fig :- Step type.

* Rake Type

it consists of providing a secondary rake on the tool through grinding, together with a small step.

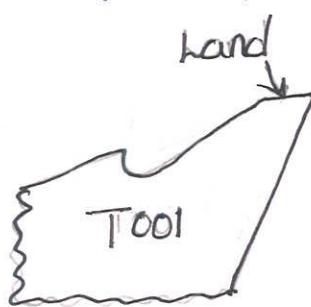


Fig :- Rake Type

* Clamp Type

this type of chip breaker is very common with the carbide tipped tools. The chip breaker is a thin and small plate which is either brazed to or held mechanically on the tool face.

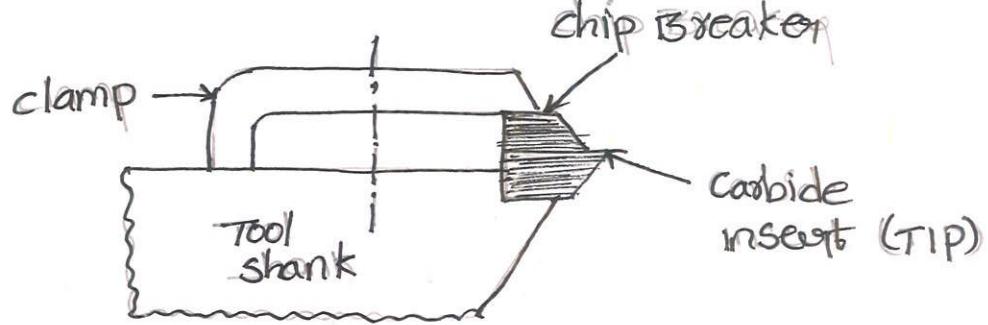


Fig : clamp type

* Types of cutting

The process of metal cutting is divided into the following two main classes.

* Orthogonal cutting and

* Oblique cutting

* Orthogonal cutting

In orthogonal cutting, the cutting edge of the tool remains at right angles to the direction of cutting velocity. This type of cutting is also known as two-dimensional cutting.

1. The cutting edge of the tool remains normal to the direction of tool feed or work feed.

2. The direction of the chip flow velocity is normal to the cutting edge of the tool.

3. The angle of inclination ' i ' of the cutting edge of the tool with the normal to the velocity v_c is zero.

4. The chip flow angle ' β ', i.e., the angle between the direction of chip flow and the normal to the cutting edge of the tool, measured in the plane of the tool face, is 'zero'

5. The cutting edge is longer than the width of the cut.

The last condition may not be fulfilled in some cases. It is then called semi-orthogonal or Restricted orthogonal cutting.

* oblique cutting

In oblique cutting, the cutting edge of the tool is inclined at an acute angle with the direction of tool feed or work feed, the chip being disposed of at a certain angle. This type of cutting is also called three-dimensional cutting. The main features of the two types of cutting are summarised below.

1. The cutting edge of tool always remains inclined at an acute angle to the direction of tool feed or work feed.
2. The direction of the chip flow velocity is at an 'P' with the normal to the cutting edge of the tool. The angle is known as chip flow angle.
3. The cutting edge of the tool is inclined at an angle 'i' with the normal to the direction of work feed or tool feed, i.e., the velocity V_c .
4. Three mutually perpendicular components of cutting forces act at the cutting edge of the tool.
5. The cutting edge may or may not be longer than the width of the cut.

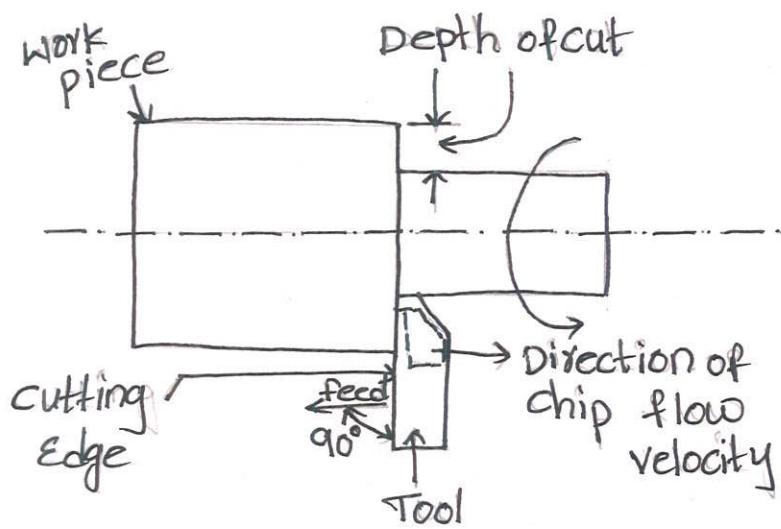
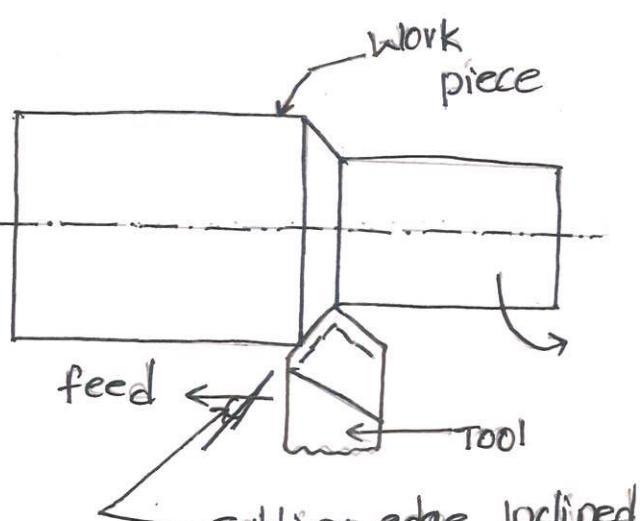


fig :- orthogonal



cutting edge inclined
at this angle with
the direction of
feed

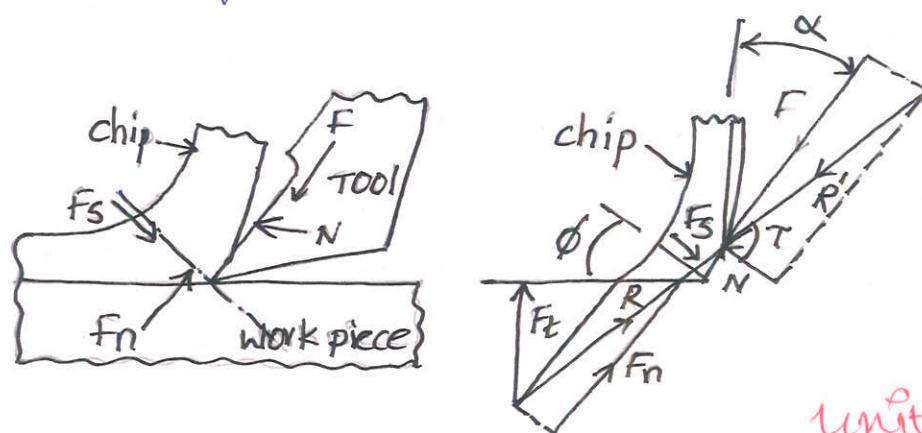
* Merchant's Force diagram.

It is clear from the figure forces acting on a chip in orthogonal cutting that a number of forces act on the chip during metal cutting. The relationships among these forces were established by merchant with the following assumptions.

1. cutting velocity always remains constant
2. cutting edge of the tool remains sharp through out cutting and there is no contact between the workpiece and tool flank.
3. there is no sideways flow of chip
4. only continuous chip is produced.
5. There is no built-up edge.
6. NO consideration is made of the inertia force of the chip
7. The behaviour of the chip is like that of a free body which is in the state of a stable equilibrium due to the action of two resultant forces which are equal, opposite and collinear.

However, there were a number of flaws and practical difficulties in these assumptions and that is why they were modified later.

The forces acting on a chip in orthogonal cutting. The forces represented are the following.



unit-1, pg-14/13

fig :- Forces acting on a chip in orthogonal cutting

F_s = metal resistance to shear in chip formation, acting along the shear plane, or shear force.

F_n = Backing up force exerted by the workpiece on the chip, acting normal to the shear plane.

N = Force exerted by the tool on the chip, acting normal to the tool face.

$F = \mu N$ = frictional resistance of the tool against the chip flow, acting along the tool face; μ being the coefficient of friction between the tool face and the chip.

$$\mu = F/N$$

These forces are vectorially represented in the free-body diagram shown on the right hand side. It will be observed that forces F_s and F_n can be easily replaced by their resultant R and forces F and N by their resultant R' . Thus, all these forces are resolved to only to forces R and R' . For equilibrium, these forces R and R' should be equal, act opposite to each other and should be collinear, i.e.,

$$\vec{R}' = \vec{F} + \vec{N}$$

and,
$$\vec{R}' = \vec{F}_s + \vec{F}_n$$

$$= \vec{F}_c + \vec{F}_t$$

or,
$$\vec{R} = \vec{R}'$$

For the convenience in studying further relation ship, the two triangles of forces of the above free body diagram have been combined together called the merchant's circle diagram for cutting forces, in which the following new components figure

F_c = horizontal cutting force exerted by the tool on the workpiece.

F_t = vertical or tangential force which helps in holding the tool in position and acts on the tool nose.

These two forces can easily be found out with the help of strain gauges or force dynamometers. The angle α is a known quantity, being the rake angle of the tool. With the help of the equations given the value of ' ϕ ' can also be determined. When all these four values i.e., of F_c , F_t , α and ϕ , are known, all the other forces can be easily calculated with the help of geometry with reference.

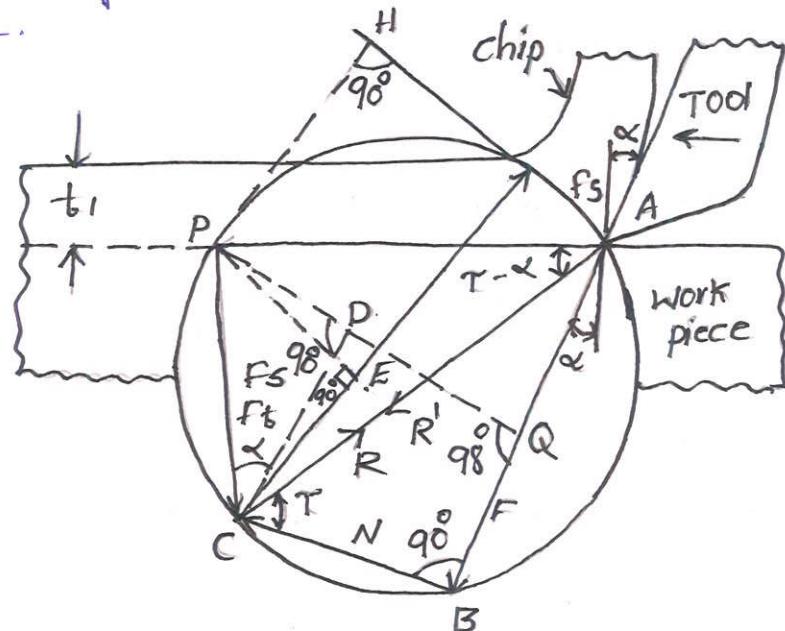


Fig : Forces acting in orthogonal cutting.

$$\begin{aligned} F &= -AQ + QB \\ &= AQ + DC \quad [\because QB = DC] \end{aligned}$$

i.e., $F = F_c \sin \alpha + F_t \cos \alpha \quad \text{--- } ①$

and $N = QD = PQ - PD$

or $N = F_c \cos \alpha - F_t \sin \alpha \quad \text{--- } ②$

Again $F_s = AH - HK \quad [\because HK = PE]$

$$F_s = F_c \cos \phi - F_t \sin \phi \quad \text{--- } ③$$

unit - 1, pg - 16/13

$$F_n = CR = CE + \epsilon K$$

$$= CE + PH \quad \text{--- } (4)$$

$\because \epsilon K = PH$

$$F_n = F_t \cos \phi + F_c \sin \phi$$

$$\text{and, } F_c = AC \cos (\tau - \alpha)$$

$$\text{Or, } F_c = R \cos (\tau - \alpha) \quad \text{--- } (5)$$

$$\text{also, } F_s = R \cos (\phi + \tau - \alpha) \quad \text{--- } (6)$$

$$\text{Now, } \frac{F_c}{F_s} = \frac{R \cos (\tau - \alpha)}{R \cos (\phi + \tau - \alpha)} = \frac{\cos (\tau - \alpha)}{\cos (\phi + \tau - \alpha)}$$

$$F_c = F_s \cdot \frac{\cos (\tau - \alpha)}{\cos (\phi + \tau - \alpha)} \quad \text{--- } (7)$$

From equations (1) and (2) we have

$$\frac{F}{N} = \frac{F_c \sin \alpha + F_t \cos \alpha}{F_c \cos \alpha - F_t \sin \alpha} = \mu \quad \text{--- } (8)$$

Also, by dividing the numerators and denominators both by $\cos \alpha$, we get

$$\frac{F}{N} = \frac{F_t + F_c \tan \alpha}{F_c - F_t \tan \alpha} = \mu \quad \text{--- } (9)$$

From right angled triangle ABC, we also have

$$\frac{F}{N} = \tan \tau = \mu \quad \text{--- } (10)$$

where

μ = kinetic coefficient of friction between the upward sliding chip and tool face

τ = angle of friction

$$\text{Or, } \tau = \tan^{-1} \mu = \tan^{-1} \frac{F}{N}$$

$$\text{Further, } \frac{CP}{AP} = \tan \text{PAC}$$

By substituting the values of CP, AP and angle PAC, we get

$$\frac{F_t}{F_c} = \tan (\tau - \alpha)$$

* Cutting speed

cutting speed of a cutting tool can be defined as the rate at which its cutting edge passes over the surface of the workpiece in unit time. It is normally expressed in terms of surface speed in metres per minute. It is a very important aspect in machining since it considerably affects the tool life and efficiency of machining.

* Feed

Feed of the cutting tool can be defined as the distance it travels along or into the workpiece for each pass of its point through a particular position in unit time. For example, in turning operation on a lathe it is equal to the advancement of the tool corresponding to each revolution of the work.

* Depth of cut

It is indicative of the penetration of the cutting edge of the tool into the workpiece material in each pass, measured perpendicular to the machined surface, i.e., it determines the thickness of metal layer removed by the cutting tool in one pass.

For example, in turning operation on a lathe it is given by.

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

unit-1, pg-18/13

where

D = original diameter of the stock in mm

d = diameter obtained after turning, in mm

* Tool Life

Tool life can be defined as the time interval for which the tool works satisfactorily between two successive grindings. Thus, it can be basically conceived as functional life of the tool. As already discussed earlier, the tool is subjected to wear continuously while it is operating. Obviously, after some time, when the tool wear is increased considerably, the tool loses its ability to cut efficiently and must be reground.

→ there are three common ways of expressing tool life.

1. As time period in minutes between two successive grindings

2. in terms of number of components machined between two successive grindings. This mode is commonly used when the tool operates continuously, as in case of automatic machines.

3. in terms of the volume of material removed between two successive grindings. This mode of expression is commonly used when the tool is primarily used for heavy stock removal.

⇒ volume of metal removed per minute

$$= \pi \cdot D \cdot t \cdot f \cdot N \text{ mm}^3/\text{min} \quad \text{--- (1)}$$

where

D = dia. of workpiece in mm

t = depth of cut in mm

f = feed rate in mm/rev.

$N = \text{No. of revolutions of work per minute}$

If ' T ' be the time in minutes to tool failure, then

\Rightarrow Total volume of metal removed to tool failure

$$= \boxed{\pi \cdot D \cdot t \cdot f \cdot N \cdot T \text{ mm}^3} \quad \rightarrow \textcircled{2}$$

We also know that the cutting speed

$$v = \frac{\pi D N}{1000} \text{ m/min}$$

$$\pi D N = v \times 1000$$

By substituting this value in equation $\textcircled{2}$ we get

\Rightarrow Total volume of metal removed to tool failure

$$= v \times 1000 \times t \times f \times T \text{ mm}^3$$

Therefore, tool life (T_h) in terms of the total volume of the metal removed to tool failure is given by

$$\boxed{T_h = v \cdot 1000 \cdot t \cdot f \cdot T (\text{mm}^3)}$$

* Machinability.

Machinability of a material gives the idea of the ease with which it can be machined. The parameters generally influencing the machinability of a material are.

\Rightarrow physical properties of a material

\Rightarrow mechanical properties of a material,

\Rightarrow chemical composition of the material,

\Rightarrow micro-structure of the material, and

\Rightarrow cutting conditions.

Since this property of the material depends on various variable factors; it is not possible to evaluate the same in terms of precise numerical values, but as a relative quantity. The criteria of determining the same may be as follows.

* Tool life

The longer the tool life it enables at a given cutting speed the better is the machinability.

* Surface finish

It is also directly proportional, i.e., the better the surface finish the higher is the machinability.

* Power consumption

Lower power consumption per unit of metal removed indicates better machinability.

* Cutting forces

The lesser the amount of cutting force required for the removal of a certain volume of metal or the higher the volume of metal removed under standard cutting forces the higher will be the machinability.

* Shear angle

Large shear angle denotes better machinability.

* Rate of metal removal

Under standard cutting conditions.

* Tool Material

The main characteristics of a good cutting tool material are its hot hardness, wear resistance, impact resistance, heat conductivity, strength etc. What is important to tool life is the likely changes in these characteristics at high temperature because the metal cutting process is always associated with generation of high amount of heat and, hence, high temperatures. We have already seen that the cutting speed has the maximum effect on tool life, followed by feed rate and depth of cut.

14. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

15. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

16. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

17. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

18. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

19. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

20. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

21. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

22. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

23. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

24. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

25. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

26. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

27. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

28. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

29. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

30. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

31. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

32. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

33. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

34. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

35. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

36. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

37. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

38. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

39. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

40. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

41. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

42. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

43. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

44. $\frac{1}{4} \cdot 2 \cdot 3 \cdot 4 = 12$

Chapter-1 Lathe and Lathe Work.

Introduction:- The lathe is one of the oldest machine tools. It came onto existence from the early tree lathe, as shown in Fig. 1.1. In tree lathe, a rough log having thick and rough skin was made to hang between two strong trees inserted across the two trees. A rope was wound round the work with its one end attached to a flexible branch of a tree and the other being pulled by a man, caused the gob to rotate intermittently. While the other man pressed chisel like cutting tool onto the gob, drives it towards left, thus turning of the gob was carried out and a cylindrical gob was produced.

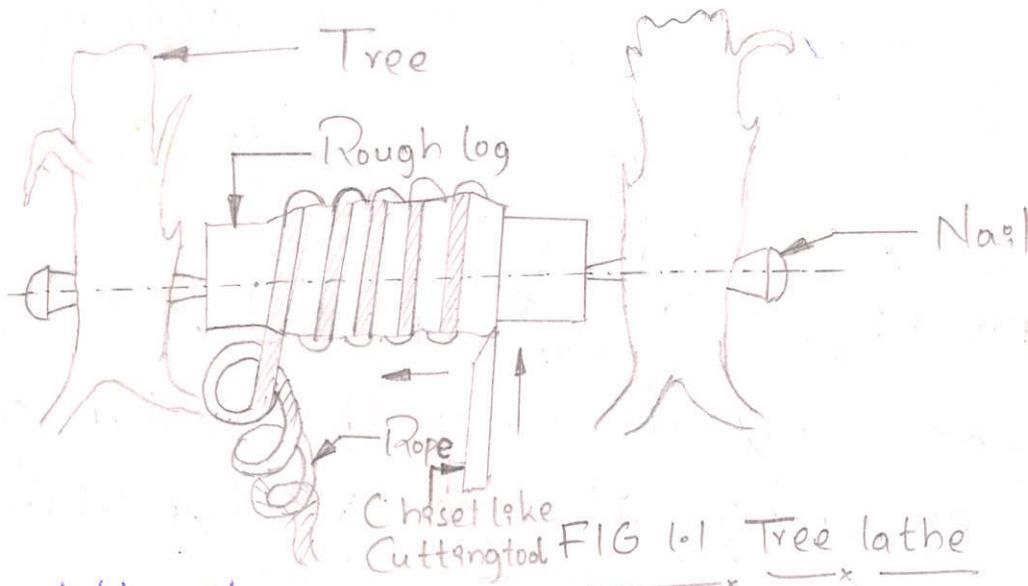


FIG 1.1 Tree lathe

With its further development a strip of wood called "lath" was used to support the rope, and that is how the machine came to be known as lathe. This device continued to develop through centuries and in the year 1797, Henry Maudslay

an Englishman, designed the first screw cutting lathe, which is fore runner of the present day high speed, heavy duty production lathe.

Lathe is employed for the job and mass production and also for repair works. Lathe was basically developed for producing cylindrical surfaces on work pieces.

1.1 Working Principle of lathe:- The working principle of lathe is to remove the excess material in the form of chips, from a rotating work piece held between two centres, with the help of a cutting tool fed against the work piece.

The working is illustrated in Fig 1.2.

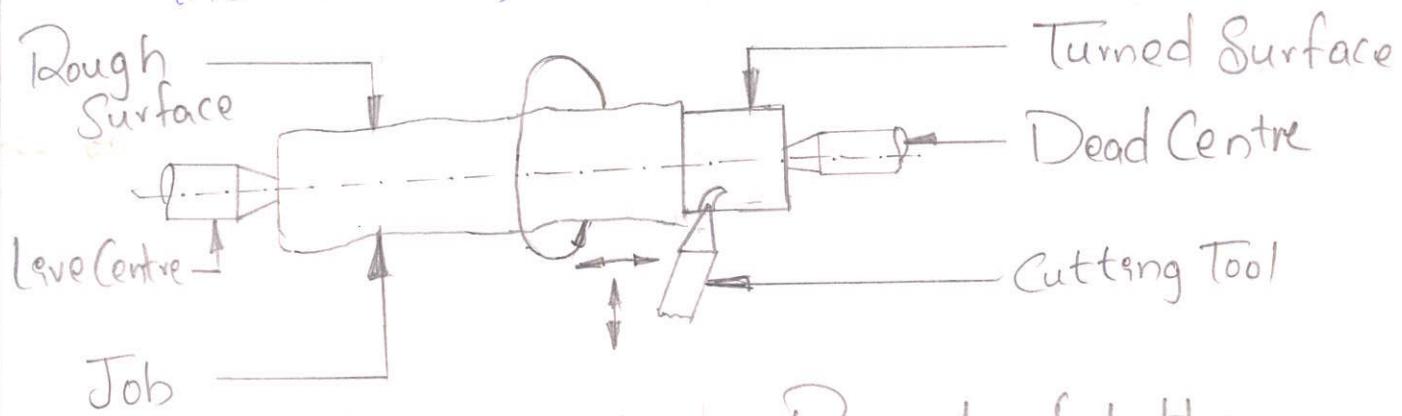


FIG 1.2 : Working Principle of lathe

The centres between which the work piece is rotating are head stock centre (live centre) and tail stock centre (Dead Centre). The tool can be fed parallel to the work piece (longitudinal feed) or perpendicular to the work piece.

To cut the material properly

* The tool should be harder than the material of

the work piece,

- * Work piece should be rigidly held on the machine, and
- * The cutting tool should be fed in a definite way relative to the work.

Types of lathe:- Various types of lathes have been developed to meet the different requirements in different situations. But all of them employ the same fundamental principle of Operation.

The types of lathes generally used are:-

1. Speed lathe
2. Engine lathe
3. Bench lathe
4. Tool room lathe
5. Turret lathes
- ① Capstan lathe ② Turret lathe
6. Special purpose lathe.
7. Duplicating lathe 8. Gap bed lathe
9. Wheel lathe
10. Axle lathe
7. Automatic lathe
8. Semi Automatic lathe.

Speed lathe:- It is the simplest form of the lathe in construction and operation. It consists of bed, head stock, Tail Stock and tool post. It is usually driven by the variable speed motor built into the head stock. The work piece is held between the centres revolved at high speeds by head

stock and the tool is fed by hand. As the tool is controlled by hand, the depth of cut is very small and hence less metal removal.

The speed lathe has been so named because of very high speed of the head stock spindle.

The speed lathe is principally used in wood working, centering, spinning and polishing.

Engine lathe or Centre lathe: It is a general purpose lathe normally used in all types of machine shops. It is called Engine lathe, as the steam engine was used as a power source, in olden days. The engine lathe consists of all the basic parts i.e., bed, head stock, Tail Stock, Carriage, feed rod and lead screw. Unlike speed lathe, the engine lathe is more robust in construction and it contains additional mechanism for driving the lathe spindle at multiple speeds.

Further an engine lathe can be given different names based upon the method of transmitting power to the machine. It may be

- (a) Belt driven lathe
- (b) Motor driven lathe
- (c) All geared Head Stock lathe.

Bench lathe: It is a comparatively a small lathe, that can usually (or) easily mounted on a work bench. It has a same features as speed lathe or engine lathe, performs almost all the operations, but (engine) differs only in its size. It is used for small and precision work.

Tool room lathe: It is having features similar to an engine lathe and has a wide range of spindle speeds ranging from a very low to a quite high speeds. It is equipped with all necessary accessories for accurate tool room work e.g., it is equipped with quick change gears, thread chasing deals, chuck, coolant pump, steady and follower rest, taper turning attachment, draw on collet attachment and frequently a relieving attachment to control accuracy. They are specially adopted for making small tools, test gauges, dies and other precision parts. This lathe is costlier than engine lathe of the same size.

Turret lathe: These lathes are development of the engine lathe and are used for production work. In this type, the tail stock of an engine lathe is replaced by a hexagonal turret, on the face of which multiple tools may be fitted and fed into

the work in proper sequence. These are,

(a) Capstan lathes: Suitable for bar work and

(b) Turret lathes: Suitable for chucking work, heavier products

Special Purpose lathe: As the name implies, these lathes are used for special purposes and for jobs which cannot be conveniently machined on other lathes. These lathes are used in machining railway wheels and axles, turning crank shafts, duplicating work etc.

Automatic lathe: These are high speed, heavy duty, mass production lathes with complete automatic control. Once the tools are set and the machine starts it performs automatically all the operations to finish the job. The changing of tools, speeds and feeds are also done automatically. After the job is complete, the machine will continue to repeat the cycles producing identical parts even without the attention of an operator. Operator attention is only required for bar feeding, disposal of finished job and frequent checking of job.

Semi Automatic lathes: In these machines, although the movements of work piece has to be loaded onto and removed) or tools are automatically controlled, but the work piece has to be loaded onto and removed from the chuck at the beginning and end of each cycle of operations

The machining cycle is automated, but the direct participation of the operator is required to start to each subsequent cycle i.e., to machine each subsequent work piece. The operator loads the blank onto the machine, checks the work size and removes the completed component by hand.

Description and Functions of lathe parts:-

Line diagram of an engine lathe is shown in Fig 1.3 and the detailed block diagram of lathe is shown in Fig 1.4.

The main parts of an Engine lathe are:-

- 1. Bed
- 2. Head Stock
- 3. Tail Stock & Carriage
- 4. Feed Mechanism
- 5. Screw Cutting Mechanism.

The parts of the lathe are described as follows:-

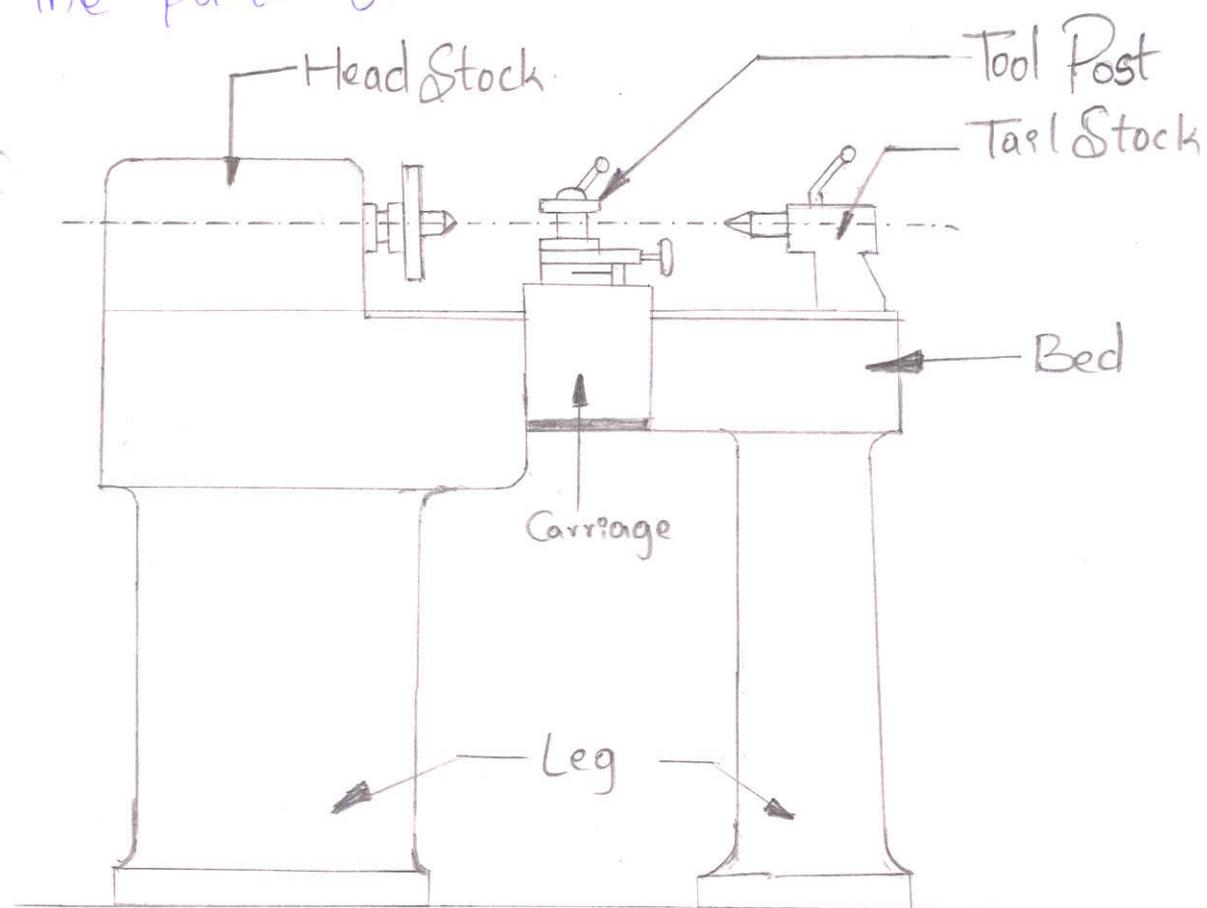


FIG 1.3: Line Diagram of Engine lathe.

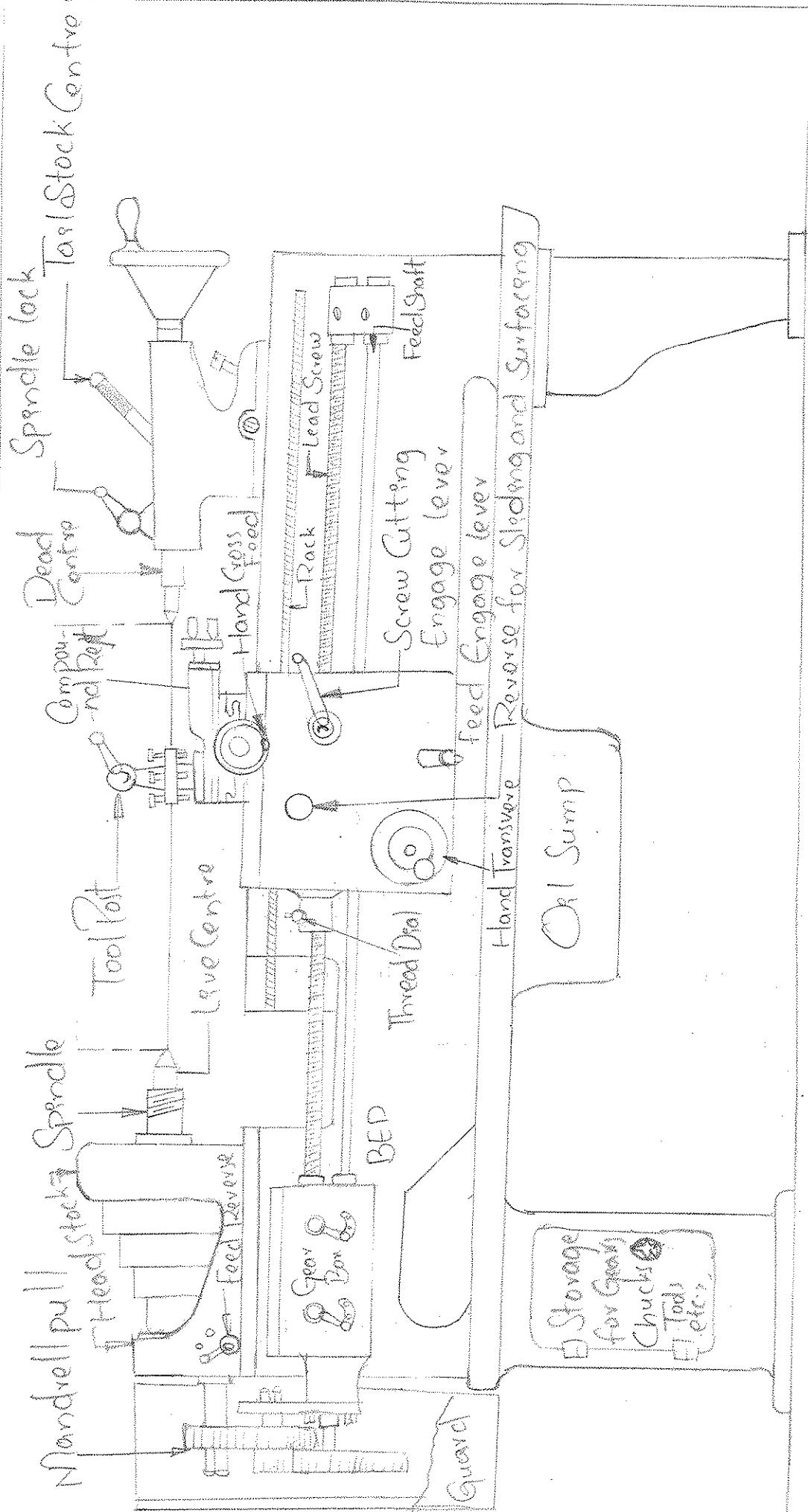
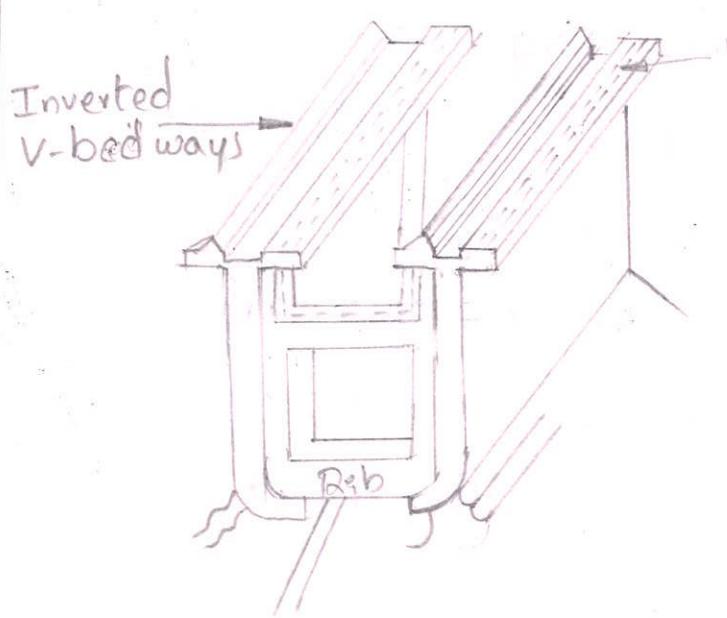
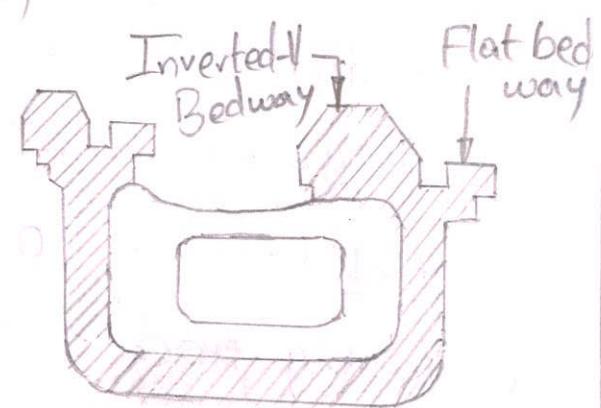


FIG 1.4 Centre lathe

BED The lathe bed forms the base of the machine. It supports head stock and Tail Stock at either end of it, and carriage in between them. It facilitates the movement of Tail stock and carriage, over the guide ways provided on its top. The outer guide ways provide sliding surfaces for the carriage, and the inner ways for the tail stock. Fig 1.5 illustrates the construction of bed and the guide ways provided on it.



(a) Lathe Bed



(b) Lathe Bed ways

FIG 1.5

The lathe bed being the main guiding member of the tool, for accurate machining work, it must satisfy the following conditions:

1. It should be sufficiently rigid to prevent deflection under severe cutting tool conditions.
2. It must be massive with sufficient depth and width to absorb vibrations.

3. It must resist the twisting stress set up during cutting.

ii. It should be wear resistant

Many lathes are made with gap in the bed. This gap is used to swing extra large diameter pieces.

The bed is mainly made of cast iron alloyed with nickel and chromium. This material provides the bed high compressive strength, wear resistance and to absorb vibrations.

Head Stock: The head stock is mounted permanently on the inner ways at the left hand end of the lathe bed. It provides mechanical means of holding and rotating the work at multiple speeds for driving and altering the spindle speed. All the parts are enclosed within the head stock housing.

FIG.6 illustrates the head stock spindle, made of carbon or nickel-chrome steel. The head stock spindle is hollow throughout, to accommodate a long bar through its bore. The hollow spindle is built into the

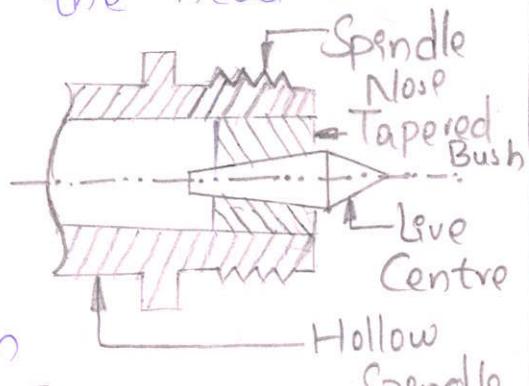


FIG.6 Head Stock Spindle

head stock with the spindle nose projecting from the housing of the head stock. The spindle nose is usually threaded. Either a face plate or a chuck can be turned on the threaded nose spindle to support and rotate the work piece. The spindle is tapered at the nose, for holding the centers. A tapered bush is fitted onto the taper hole, hold the live centre, which supports the works and revolves

the work with the spindle.

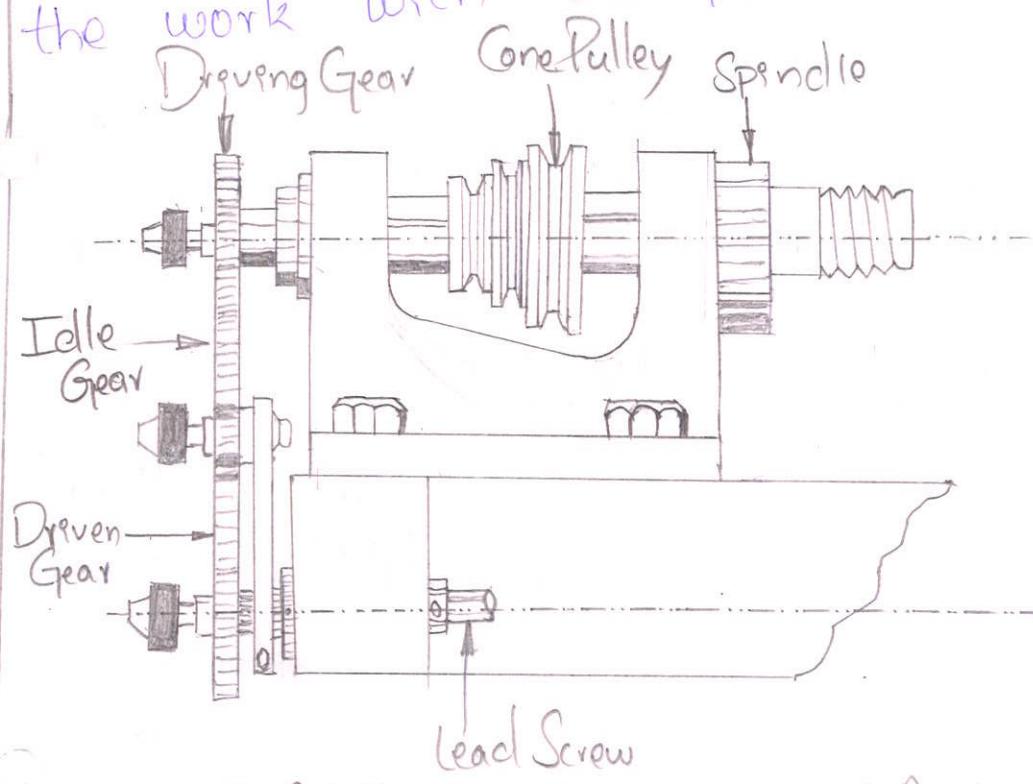


FIG 1.7 Speed Changing Mechanism in the Head Stock Housing.

The speed of spindle in engine lathe is varied with the use of different steps of the cone pulley and the back gears, provided in the head stock housing, as shown in Fig 1.7. On the three step pulley, three speeds can be obtained by driving directly from the pulley three to the spindle without the back gears in mesh. The smallest step gives the fastest speed. Three slower gears can be

obtained by driving the spindle through the back gears. Thus three speed changes on direct drive and three speeds ^{using} ^{back} gear drive permit a total of six changes of spindle speeds.

The back gears can be engaged as follows:-

1. Stop the machine.
2. Disengage the locking pin, and
3. Engage the back gears by pulling the handle forward mesh the gears.

Tail Stock:- The tail stock is located on the inner guide ways at the right hand end of the bed. The base of the tail stock can slide on the guide ways to accommodate different lengths of work and it can be clamped at any desired position by means of nuts and bolts provided along the ways.

The Tail Stock has Two Main Uses:-

1. It is used to support the other ends of the work piece when it is turned between centres and
2. Its spindle can hold tools, for performing drilling, reaming, tapping etc.,

A typical tail stock is illustrated in Fig 1.8. The body of the tail stock is bored to act as the barrel, which carries the tail stock spindle, that

can be moved in and out of the barrel by means of a screw, when the tail stock hand wheel is turned clockwise. The front end of the spindle has Morse taper, onto which the dead centre or other tools can be fitted. The dead centre will not revolve. The dead centre or any other tool mounted on the tail stock spindle can be removed by turning the tail stock hand wheel anti-clockwise.

A spindle binding lever clamps the spindle at any desired position in its travel.

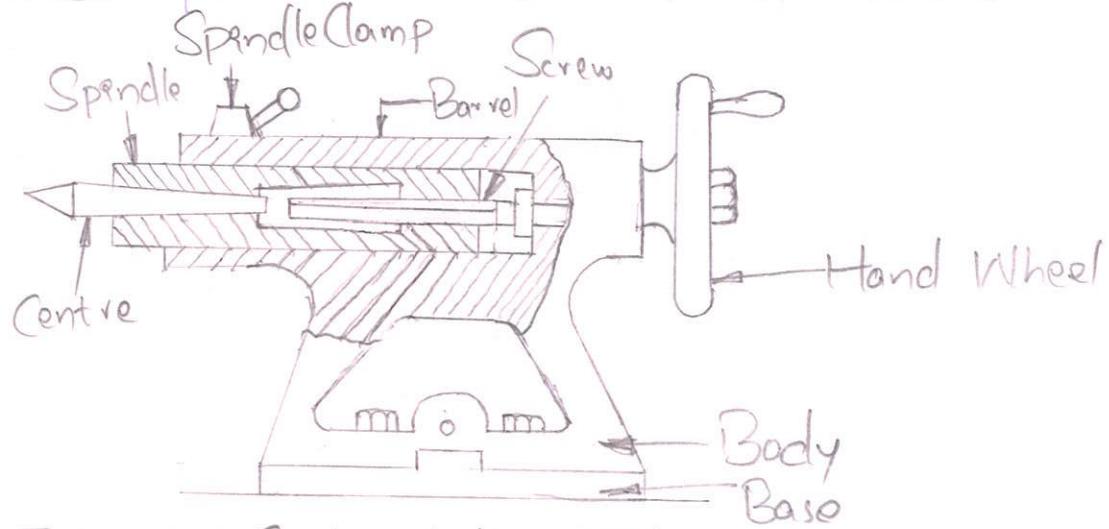


FIG 1.8 : Centre Lathe Tail Stock.

It is essential that at any position of tail stock along the bed of the lathe, the centre line of the tailstock be a continuation of centre line of the lathe. The upper casting of the tailstock body can be tilted towards or away from the operator by means of adjusting screws, to offset the tailstock spindle intentionally, to hold a work piece between centres at an angle, for taper turning.

Carriage The carriage is mounted on the outer guide ways of lathe between tail stock and head stock. The carriage has several parts to support, move and control the cutting tool. It consists of following parts

1. Saddle
2. Cross-Slide
3. Compound Slide (or) Compound rest
4. Tool Post, and
5. Apron.

FIG 1.9 shows the view of carriage and the important parts shown on it.

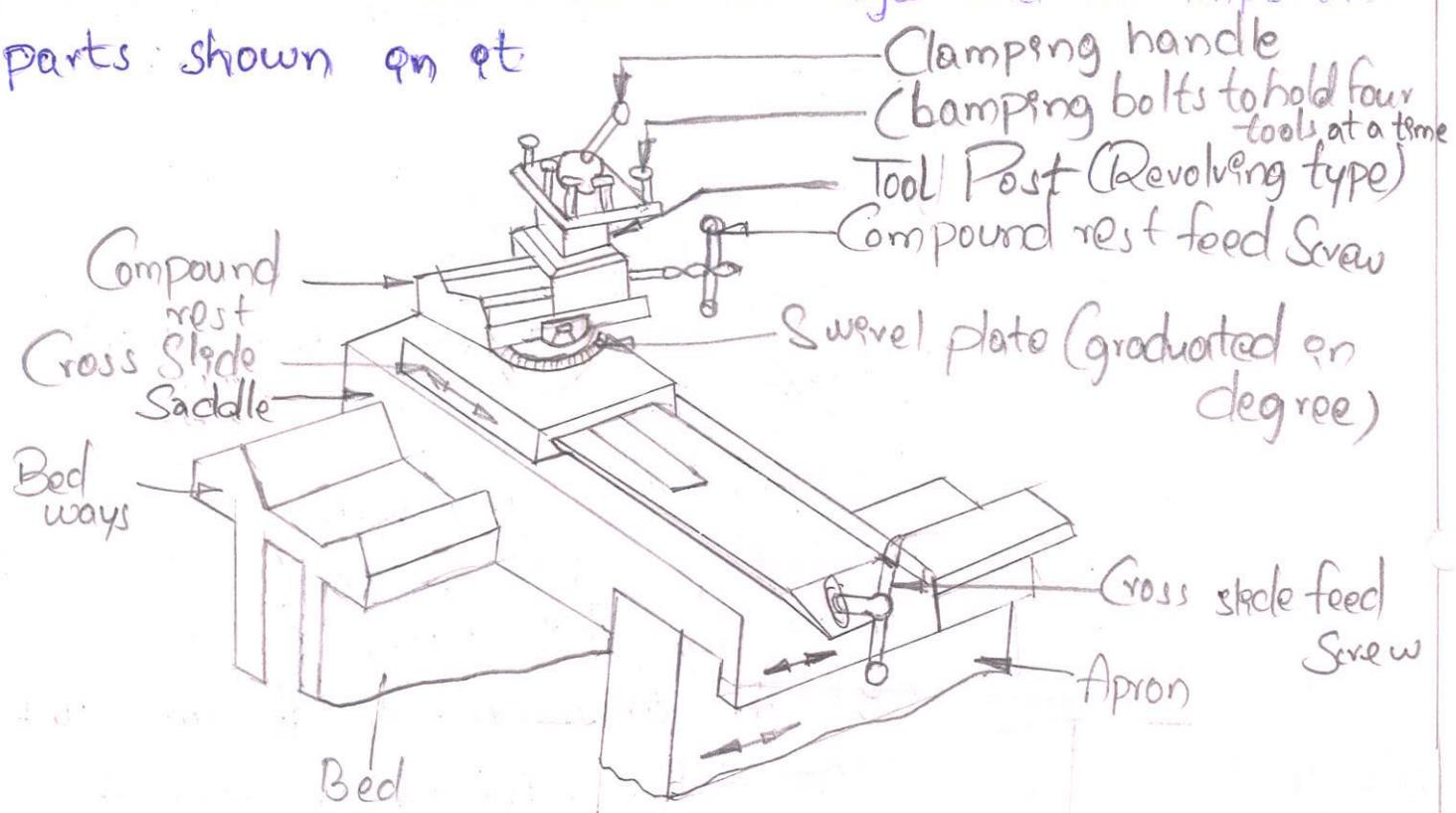


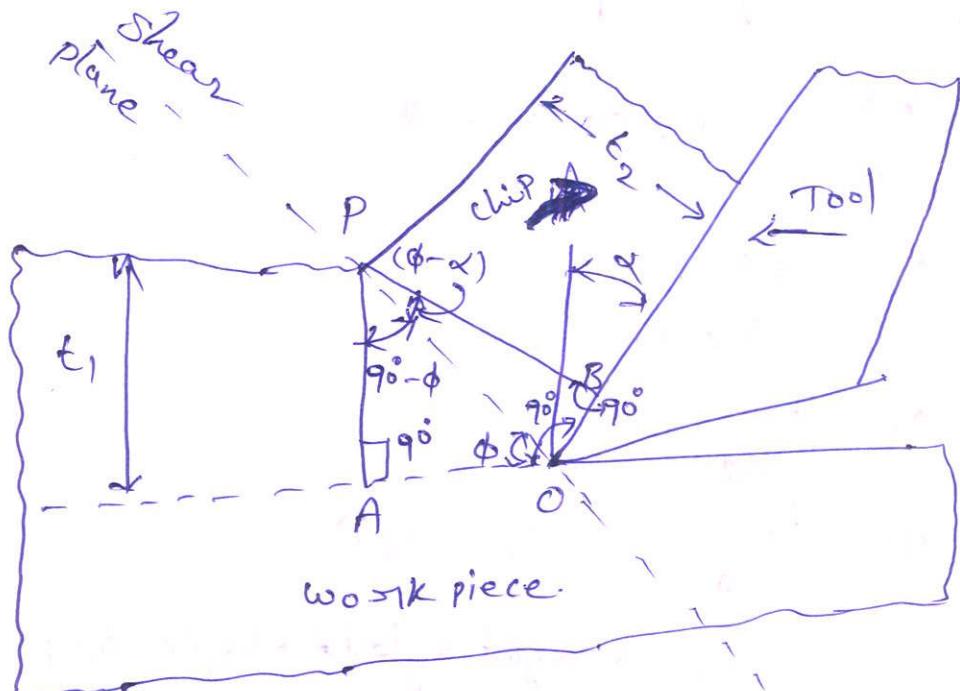
FIG 1.9 The Carriage.

The important parts of the carriage are discussed below:-

1. Saddle- The saddle is an H-shaped casting, that fits over the outer ways of the lathe bed and slides along the way through the gearing mechanism in the apron. It carries the cross slide and Tool Post.

chip thickness ratio

20



An orthogonal cutting operation

Refer to fig Let

t_1 = chip thickness prior to deformation

t_2 = chip thickness after deformation.

The above discussion leads to the result that $t_2 > t_1$

The chip thickness ratio "γ" is given by

$$\gamma = \frac{t_1}{t_2}$$

If k is the chip reduction coefficient then:

$$k = \frac{1}{\gamma}$$

Let L_1 & L_2 are the lengths of the metal cut.

$$t_1 \times L_1 = t_2 \times L_2$$

$$\frac{t_1}{t_2} = \frac{L_2}{L_1}$$

$$\gamma = \frac{L_2}{L_1}$$

$$\therefore K = \frac{1}{\gamma} = \frac{L_1}{L_2} = \frac{t_2}{t_1}$$

unit - 1, pg-37/113

We have two right angled triangles OAP & OBP .
Considering the right angled triangle OAP , we have.

$$\frac{AP}{OP} = \sin AOP = \sin \phi$$

$$OP = \frac{AP}{\sin AOP}$$

$$OP = \frac{t_1}{\sin \phi}$$

$$\therefore OP = \frac{t_1}{\sin \phi} \quad \text{--- (1)}$$

Now considering the right angled triangle OBP , we have

$$\frac{BP}{OP} = \sin BOP = \sin(90^\circ - \phi + \alpha) = \cos(\phi - \alpha)$$

$$OP = \frac{BP}{\cos(\phi - \alpha)} \quad (\text{But } BP = t_2)$$

$$OP = \frac{t_2}{\cos(\phi - \alpha)} \quad \text{--- (2)}$$

Now by equating the equations (1) & (2)

we get

$$\frac{t_1}{\sin \phi} = \frac{t_2}{\cos(\phi - \alpha)}$$

$$\frac{t_1}{t_2} = \frac{\sin \phi}{\cos(\phi - \alpha)} = \gamma$$

$$\gamma = \frac{\sin \phi}{\cos(\phi - \alpha)} \quad \text{--- (3)}$$

The equation (3) above can be expanded as

$$\gamma = \frac{\sin \phi}{\cos \phi \cos \alpha + \sin \phi \sin \alpha}$$

(or)

$$\gamma(\cos \phi \cos \alpha) + \gamma(\sin \phi \sin \alpha) = \sin \phi$$

$$\frac{\gamma(\cos \phi \cos \alpha)}{\sin \phi} + \frac{\gamma(\sin \phi \sin \alpha)}{\sin \phi} = 1$$

$$\frac{\gamma \cos \alpha}{\tan \phi} + \gamma \sin \alpha = 1$$

$$\frac{\gamma \cos \alpha}{\tan \phi} = 1 - \gamma \sin \alpha$$

$$\tan \phi = \frac{\gamma \cos \alpha}{1 - \gamma \sin \alpha}$$

Also by substituting the value of γ in terms of t_1 and t_2 we get

$$\boxed{\tan \phi = \frac{t_1/t_2 \cos \alpha}{1 - t_1/t_2 \sin \alpha}}$$

- (b) Cross Slide: - Cross slide is mounted on the saddle. The purpose of cross slide is to provide movement of the tool at right angles to the centre lines of the lathe by operating cross traverse hand wheel. Cross slide hand wheels are graduated on their rims, to know the amount of feed applied.
- (c) Compound Rest: - The compound rest or compound slide is mounted on the top of cross slide and has a circular base graduated in degrees. The compound rest can be swivelled to any desired angle, with the axes of the work piece. It is used for obtaining angular cuts and short tapers as well as convenient positioning of the tool to the work. There is no power feed to the compound rest and it is hand operated.
- d. Tool Post: - The tool post is located on the top of the compound rest to hold the work tool and enable it to be adjusted to a convenient working position. The type and mounting of the tool depends upon the class of work for which it is to be used.
- e. Apron: - The apron is the bracket that hangs from the front of the saddle. It contains gears, clutches and levers for moving the carriage along the bed by hands and power feeds. In addition

there is a screw cutting engage lever (split nut) which engages, when required, with the lead screw, when cutting either external or internal threads. Turning the hand wheel situated on front of the apron, turns a small pinion extending from the rear side of the apron, and the pinion is engaged with a rack bend attached to the bed, and pulls the carriage back and forth longitudinally. Usually, a chasing dial or thread cutting dial is fitted either to the side or top of the apron. It carries an entirely independent drive provided by a worm wheel, which is in constant mesh with the lead screw.

Feed Mechanism: The movement of the tool relative to the work is termed as "feed". A lathe tool may have three types of feed - longitudinal, cross and angular. When the tool moves parallel to the lathe axis the movement is termed as longitudinal feed and is effected by the movement of the carriage. When the tool moves at right angle to the lathe axis, with the help of cross slide the movement is termed as cross feed, while the movement of the tool by compound slide when it is swivelled at an angle to the lathe axis termed as angular feed. Cross

and longitudinal feed are both hand and power operated, but angular feed is only hand operated.

The power (or) motion is transmitted from the head stock spindle to the carriage through the feed mechanism, which is located at the left of the handle. The feed mechanism has different units.

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

1. Feed gear box:- The feed gear box or quick change gear box is fitted directly below the head stock gear assembly. Power from the lathe spindle is transmitted through gears to the quick change gear box. This gear box contains a number of different sizes of gears, the arrangement of which are employed to obtain multiple speeds and different rates of feed.

Feed rod and lead screw:- The feed rods are a long shaft that has the keyway extending from the feed box across and in front of the bed. The power transmitted from the lathe spindle to the apron gears through a feed rod via a large number of gears. The feed rod is used

to move the carriage or cross slide for turning, boring, facing and all other excepting thread cutting.

The lead screw is a long threaded shaft, brought onto operation only when threads have to be cut. In all other times, the lead screw is disengaged from the gear box and remains stationary.

Endbed Gearing: This gearing serves the purpose of transmitting the driven to the lead screw and feed shaft, either direct or through gear box.

Apron mechanism: This mechanism is used for transforming rotatory motion of the feed rod and the lead screw onto feed motion of the carriage. This mechanism also ensures that when the half nut is engaged with the lead screw the worm drops down disconnecting the feed motion.

Screw Cutting Mechanism: It contains either split nut or half nut mechanism. The half nut mechanism makes the carriage to engage or disengage with the lead screw. The rotation of lead screw is used to transverse the tool along the work to produce screw thread. Closing

the half nuts causes the carriage to move a fixed distance for each revolution of the spindle. The direction in which it moves depends upon the position of the feed reverse lever on the head stock. The split nut is used only for thread cutting and never for any other operation.

Specification of Engine lathe - The lathe is made in varying sizes. The size of the lathe is expressed or specified by the following items and illustrated in fig 1.10.

1. The height of the centres (CR) measured from the lathe bed.

2. The swing diameter over bed ($2R$) is the largest diameter of work that will revolve without touching the bed. It is twice the height of centres measured from the bed.

3. The length between centres (L) is maximum length of work that can be mounted between lathe centres.

4. The swing diameter over carriage ($2R_1$) is the largest diameter of work that will revolve over the lathe saddle, and is always less than swing diameter over bed.

5. The maximum diameter (D_1) is the maximum diameter of bar stock that will pass through the hole of the head stock spindle.

8. The length of bed indicates the approximate floor space occupied by the lathe.

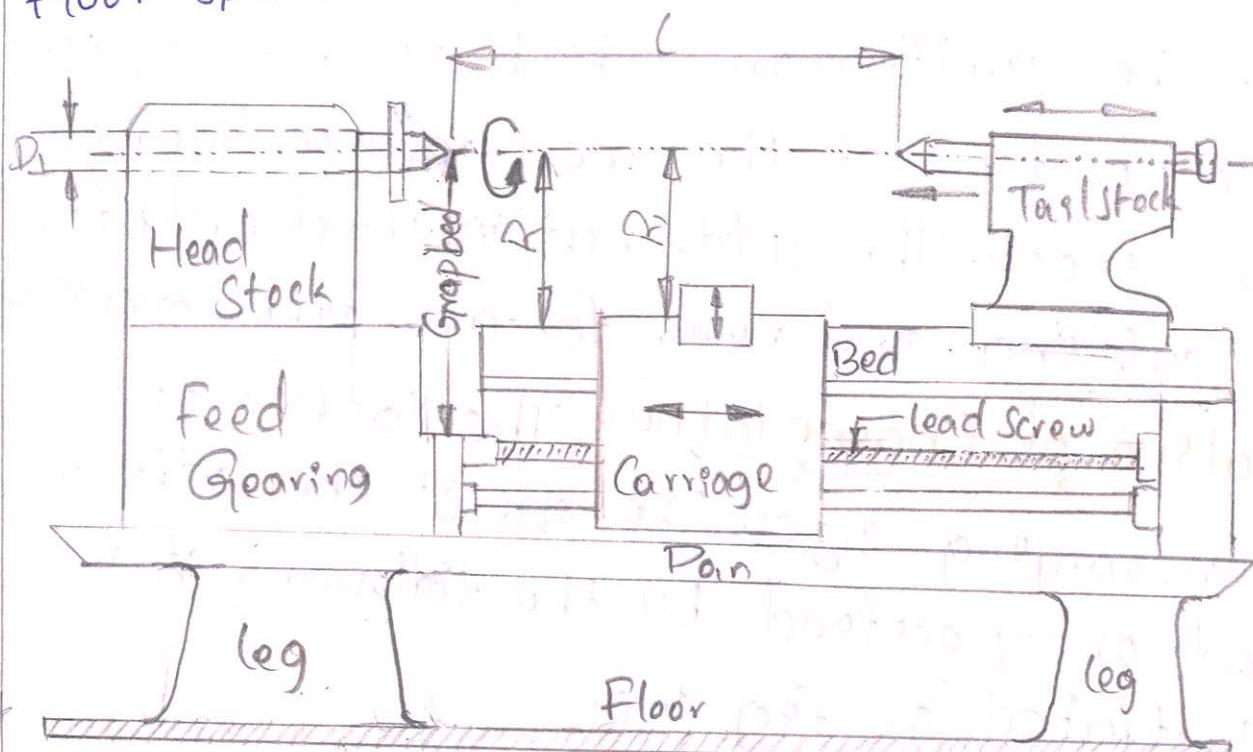


FIG. 1010 - Specification of Centre Lathe

However, certain other important particulars are necessary to specify a lathe correctly. These are width of the bed, depth and width of the width of the bed, depth and width of the gap, swing over gap, spindle nose diameter, number of feeds, number and range of spindle speeds, a lead screw pitch, and power input and floor space.

Lathe Accessories: A large variety of jobs are done on the lathe. Since the sizes, material and shapes of job vary, many different types of work holding and tool holding are required for lathe work. These devices used for holding the work or tool on lathe are called lathe accessories.

Work holding devices

Work holding devices used on lathe are

1. Centres
2. Catch Plates and Carriers
3. Chucks
4. Face Plates
5. Mandrels
6. Angle Plates
- and 7. Rests.

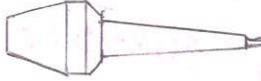
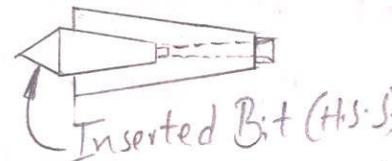
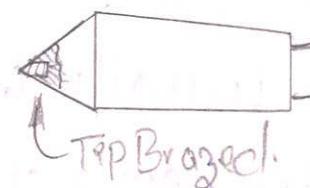
1. Lathe Centres - The most common method of holding the work on a lathe is between the two centres - live centre and dead centre. The live centre, fitted on the spindle nose of a head centre, fotted in the spindle nose of a head stock and the dead centre is placed in the tail stock spindle. The live centre always rotates with the work (so named 'live') whereas dead centre remains nonstationary (so named "dead")

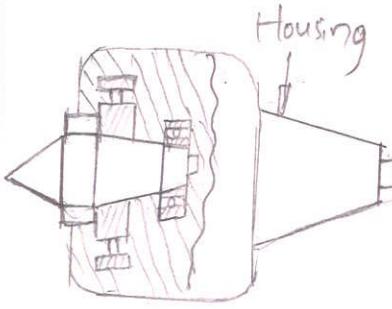
The two centres take up the thrust due to metal cutting and the entire load of the work piece on small bearing surfaces. So they are made of very hard materials to resist deflection and wear. The dead centre is subjected to more wear, because it does not rotate and must withstand the friction of the work piece against it. Oil, lac, graphite, may be used at the dead centre point to reduce friction. The induced angle of the centres is usually 60° for general purpose work and 75° for heavy work.

Different types of lathe centres commonly used,

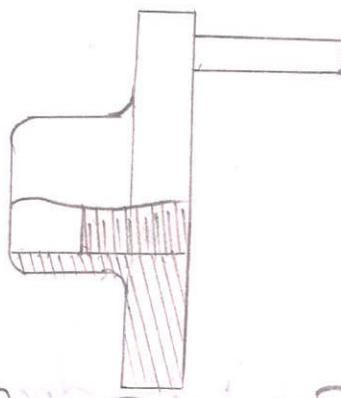
along with their applications are shown in Table 1.1

Table 1.1 Types of Centres with their Applications:

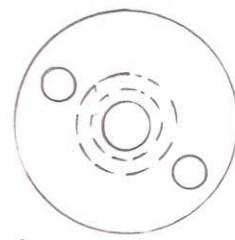
Types	Sketch	Application
Ordinary Centre	 <p>Point 60° Shank (Morse taper)</p>	For general purpose
Half Centre		It is used at the tail stock end, to facilitate facing of the bar ends without removal of the centre
Ball Centre		It is used to minimize wear and strain on the ordinary centre while taper turning by tail stock set over method.
Pipe Centre		It is used for supporting the open ends of hollow jobs such as pipes, shells etc., for turning or thread cutting.
Inserted bit type centre	 <p>Inserted Bit (H.S.S.)</p>	It minimises the running cost of the centre as bit made of HSS will reduce wear.
Tipped Centre	 <p>TIP Brazed</p>	Cemented carbide tip is brazed onto an ordinary steel shank. less wear and strain than inserted type but

Type	Sketch	Application.
-		Expensive. It is used in production work.
Fraction less Centre	 <p>Housing</p>	It is always used in the tail stock end for supporting heavy job rotating at high speed, without developing many appreciable heat.

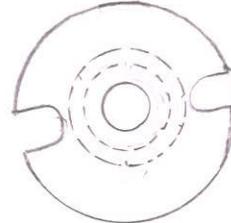
Catch Plates and Carriers: Catch plates (drive plates) and carriers (lathe dog) are used to drive a work piece when it is held between two centres. Catch plates are screwed or bolted to the nose of the head stock spindle; and carriers are attached to the end of the work piece by a set screw. A projecting pin from the catch plate or carrier fits into the slot provided in either of them. This imparts a positive drive between the lathe spindle and work piece. Fig 6.11 illustrates different types of catch plates and carriers.



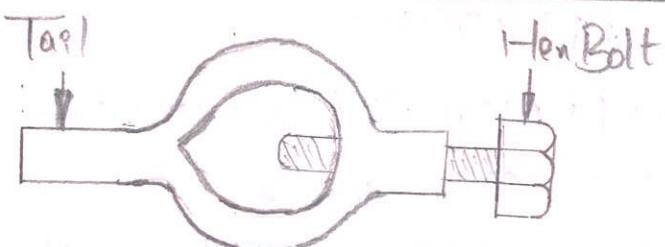
(a) Single Pin Catch Plate



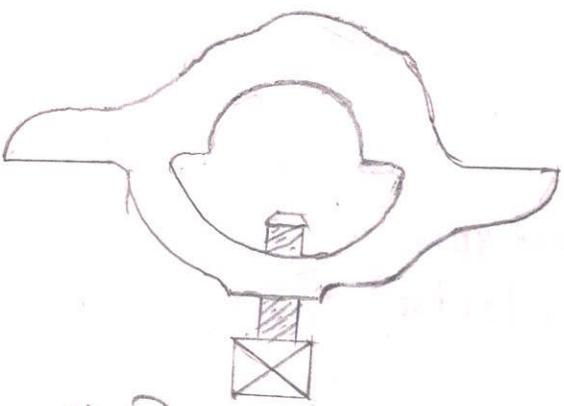
(b) Double Pin Catch Plate



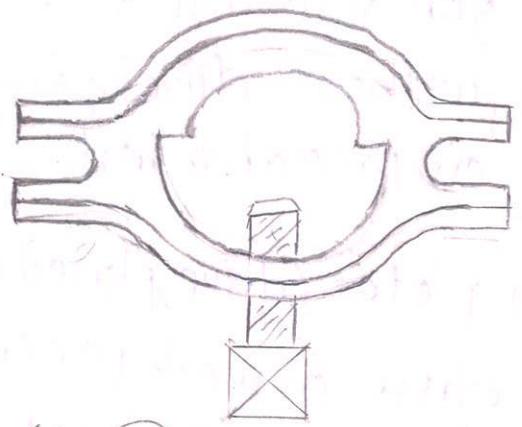
(c) Double Slotted Catch Plate



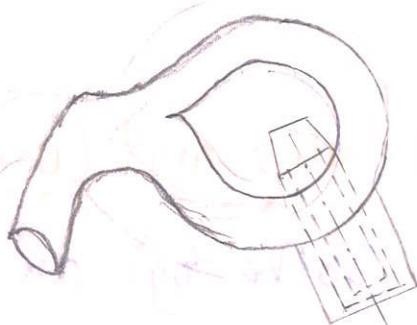
(d) Straight Tail Carrier



(e) Double Tail Carrier



(f) Double Slotted Carrier



(g) Bent Tail Carrier

FIG 1.11 : Catch Plates and Carriers.

The projecting pin of a single pin catch plate drives the straight end or tail of a carrier attached to the work piece. Two pins a double pin catch plate engage with the double slotted carrier and provided uniform drive. The bent tail carriers is used in conjunction with face plate or slotted catch plate as shown in Fig 1.2.

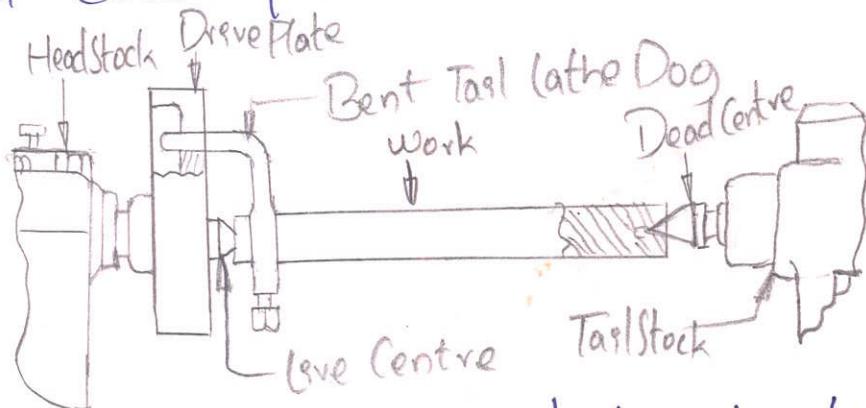


FIG 1.12: Drive plate and bent-tail lathe dog used to drive work mounted between the lathe centres

3. Chucks - It is the most important device used for holding and rotating the work piece in a lathe. Work pieces of short length, irregular shape or of large diameter, which cannot be conveniently mounted between centres and are held quickly and rigidly in a chuck. A chuck is attached to the lathe spindle by means of bolts with the back plate screwed on to the spindle nose. Accurate alignment of the chuck axes with the lathe axes is essential. Different types of chucks are:

- a) Three jaw (or) Universal chuck
 - b) Four jaw (or) Independent Chuck
 - c) Combination chuck.
 - d) Magnetic chuck
 - e) Collet chuck
 - f) Air (or) hydraulic operated chuck
 - g) Drill chuck.
- a) Three jaw (or) Universal Chuck (or) Self Centering Chuck: In a three jaw universal chuck, illustrated in fig 1.03 all the three jaws may be made to slide backward (or) forward simultaneously by an equal

amount within the slots provided on the body, by rotating any one of three pinions. The chuck is suitable for holding round, or hexagonal and other similar shaped work piece and the job is centred automatically and quickly. But it has less gripping capacity as only three jaws are used and centering accuracy is soon lost due to wear.

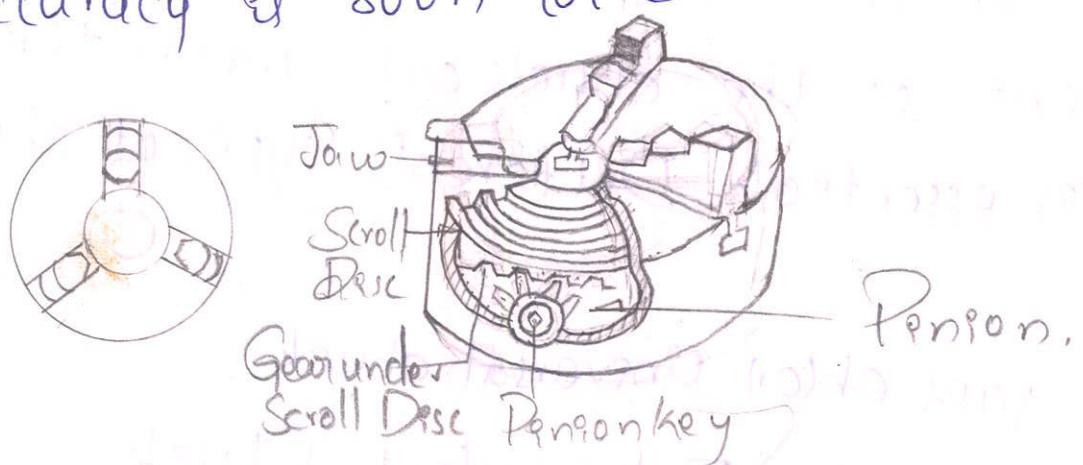


FIG 1.13 Universal Chuck

Four Jaw Independent Chuck:- A four jaw independent chuck is illustrated in Fig 1.14 has four jaws which may be moved independently by rotating the screw, with in the slots provided on the body of the chuck, for gripping different sizes of work piece.

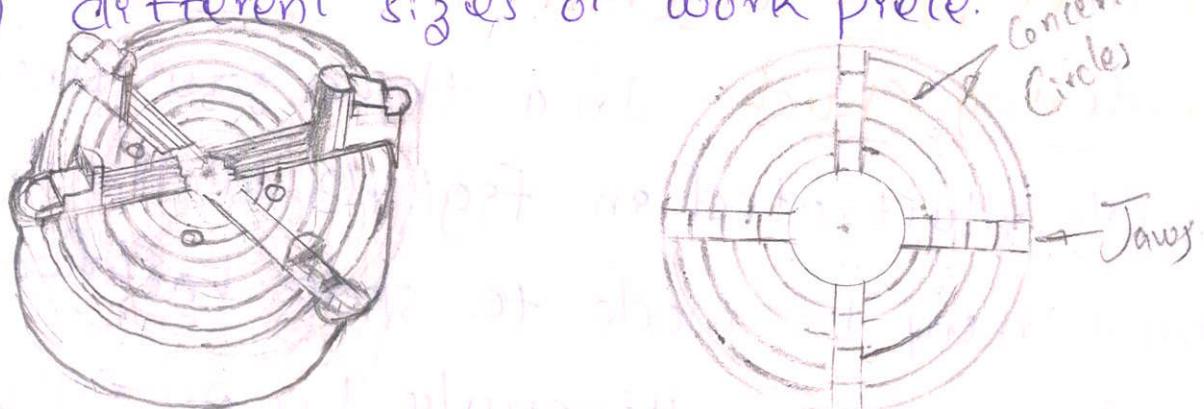


FIG 1.14 Four Jaw Independent Chuck

Each jaw has three inner and one outer gripping surfaces. The outer gripping surfaces are used for holding larger sizes workpiece by reversing the jaw. The concentric circles on the face of the chuck can be used as a guide in centering the work piece. This chuck is particularly used in the setting up heavy & irregular shaped articles.

Combination Chuck: As the name indicates, it can be used as a self centering and a independent chuck to take advantage both the types. The jaw may be operated individually by separate screws or simultaneously by the scroll device.

Magnetic Chuck: It is illustrated in Fig 1.15, used for hold a very thin workpiece made of magnetic material which can be held in an ordinary chuck. The holding power of the chuck is obtained by the magnetic flux radiating from the permanent magnets introduced within the chuck.

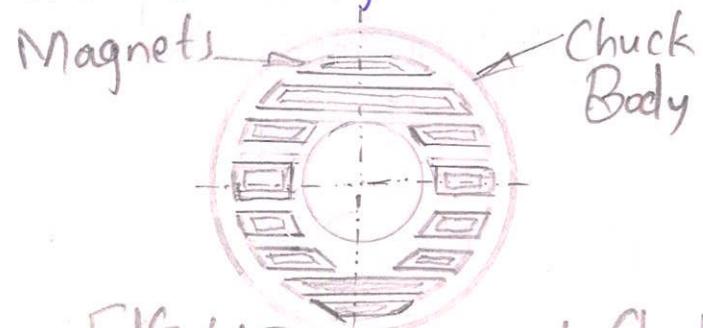


FIG 1.15

Magnetic Chuck

Collet chuck: Collet chucks are used for holding bar work in production work, where quick setting and accurate centering is needed. The chuck comprised of a hollow draw-in spindle or bar, which extends through a head stock spindle. The inside bore of collet may be cylindrical, hexagonal, square, etc., depending on the shape of the work that will pass through it.

The outside surface of the collet is tapered to fit in a taper hole of chuck. The tail end of collet is threaded and it meshes with a key. When the key is turned, from outside, the collet is drawn in resulting the split tapered end to be pushed inward due to springy action and the work piece is securely and accurately held in the chuck. Different sizes of collets used for holding different sizes of bar stock. These chucks are commonly used in capstan and turret lathes.

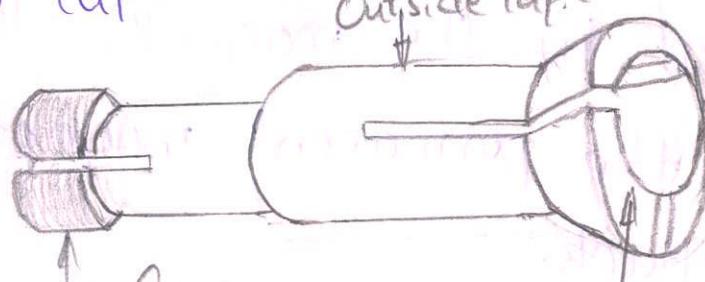


FIG. 1.16 Collet Chuck ... Accommodate Round Bar

Air (or) Hydraulic Operated Chuck:- This type of chuck is used in mass production work for its fast and effective grouping capacity. For its operation, additional plant for the supply of either compressed air or oil is required. The jaws are opened or closed by the supply of air or oil pressure and can be operated either by hand or automatically.

Drill Chuck:- A drill chuck is used for holding straight shape drill, reamer or tap for drilling, reaming or tapping operation. The chuck may be held either on head stock (or) Tail stock spindle. It has self centering jaws which may be operated by rotating a key.

Face Plates:- A face plate consists of steel circular having a bore in the center. The bore is threaded to fit on the nose of the head stock spindle. It has several T slots placed radially for clamping the job by bolts, angle plates, clamps, jaws, etc., conveniently held between centres or by chucks. Fig. illustrates Face Plates.

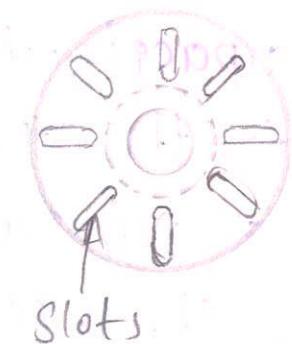


FIG 1.17: Face Plate

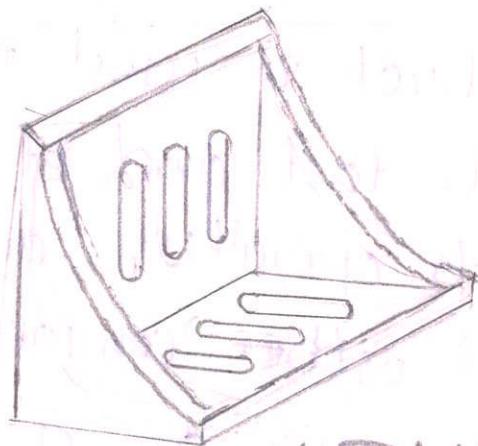
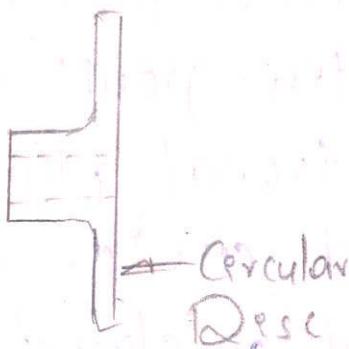


FIG 1.8 Angle Plate

Angle Plates: This is a cast iron plate having two faces machined to make them absolutely at right angles to each other. Holes and slots are provided on both faces, as shown in Fig 1.18, so that it may be clamped on a face plate and can hold the work piece on other face by bolts and clamps.

Angle plates are used in conjunction with a face plate. When eccentric gobs are bolted to the face plate, a balance weight or counter weight must be added: Fig 1.19 illustrates the use of an angle plate.

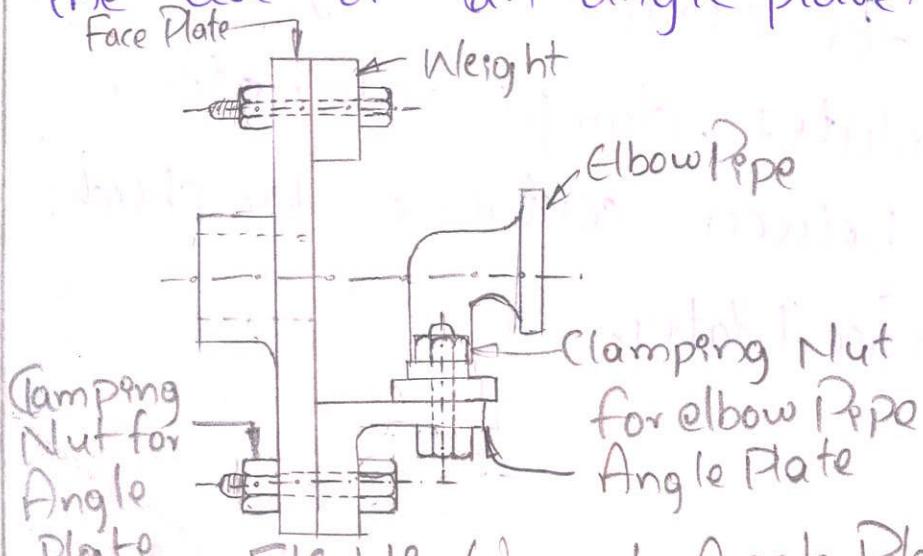


FIG 1.19 Use of Angle Plate

Mandrel: A mandrel is a device, mounted between two centres used for holding and rotating a hollow work piece, for machining its outer surface concentric with the bore. The work revolves with the mandrel. The ends of the 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 drives the work by friction. The mandrel is never placed in a chuck for turning the work piece.

Different types of mandrels are employed according to specific requirements:-

(e) Plain Mandrel: It is illustrated in Fig 1-20. This type of mandrel is most commonly used in shops and finds wide application in mass production. The body of the mandrel is slightly tapered to 2mm per 100mm length, for providing proper gripping of the work. This type of mandrel is suitable for only one size of bore. For different sizes of bores, different mandrels are used.

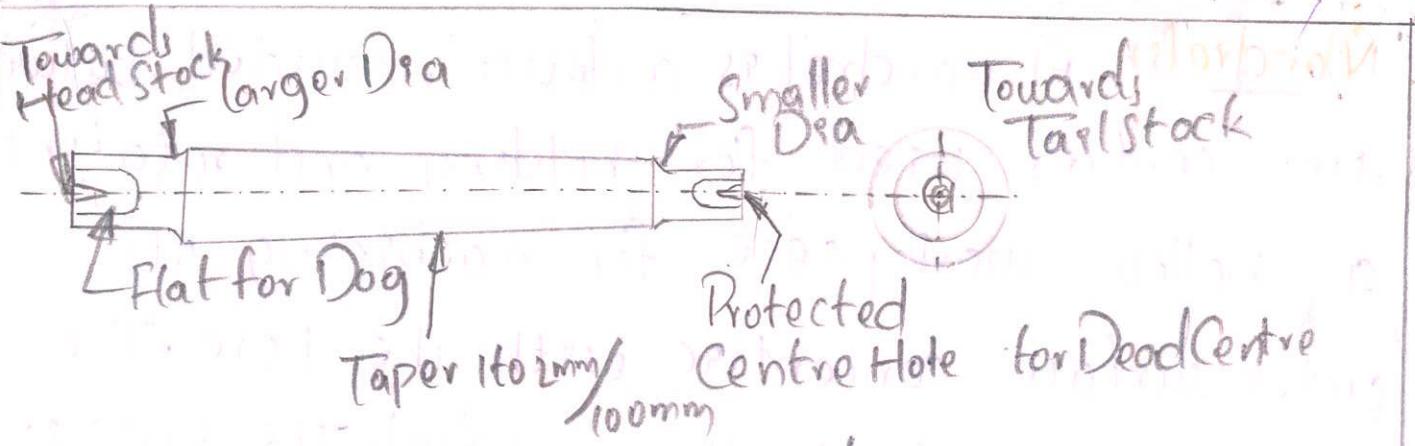


FIG 1.20 : Plain Mandrel.

(ii) Step Mandrel: A step mandrel as shown in Fig 1.21, have steps of different diameters used to drive different work pieces having different sizes of holes without replacing the mandrel each time. This type of mandrel used for turning collars, washers and odd sizes jobs.

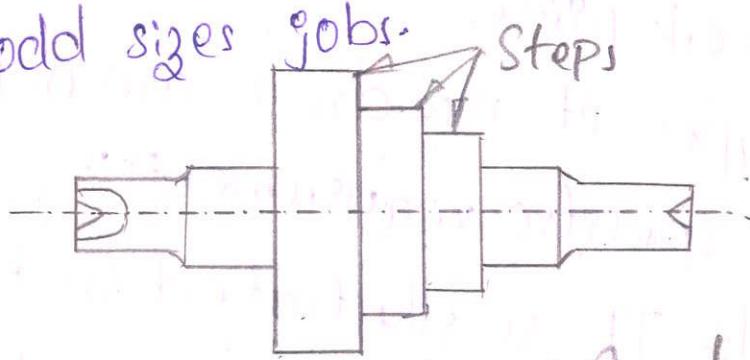


FIG 1.21 : Step Mandrel.

(iii) Collar Mandrel: A collar mandrel, shown in Fig 1.22, have solid collars, used for turning work pieces of larger diameter holes more than 100 mm. This construction reduces weight and fits better than a solid mandrel of equal size.

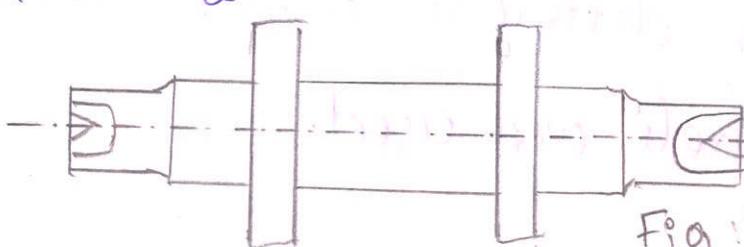


Fig 1.22 Collar Mandrel.

Gang Mandrel: This mandrel as shown in Fig 1.23 is used to hold a set of identical hollow work pieces between fixed collar and a washer by tightening the nut. The friction between the sides of the work and by the collar is sufficient to drive the work without slipping on the mandrel. Gang mandrel will reduce setting and machining time.

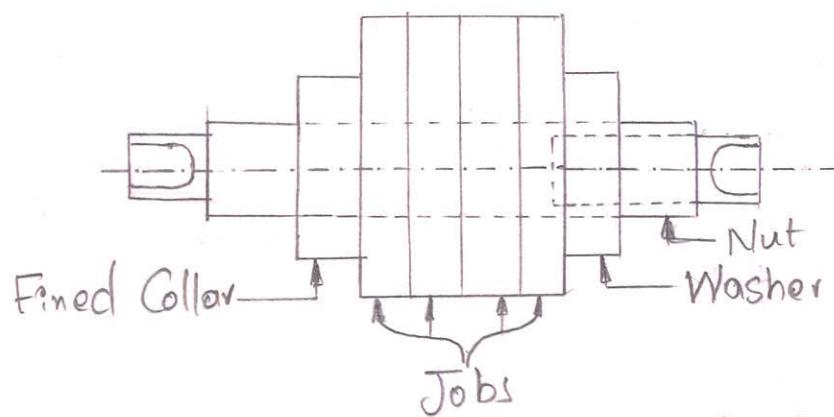


FIG 1.23: Gang Mandrel

Screwed Mandrel: A screwed mandrel, shown in Fig.1.24, is threaded at one end of the collar. Work piece having internal threads are screwed on it, against the collar for machining. External surfaces of screwed flanges, nuts back plates of chucks, etc are machined on lathe by holding them on screwed mandrel.

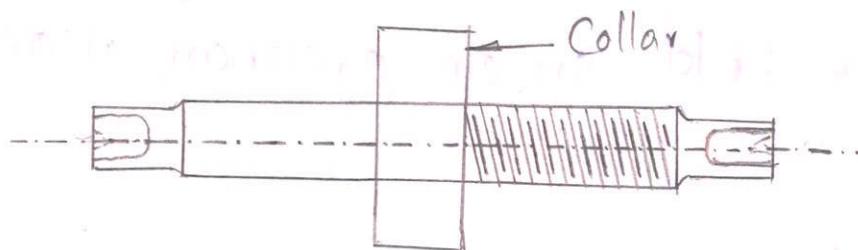


FIG 1.24:- Screwed Mandrel.

Cone Mandrel: A cone mandrel shown in Fig 1.25 consists of a fixed cone attached at one end of the body, and a sliding (adjustable) cone which can be adjusted by turning a nut at the threaded end. It is suitable for holding work pieces of different hole diameters by placing the work piece on two cones and tightening the nut.

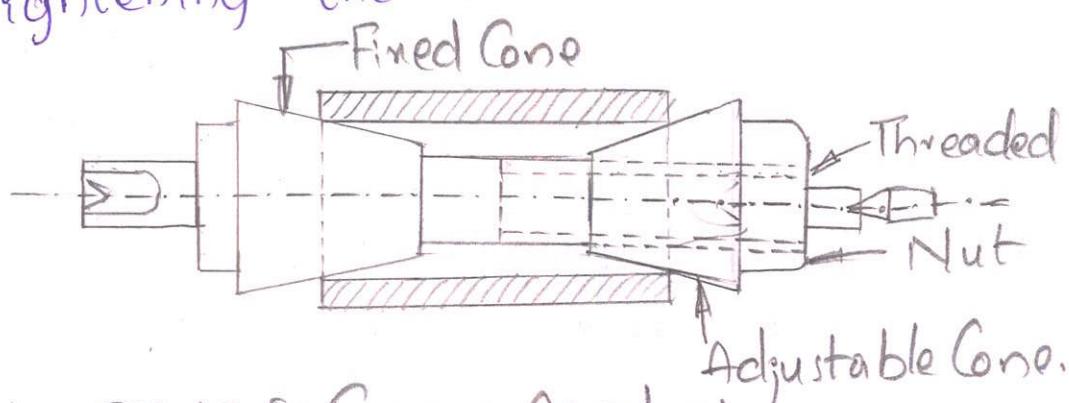


FIG 1.25: Cone Mandrel

Expansion Mandrel: It is shown in Fig 1.26, consists of a tapered pin which is driven into a sleeve that is parallel outside and tapered inside. The sleeve has three longitudinal slots two of which are cut nearly through, and the third splits at completely. This construction makes an expansion mandrel to grip various work pieces with different hole diameters that cannot be held on an ordinary mandrel.

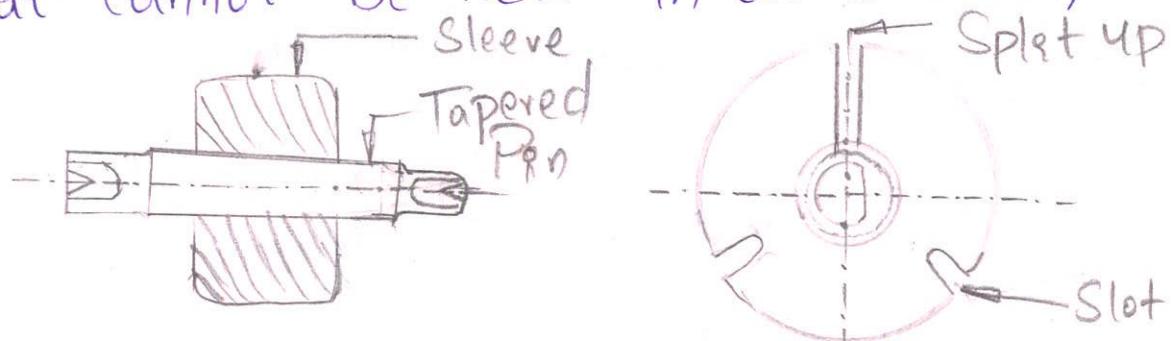


FIG 1.26 Expansion Mandrel

To use this mandrel the sleeve is first placed within the work with pin removed. The tapered pin is then pressed from the end into the sleeve, & the sleeve expands, gripping the work securely & accurately.

Rests—A rest is a mechanical device, used to support a long slender workpiece (having its length 10 to 12 times the diameter), when it is turned between centres or by a chuck at some intermediate point, to prevent bending of the workpiece due to its own weight and vibration set up due to cutting force. The two types of rests used in an engine lathe are:

i) Steady (or) Fixed (or) Centre rest.

ii) Follower rest.

a) Steady rest—Steady rest shown in Fig 1.27 consists of a cast iron base that may be made to slide on the lathe bed ways and clamped at any desired position where a support is needed. It has three jaws 120° apart, two on the lower base and one on the upper base and one. The jaws may be adjusting radially by rotating individual

screws to accommodate work pieces of different diameters. The upper portion of the rest is hinged at one end, facilitating setting and removal of the work piece without disturbing the position of steady rest. One or more rests may be used at a time depending on the job length.

It is also used to support the free end of a long work piece for drilling, Boring, tapping etc., operations when given. The carriage cannot be fed to the full length of the work when steady rest is used.

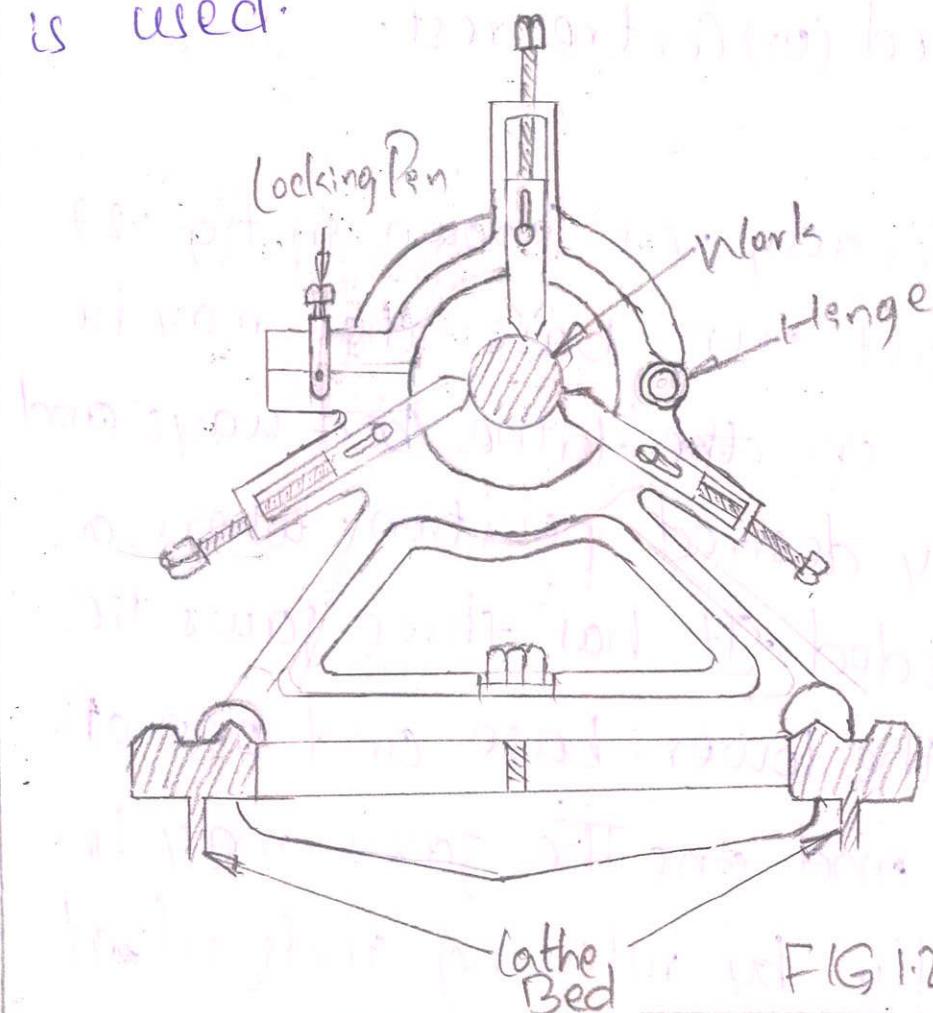


FIG 1.27 Steady Rest

Follower Rest: A follower rest shown in fig 1.28 have two adjustable jaws to support the workpiece. The rest is bolted to the back end of the carriage and moves with it. The tool is set slightly in advanced position than the jaws and as the tool is fed longitudinally by the carriage, the jaws always follow the tool giving continuous support to the work piece and prevents any deflection of work. The entire length of the work piece will be turned without disturbing the settings.

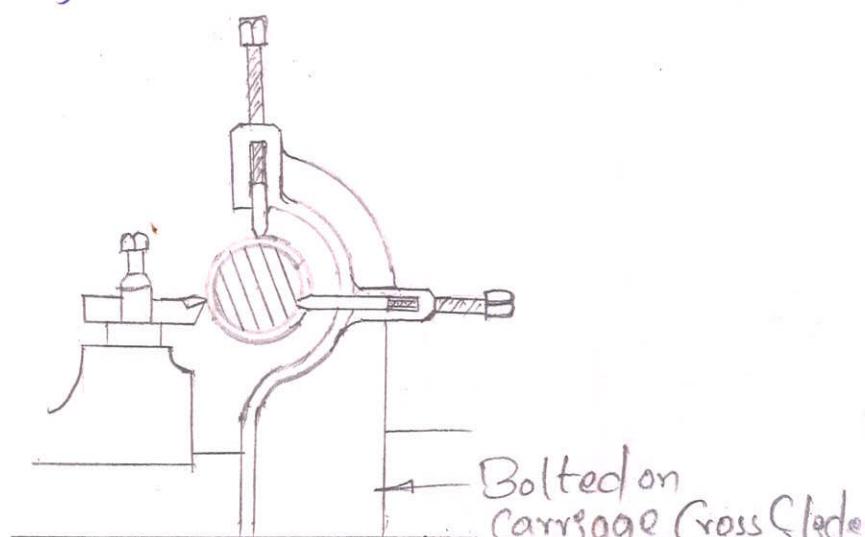


FIG 1.28 : Follower Rest

Tool Holding Devices

(lathe Tools are held in a tool post, which sits on the compound rest. The main objective of tool post is to hold the various cutting tools in most effective manner.)

Tool Post vary in design, in general there are three main types of tool posts. They are:

1. Single tool Post
2. American (Pillar) type Tool post
3. Four-way (Turret) tool post.

1. Single Tool Post: The single tool post shown in Fig 1.29 can take only one tool. It can be rotated and clamped at any desired position. It generally used when small chamfers are to be cut.

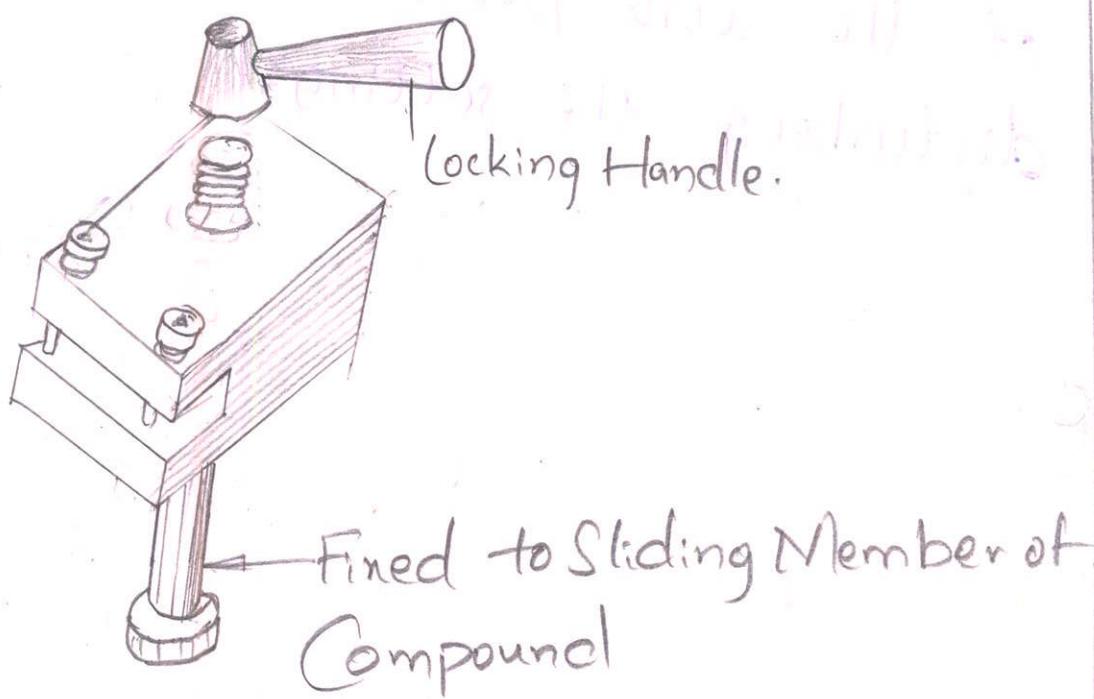


FIG 1.29 Single Tool Post.

2. American Tool Post: This shown in fig 1.30, consists of a pillar with a slotted hole in the centre for fixing the by tool by means of set screw. The tool post with a seating and boat piece, slides in a T-slot on the top of the

compound rest. The height of the tool point can be adjusted by tilting the boat piece and clamping it in position by the set screw. The tool post can be swivelled about its vertical axis. The disadvantage with this type of tool post is that adjustment to height by tilting, obviously alters all the cutting angles of the tool. The tool post is not so rigid enough for heavy work only one clamping screw is used to clamp the tool.

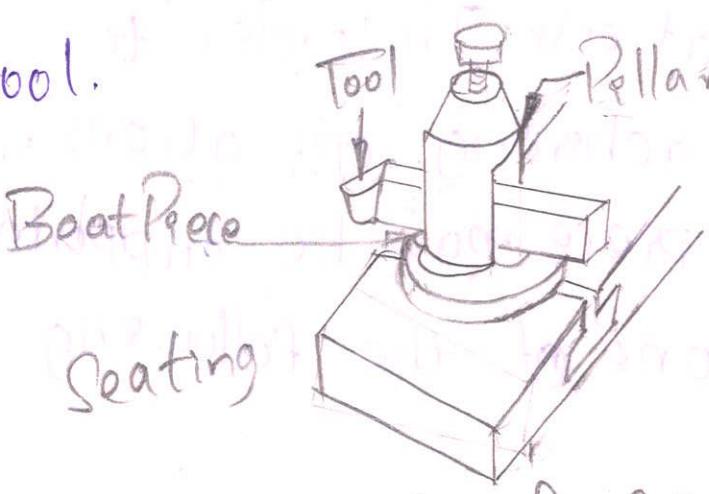


FIG 1.30 American Tool Post

Four way Tool Post: The four way tool post, shown in Fig 1.31 consists of four sides to accommodate four tools at a time. The tool is held in position by separate screws and a locking bolt, is located at the centre. The tools are indexed in proper sequence of operation and by indexing the tool post through 90° any one of the tool

may be fed onto the work. This type of tool post is used on moderately heavy lathes & is suitable for repetition work.

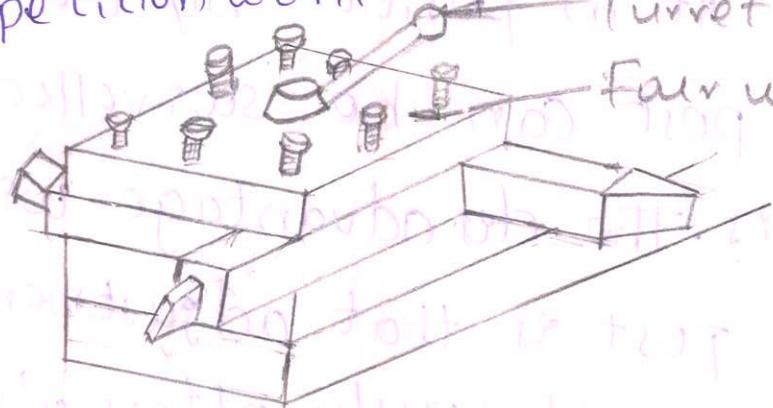


FIG 6.31: Turret (4-way) Tool Post
(lathe operations)

Lathe is such a versatile machine tool, that can produce another lathe, involving several operations. In order to perform different machining operations on a lathe, the work piece may be supported and driven by any one of the following methods:-

1. Held between centers and driven by carriers and catch plates.
2. Held on mandrel which is supported between centers and driven by carriers and catch plates.
3. Held and driven by chuck with the other end supported on the tail stock centre.

u. Held and driven by a chuck or a face plate or an angle plate.

General and special operations performed on a lathe are:-

1. Centering
2. Facing
3. Turning
4. Taper turning
5. Chamfering
6. Thread cutting
7. Knurling
8. Forming
9. Drilling
10. Boring
11. Reaming
12. Parting off
13. Key way cutting.

Centering: When the work is required to be turned between centres or between a chuck and a centre, conical shaped holes must be provided at ends of workpiece to provide bearing surface for lathe centers. The process of producing conical holes for work pieces is called centering. For example centering, first the centre hole is marked the conical holes are produced, by means of a drill chuck, held in a tail stock spindle. The operation is shown in Fig: 1.32.

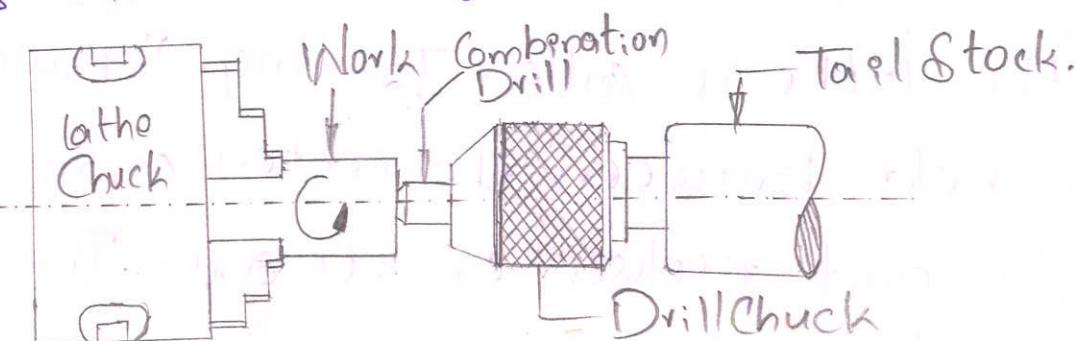


FIG 1.32: Centering Operation.

Facing: Facing is the operation of machining the ends of a piece of work to produce a flat surface square with the axis and also to cut the work of the required length. The operation involves feeding the tool perpendicular to the axis of rotation of work piece. A properly ground facing tool is mounted in a tool holder in the tool post. The cutting edge of the tool should be set at the same height, at the centre of the work piece. Fig 1.33 (a) & (b) illustrates the facing operation.

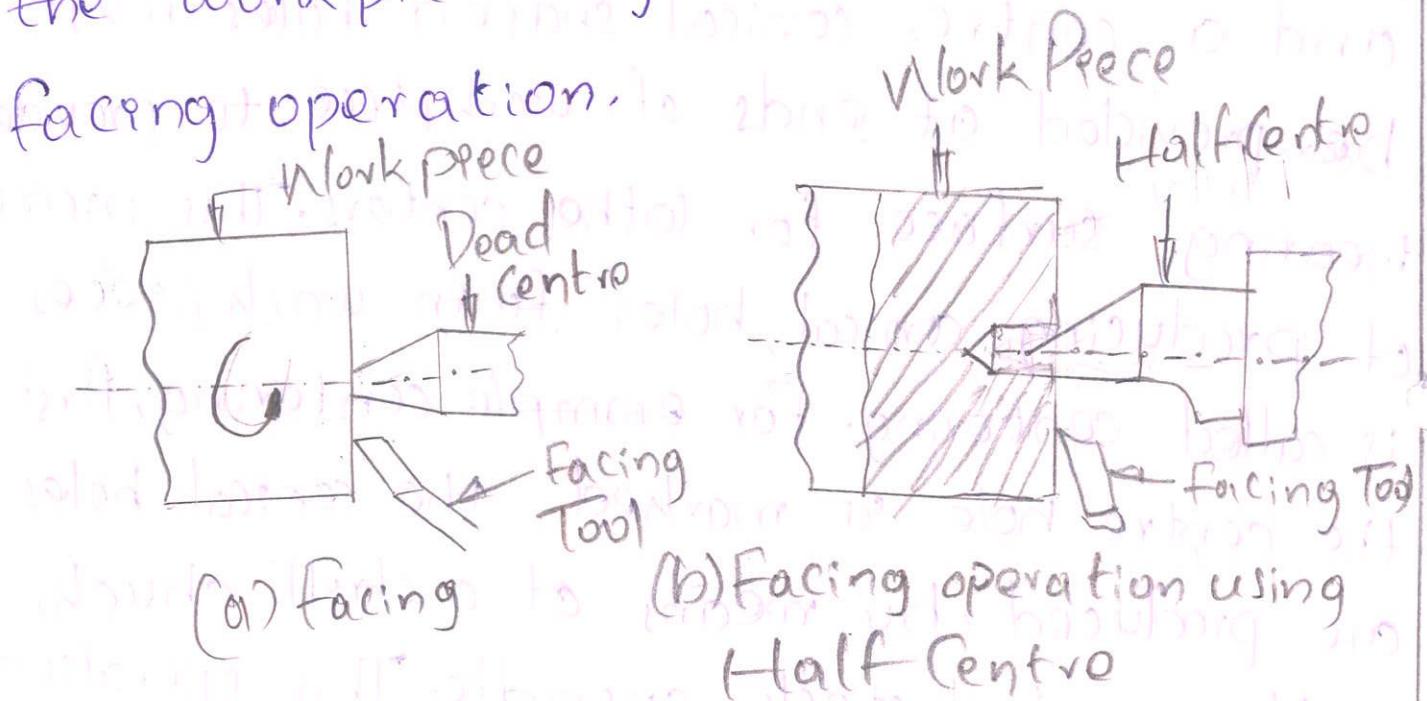


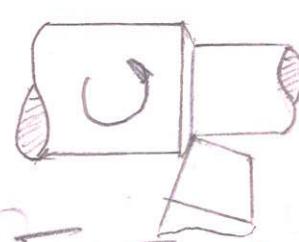
FIG 1.33:

Turning: The most common operation which is done on the lathe is called Turning. The work piece is held between the centers or in the chucks and revolves on its axis. The tool is held in the tool post moves parallel

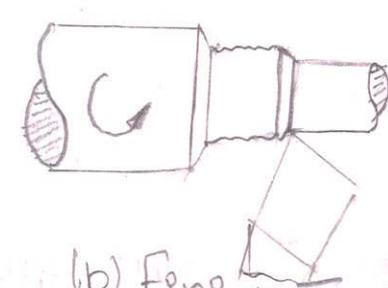
to the ones of the work piece penetrating its surface. The tool removes the metal on the form of chips, from the outer surface of the work piece and the cylindrical surface is produced. This operation is called turning. Based on the amount of feed and depth of cuts, there are two kinds of cuts in a machine desktop work.

1. Rough cut (or) Rough turning.
2. Finish cut (or) Finish Turning

1. Rough cut (or) Rough Turning: The rough turning shown in Fig 1.36 (a) is the process of removal of excess material from the workpiece in a minimum time, by applying high rate of feed and heavy depth to cut. The rough cut should be so made that the machine, the tool and the workpiece can bear the load and it does not make too rough a surface and spoil the centres. For rough cut, depth of cut varies from 2 to 5mm and the rate of feed is from 0.3 to 1.5 mm/rev.



(a) Rough Turning Operation



(b) Finish Turning

2. Finish Turning: The finish turning shown in Fig 1.3u (b) requires high cutting speed, small feed, and a very small depth to cut to generate a smooth surface. In finish turning operation the depth of cut ranges from 0.5 to 1mm and feed from 0.1 to 0.3 mm per revolution of the work piece.

Based on various purposes of work turning may be (i) Straight Turning (ii) Shoulder Turning.

(i) Straight Turning: As shown in Fig 1.35, Straight Turning is the operation of producing a cylindrical surface of a job by removing excess metal from the work piece. In this operation the job rotates about the lathe axis, and the tool is fed parallel to the lathe axis by giving the desired depth of cut.

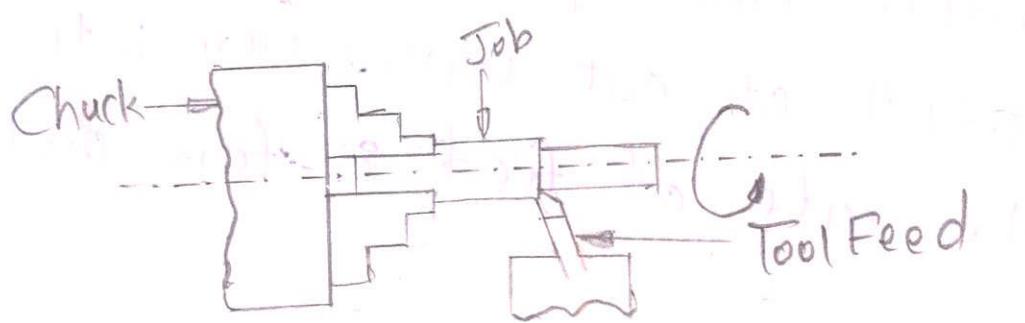
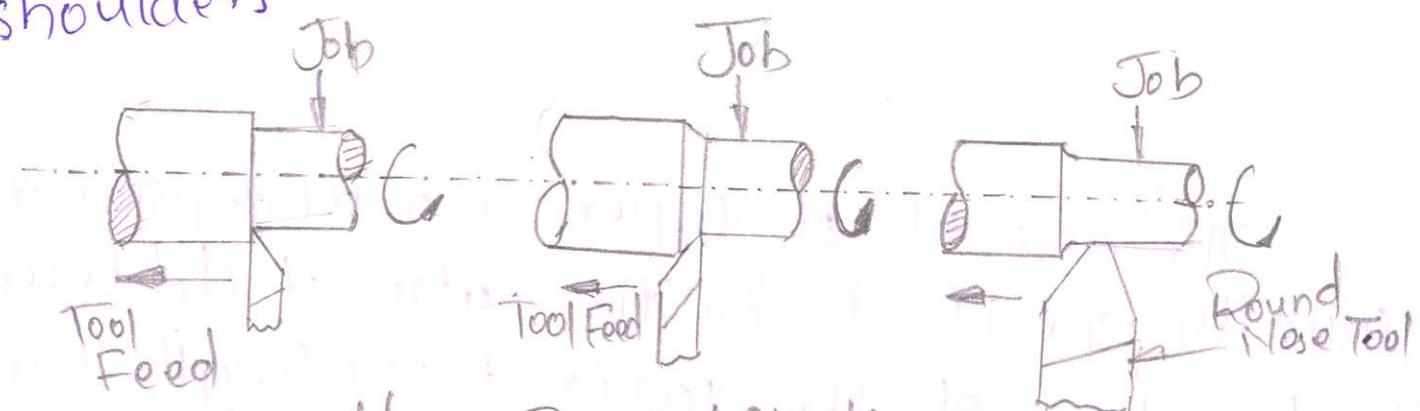


FIG 1.35: Straight Turning Operation

(e) Shoulder Turning When a work piece having different diameters is turned, the surface forming the step from one diameter to the other, is called a shoulder and machining this part of the work piece is called shoulder turning. There are several types of shoulder turning such as square, bevelled, radius etc., Fig 1.36 shows different types of shoulders.



Taper Turning A Taper is defined as uniform increase or decrease in diameter of workpiece, measured along its length. In a lathe taper turning means to produce a conical surface by gradual reduction in diameter from a cylindrical work piece.

Taper Elements A taper work piece shown in fig 1.37 is designated by the following taper elements:

D - large diameter of taper in mm.

d - Small diameter of taper in mm.

l - length of the tapered part in mm.

2α - full taper angle

α - Half Taper angle (or) Angle of Taper

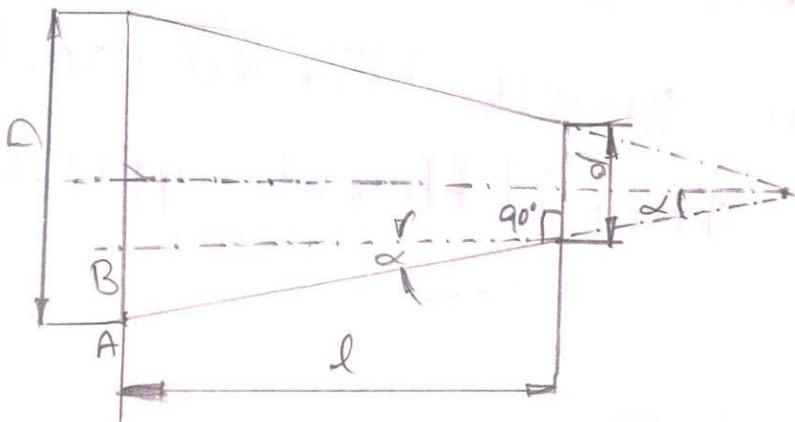


FIG 1.37 : Taper Turning

The amount of taper in a work piece is usually specified by the ratio of difference in diameters of the taper of its length. This is termed as the Conicity & it is designated by the letter K.

$$\text{Conicity } K = \frac{D-d}{l}$$

Chamfering Chamfering, shown in Fig. 1.38 is the operation of bevelling the extreme end of a work piece, to remove burns, to protect the end of the work piece from being damaged and to have a better look. It is performed after Knurling, Rough Turning, boring drilling or thread cutting. Chamfering is an essential operation after thread cutting, so that the nut may pass freely on the threaded

work piece

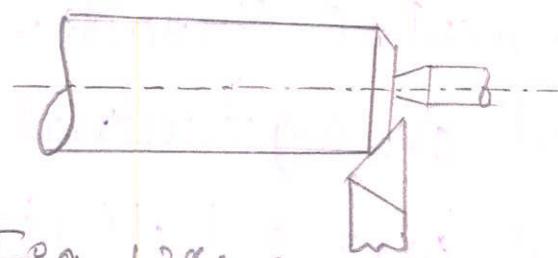
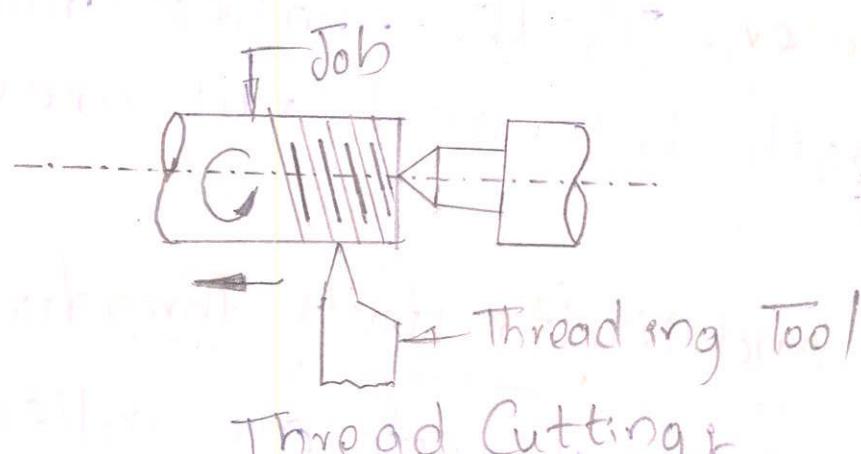


Fig 1.38: Chamfering Operation.

Thread Cutting: Thread cutting is the operation of producing a helical group on cylindrical or conical surface by the feeding the tool longitudinally, when the gob is revolved between centers or by a chuck. The longitudinal feed should be equal to the pitch of the thread to be cut per revolution of the workpiece.



Thread Cutting

Elements of a Thread: The various parameters of thread are shown in Fig 1.40.

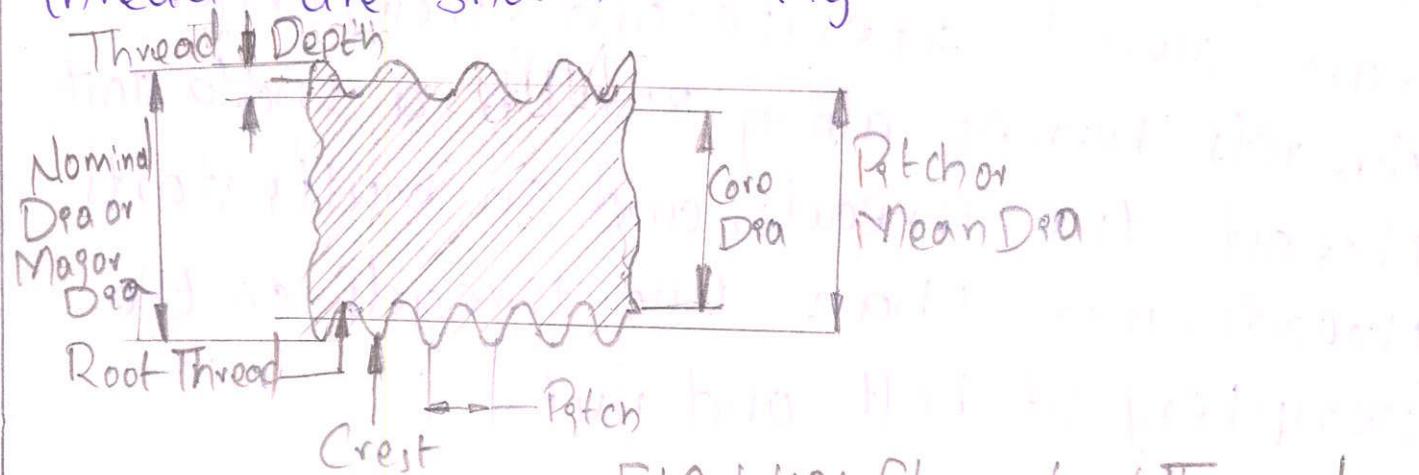


FIG 1.40: Elements of Thread.

Pitch Is the distance between two similar points of two consecutive threads.

Lead Is the axial or longitudinal distance advanced by a nut over a bolt (screw) in one turn.

Nominal (or) Major (or) Outside diameter Is the largest diameter of a thread, measured along the crest surfaces.

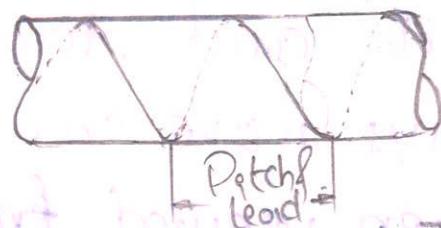
Cone (or) Minor Diameter Is the smallest diameter of thread, measured along root surfaces.

Pitch Diameter Is the smallest diameter of which both bolt and nut are in contact.

Single, Double and Multi starts Thread

The independent threads are called

In a work piece, it is possible to have several separate and independent threads running along it. In a single start thread two threads, and in multi starts threads, more than two threads on the periphery of bolt and nut.



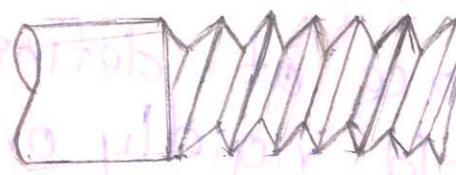
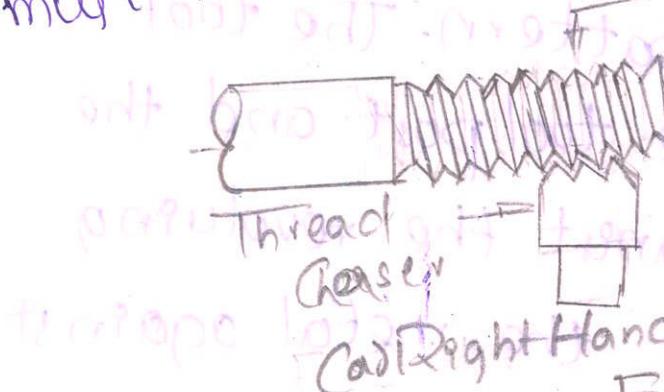
(a) Single Start Thread

(b) Double Start Thread.

Double and Multi start threads are used for fast axial movement of nut and bolt. The relationship between lead and pitch of a screw thread is

$$\text{lead} = \text{pitch} \times \text{No. of starts.}$$

Right Hand Threads: Are those in which threads are inclined towards right, and the nut advances over a screw when turned in a clockwise direction. For cutting right hand threads, the carriage must move towards the Head stock.



(b) Left Hand Thread

Left Hand Threads: Are those in which threads are inclined towards left and the nut advances over a screw when turned in a counter clockwise direction.

For cutting left hand threads, the carriage moves away from head stock and towards the tail stock. The gob always move in anti clockwise direction, when viewed from tail stock end.

Knurling - knurling shown in Fig. 1.43, is the process of embossing a diamond shaped pattern on the surface of a work piece. The purpose of knurling is to provide an effective gripping surface on a work piece, to prevent it from slipping when operated by hand. The operation is performed by a special knurling tool, which consists of a set of hardened steel rollers in a holder with the teeth cut on their surface at definite pattern. The tool is held rigidly on the tool post and the rollers are pressed against the revolving work piece, to squeeze the metal against the multiple cutting edges, producing depressions in a regular pattern on the surface of the work piece. Knurling is done at the slowest speed available in a lathe. Two or three cuts be necessary to give the full impression.

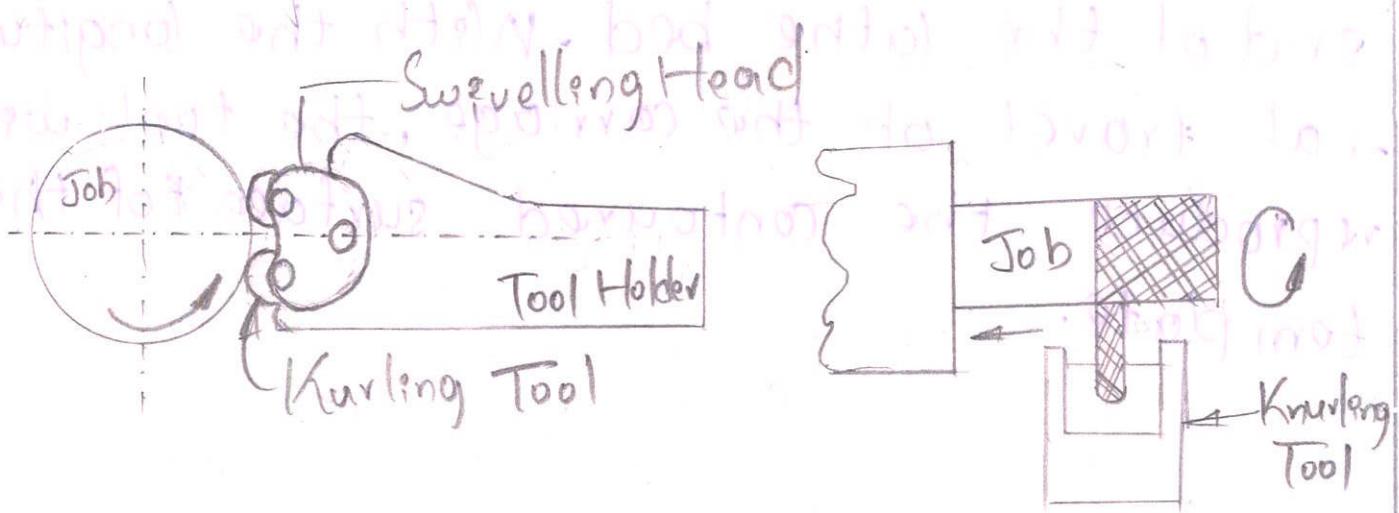


Fig:- 1043: Knurling

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

- (i) Using a form Tool or slot a previously formed surface, or form tools having the cutting edges conforming to the required shape is fed straight into the work piece, as shown in fig 1044.
- (ii) Combining cross and longitudinal feed.
- (iii) Tracing or copying a template.

For turning a small length of formed surface, or form tools having the cutting edges conforming to the required shape is fed straight into the work piece, as shown in fig 1044.

For turning a lengthy formed surface, a straight turning tool is fed onto the work piece using both longitudinal

and cross feed simultaneously by hand, and for turning a large number of wide,

formed surfaces, a template having the required shape is attached to the rear

end of the lathe bed. With the longitudinal travel of the carriage, the tool will reproduce the contoured surface of the template.

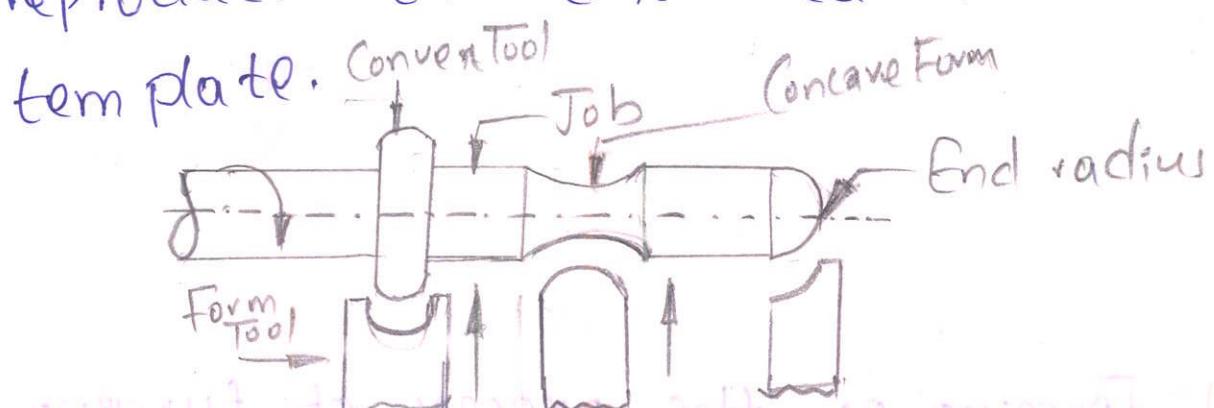


FIG 1.44: Forming

Drilling: Drilling is the operation of producing a hole in a work piece, by a drill. Drilling is done on the drilling machine, but it can be done conveniently on lathe. In this operation, shown in Fig 1.45, the work piece is held and rotated in a chuck, and the drill is inserted in the tail stock spindle and fed into the work angularly by hand.



FIG 1.45: Drilling

Boring: Boring is the operation of enlarging & turning a hole already produced by Drilling, using a boring tool. Boring cannot originate a hole. Boring produces a hole

that is concentric with the outside diameter of the work. In this operation as shown in Fig 1.46, the work is revolved in a chuck and the boring bar with a tool bit, fitted on tail stock spindle, is fed into the work axially.

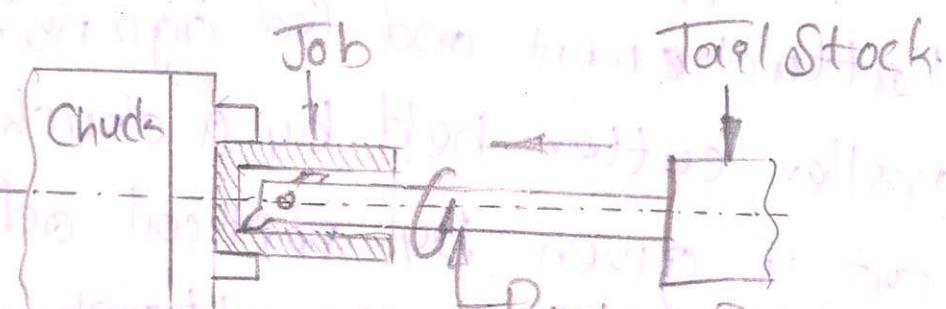
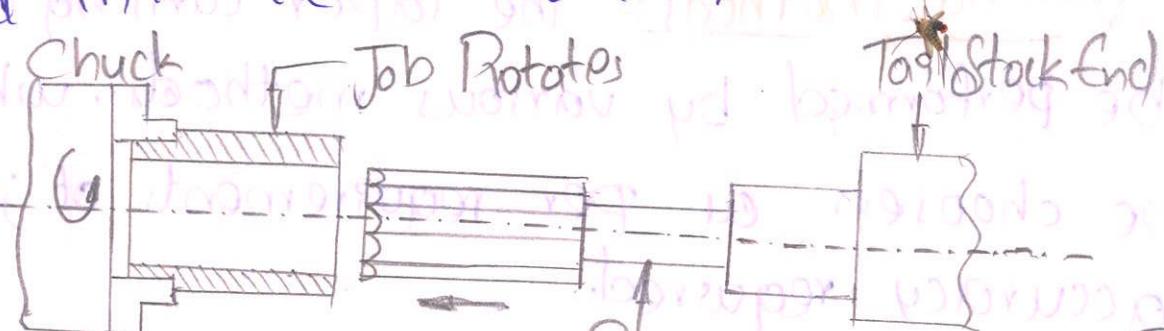


FIG 1.46: Boring,

Reaming Reaming is the operation of finishing and sizing a hole, which has been previously drilled or bored, using a reamer having multiple cutting edges. In this operation as shown in Fig 1.47, the work is rotated by a chuck and the reamer held in the tail stock spindle & fed into the work axially.



Parting-off Parting off is the operation of cutting a work piece after it has been machined to the desired shape & size. In the operation as shown in Fig 1.48, the workpiece

is held and rotated in a chuck at half the speed of turning and a parting-off tool is fed perpendicular to the lathe axis, very slowly until the tool reaches the centre of the job.

(The diagram is given below in Fig 1.48)
Key way cutting: For cutting keyways or grooves,

the work is supported on the cross slide by a special attachment and fed against a rotating miller cutter held by a chuck. The depth of cut is given by vertical adjustment of the work provided by the attachment.

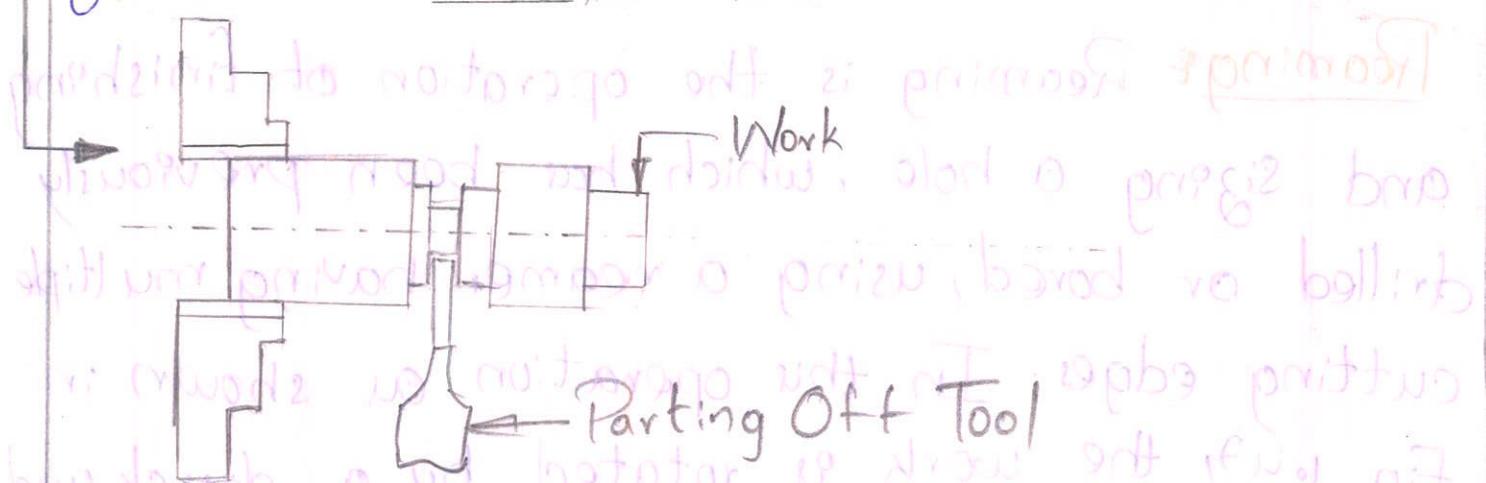


FIG 1.48 : Parting Off Operation

Taper turning Methods: The taper turning can be performed by various methods, which can be chosen as per requirements of job and accuracy required.

The various methods of Taper Turning are:

1. By a form Tool.
2. By Swivelling the Compound rest
3. By setting over the tail stock centre



u. By a taper turning attachment.

s. By combining longitudinal and cross feed.

By a form Tool:- In this method a taper is produced by a form tool. Form tool has definite shape of the taper and its cutting edge is set at some angle of taper or required for the work. This method is the easiest and simplest method. In this method as shown in Fig 10.49, the form tool is fed straight into the work piece to produce a tapered surface. This method is mostly suitable for mass production for chamfering on bolts, nuts, bushes etc. where length of taper is very short.

This method has got the following limitations:

- (1) This method is limited to turn short length of taper only.
- (2) For different taper angles, different form tools are required.

According to their principle of operations they are classified as-

1) Parallel action automatics

2) Progressive action automatics.

Semi automatic lathes.

Semi automatic are usually turning machine adapted to chuck work. In these machines although the movements of workpiece or tools are automatically loaded into and removed from the chuck at beginning and end of each cycle of operations.

The operator has to check the size of workpiece being machined. The machining cycle is automated but the direct participation of the operator is required to start each subsequent cycle of operation.

Classification of semi automatic

Depending upon the no. of work spindles, these machines are classified as.

1) Single Spindle semi automatic lathe

2) Multi " " " "

Single spindle semi automatic lathe are of the following types.

a) Centre type

b) Chucking type.

In the centre type machine the workpiece is held by the centres for which a head stock and a tailstock are mounted on the bed of the machine.

10) Side relief angle - is the angle made by the flank of the tool & a plane perpendicular to the base just under the side cutting edge.

11) End Relief Angle - is the angle between a plane perpendicular to the base and the end flank.

12) Cutting Angle - is the radius of nose is the included angle when the tool has been ground wedge-shaped.

13) Face relief angle - angle between the flank of the tool & a plane perpendicular to the base just under the side cutting edge.

14) Approach angle - angle between the flank of the tool & a plane perpendicular to the base just under the side cutting edge.

15) Edge relief angle - angle between the flank of the tool & a plane perpendicular to the base just under the side cutting edge.

16) Flank angle - angle between the flank of the tool & a plane perpendicular to the base just under the side cutting edge.

17) Tool angle - angle between the flank of the tool & a plane perpendicular to the base just under the side cutting edge.

Lathe tool Geometry-

The various parts & Angles of a lathe tool as shown in fig 1.56 & fig 1.57 are

- 1) Shank - is that portion of the tool bit which is not ground to form cutting edges & is rectangular in cross section.
- 2) Face - Is the surface of the cutting tool over which the chip flows.
- 3) Flank - of a tool is that surface which face the workpiece.
- 4) Nose - is the corner, arc or chamfer at the junction of the major and minor cutting edges.
- 5) Base - of a tool is the under side of the shank.
- 6) Cutting edge - carries out the cutting
- 7) Back Rake Angle - Measures the downward slope of the top surface of the tool from the nose to the rear along the longitudinal Axis.
- 8) Side Rake Angle measures the slope of the top surface of the tool to the side in a direction Perp to the longitudinal Axis.
- 9) End Cutting edge Angle - is the Angle between the face of the tool & a plane Perp to the side of shank.

then setover (tailstock side over) will be given by Setover

$$S = L \sin \theta = L \tan \theta$$

$$S = L \times \frac{D-d}{2L} \quad [\because \tan \theta = \frac{D-d}{2L}]$$

If the taper is turned on the entire length of the workpiece.

then $L = l$; and then

$$\text{Setover} \quad S = l \times \frac{D-d}{2l} = \frac{D-d}{2}$$

$$D-d = KL$$

$$\text{then setover} = \frac{KL}{2}$$

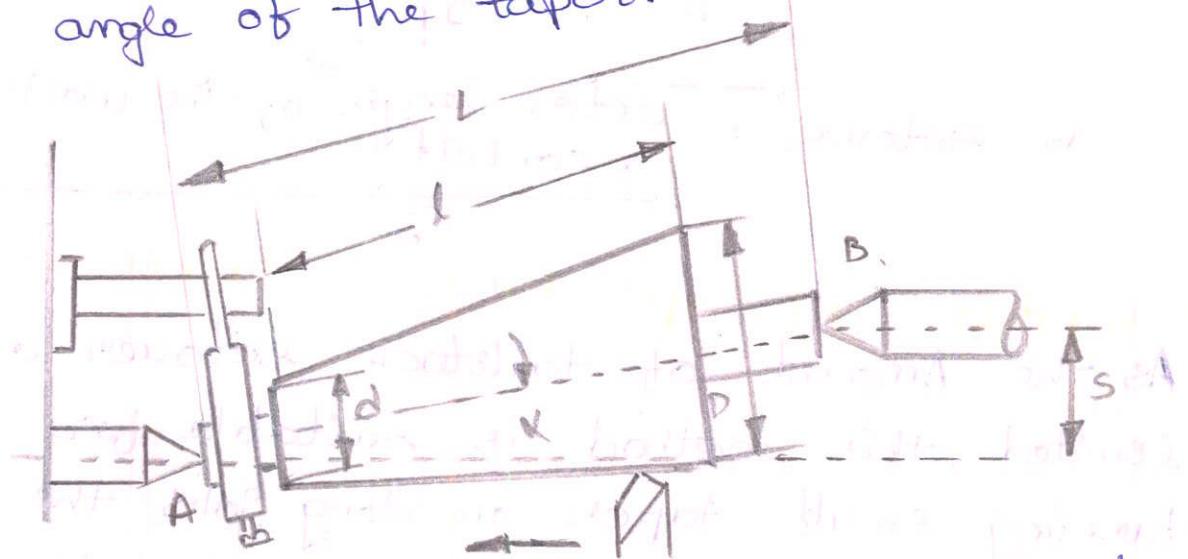
$$\text{or Setover} = \frac{\text{entire length of the work} \times \text{conicity}}{2}$$

As the amount of tailstock setover is limited, this method is suitable for turning small taper on long jobs the main disadvantages of this method is that the live and dead centres are not equally stressed & the wear is not uniform.

Explain the principle of turning taper on lathe machine.

By Setting over the tailstock Centre -

- The principle of taper turning by this method is, to shift the Axis of rotation of the workpiece by setting the tailstock base towards or away from the operator, at an angle to the lathe axis, & feeding the tool parallel to the lathe axis.
- The Angle at which the axis of rotation is shifted is equal to half angle of the taper.



The Amount of set over required to machine a particular taper may be calculated as,

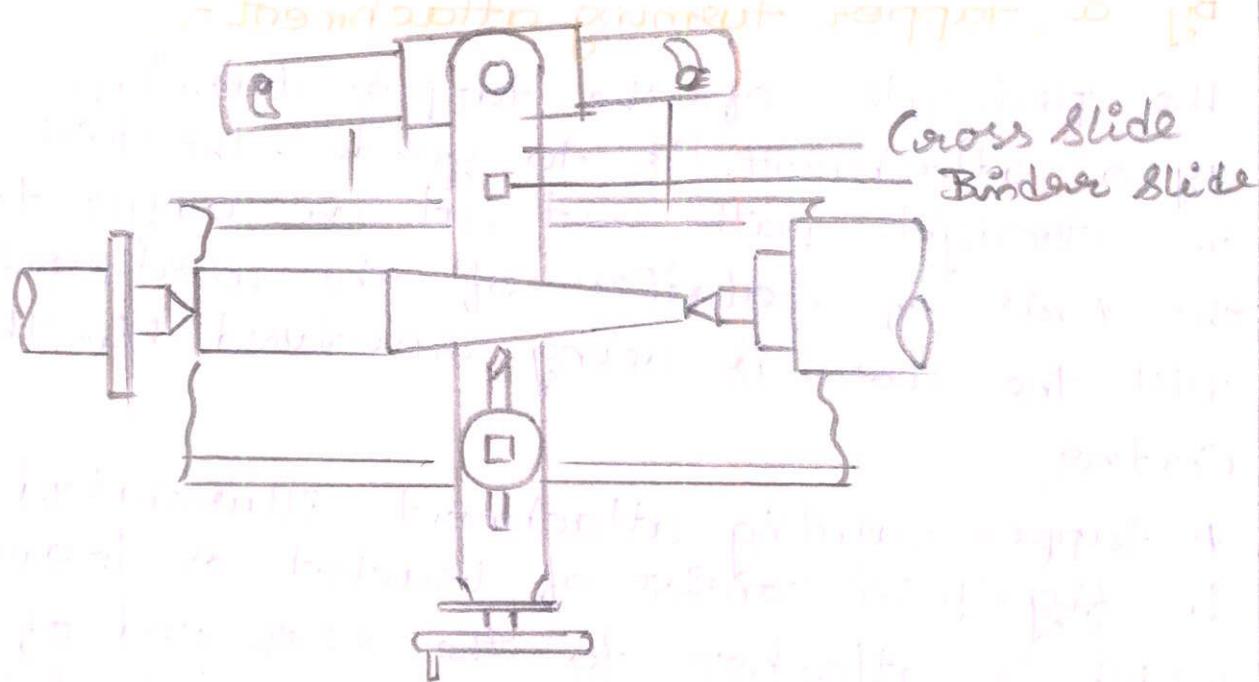
from the right angle ABC

$$\sin d = \frac{BC}{AB} \text{ (or) } BC = AB \sin d$$

$$\text{or Setover } S = L \sin d$$

If the Angle x , the Angle of taper is very small, for all practical purposes,

$$\sin d = \tan d$$



The angle of swivelling the guide bar
can be determined by -

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

Advantages of taper turning attachments -

- 1) With the use of Attachment, tapers are turned without disturbing the normal step of the length.
- 2) The Attachment can be quickly & easily set.
- 3) External & Internal tapers can be tapper turned
- 4) Very steep taper on a long workpiece may be turned
- 5) Accurate tapper on a large no. of workpiece may be turned.

By a taper turning attachment -

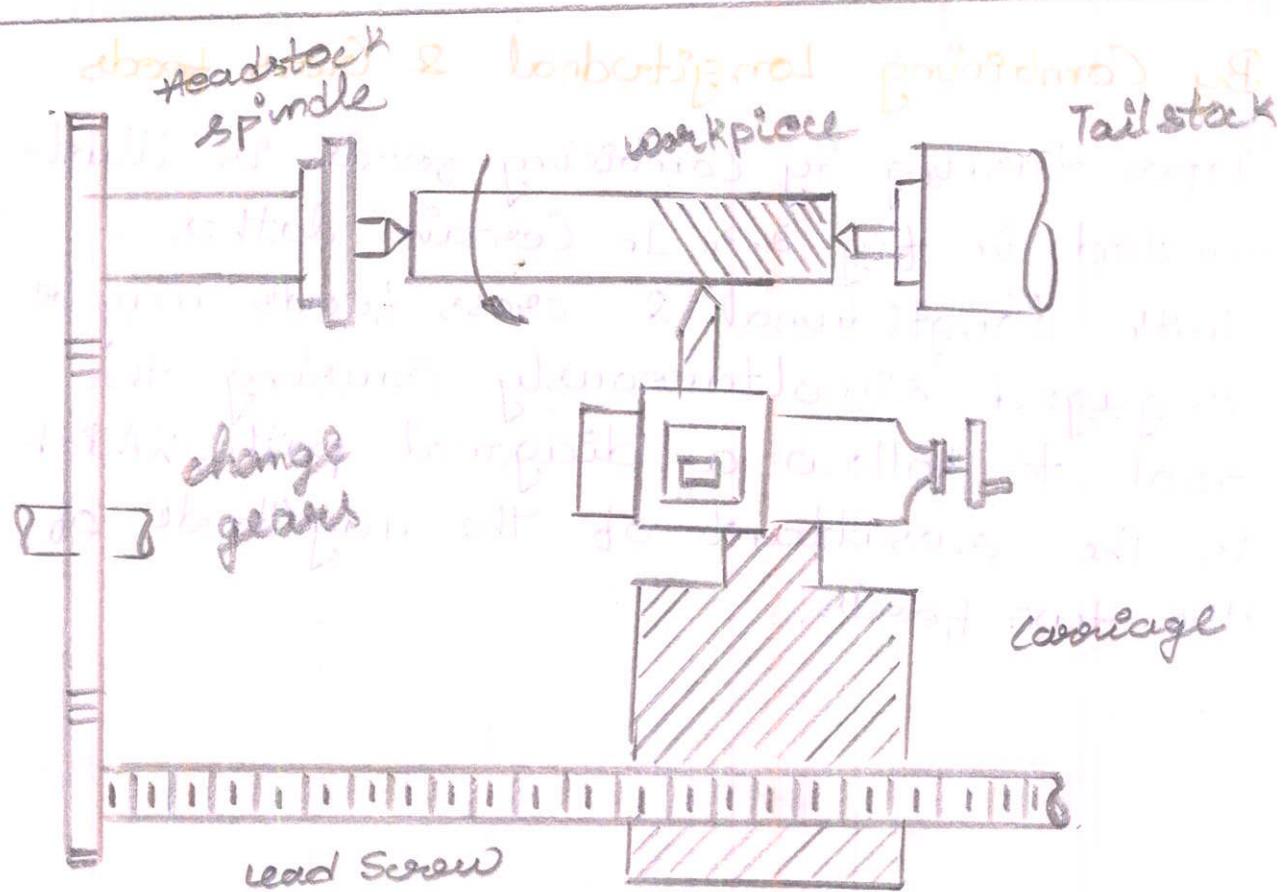
The principle of the taper turning by a attachment is to guide. The tool in straight path set at an angle to the axis of rotation of the workpiece, while the work is being revolved b/w the centre.

A taper turning attachment illustrated in fig (1.5a) consist of bracket or frame, which is attached to the rear end of the lathe bed and supports a guide bar pivoted at the centre.

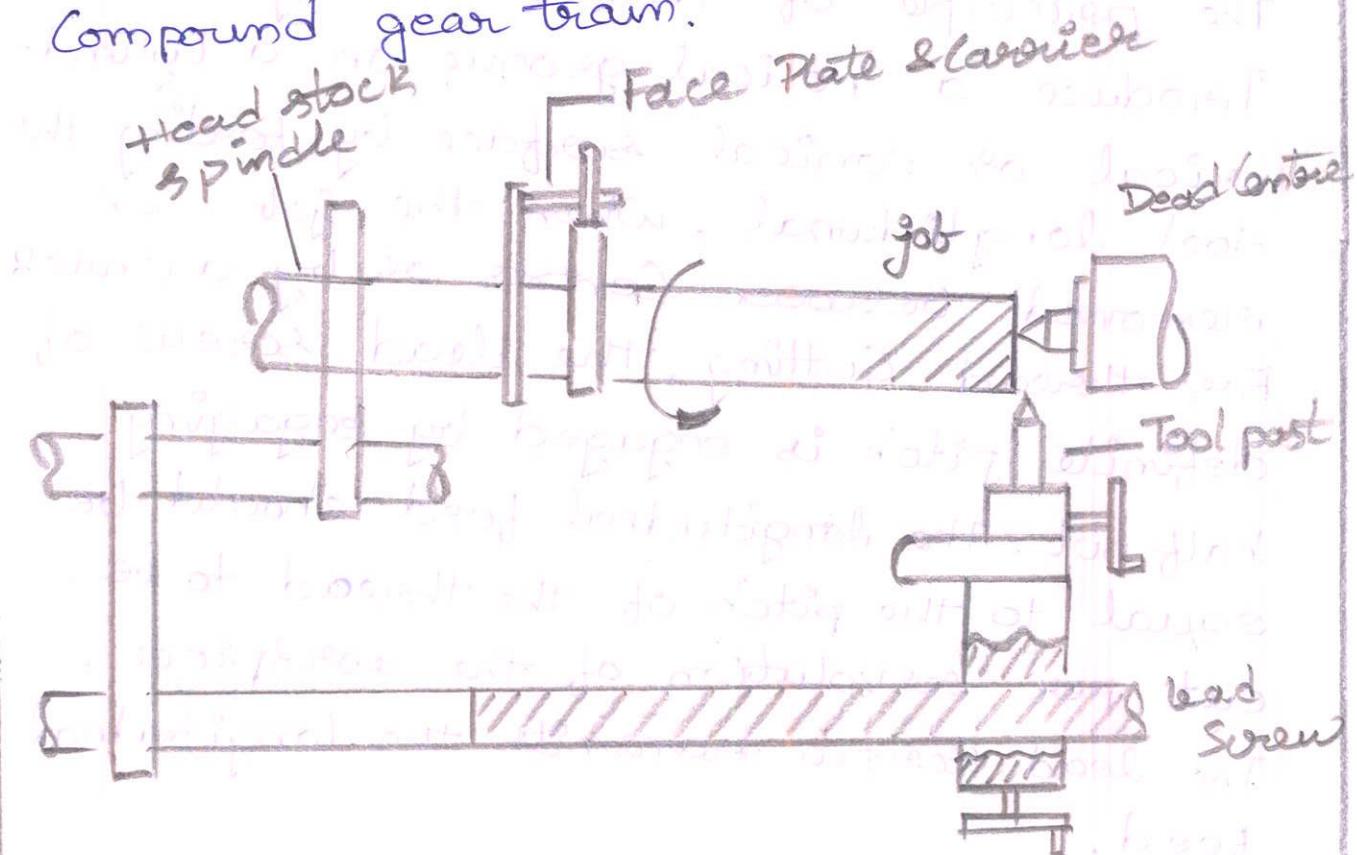
The bar having graduations in degrees may be swivelled & either side of the zero graduation & is set at any desired angle with the length of the lathe. The maximum angle is 10° - 12° on either side of the centre line.

When the taper turning attachment is used, the cross slide is first made free from the lead screw by removing the center screw. The rear end of the cross slide is then tightened with the guide lock by means of a bolt.

When the longitudinal feed is engaged, the tool mounted the cross slide will follow the angular bar set by the guide bar. The depth of cut is given by the compound rest.

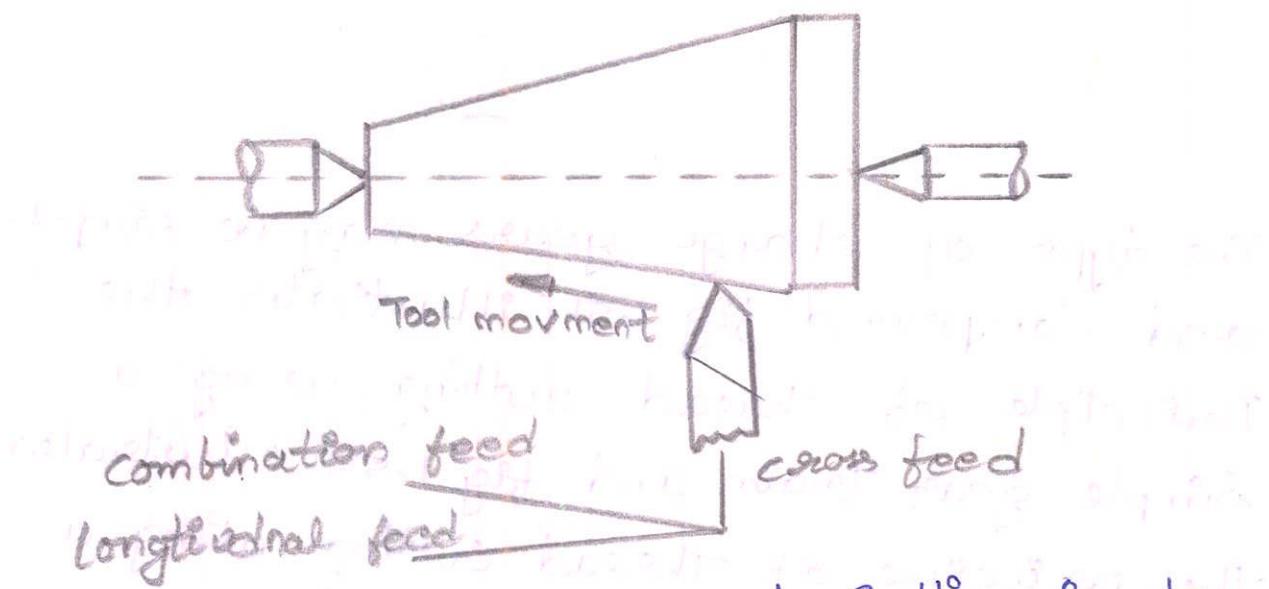


The type of change gears may be simple and compound fig 1.54 illustrates the principle of thread cutting, using a simple gear train and fig 1.55 illustrates the principle of thread cutting using a compound gear train.



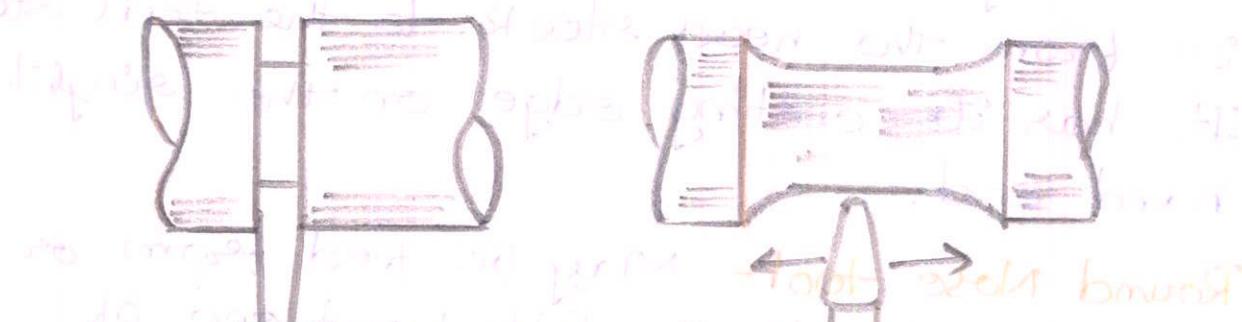
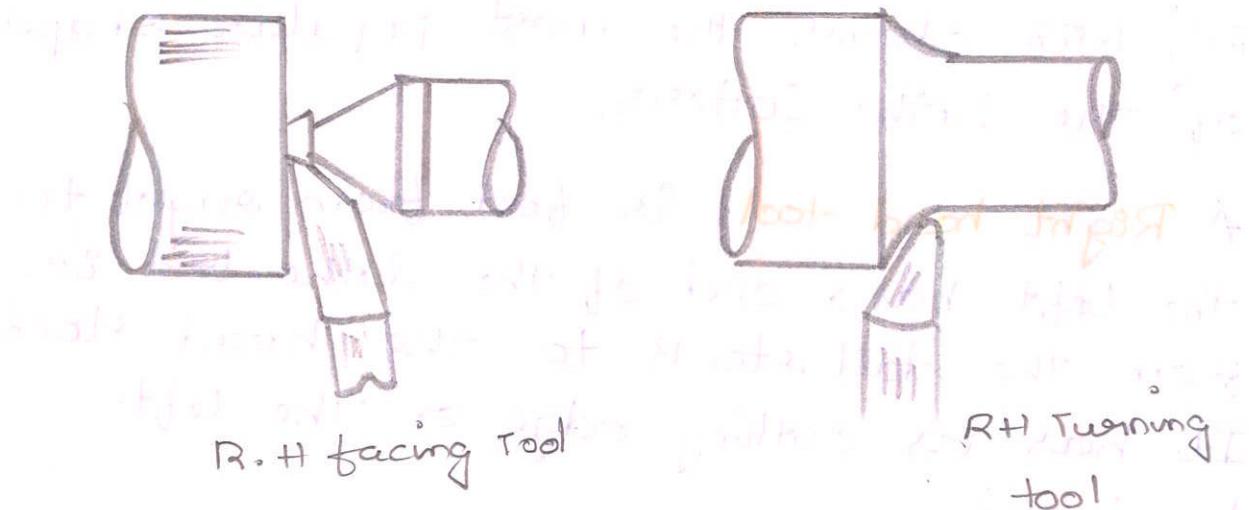
By Combining Longitudinal & Cross feeds

Taper turning by combining feeds is illustrated in fig 2.3 In Certain lathes, both longitudinal & 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.

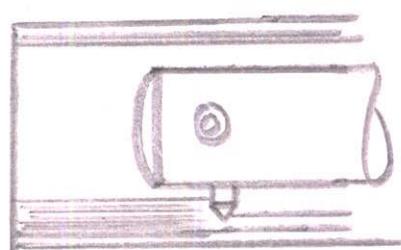


The principle of thread cutting is to produce a helical groove on a cylindrical or conical surface by feeding the tool longitudinal, when the job is removed between centres or by a chuck. For thread cutting, the lead screw of definite pitch is engaged by engaging half nut. The longitudinal feed should be equal to the pitch of the thread to be cut per revolution of the workpiece. The lead screw transmits the longitudinal feed.

To complete the part we have to follow
the following steps in clockwise direction.



R.H Turning tool (B)



Boring tool

Application of lathe cutter bits

round nose turning tools, & right or left hand facing tools.

Fig 1.58 shows the most popular shapes of the lathe cutters.

A Right hand tool is fed from right to the left hand end of the lathe bed ie. from the tail stock to the head stock. It has its cutting edge on the left hand end.

A Left hand tool is fed from left to the right hand end of the lathe bed. ie from the head stock to the tail stock. It has its cutting edge on the right hand end.

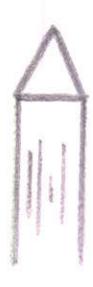
Round Nose tool - May be fed from or from right to the left hand end of the lathe bed ways.



a) left hand
Turning
tool



b) Round
Nose



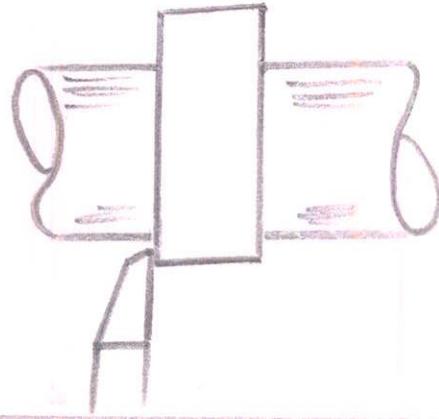
c) Thread-
ing
Tool



d) Right
hand
facing
tool

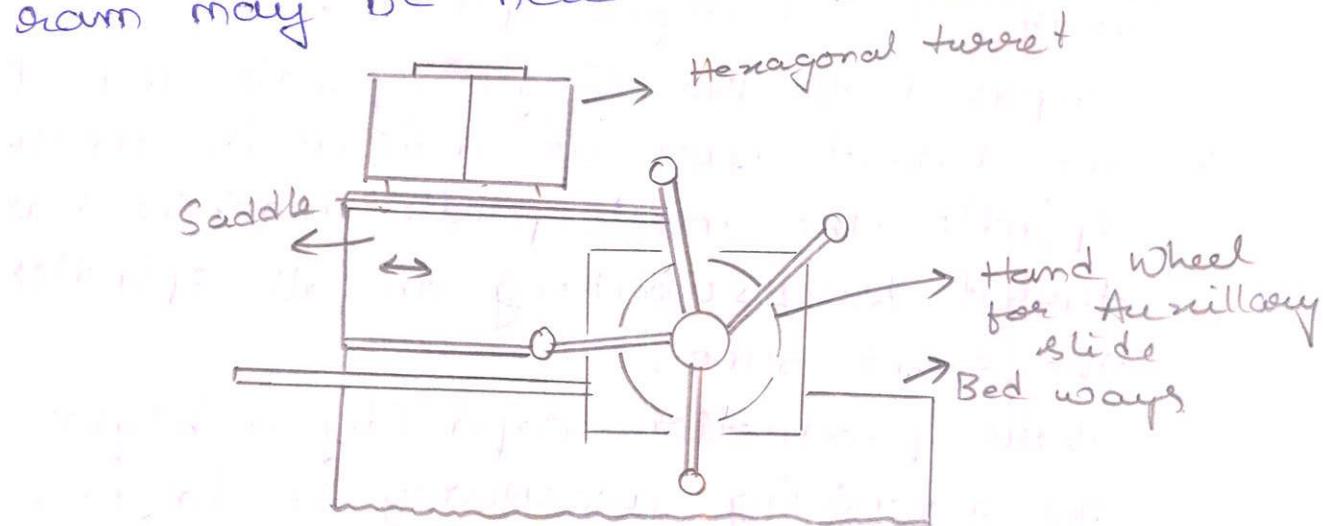


e) cut off tool



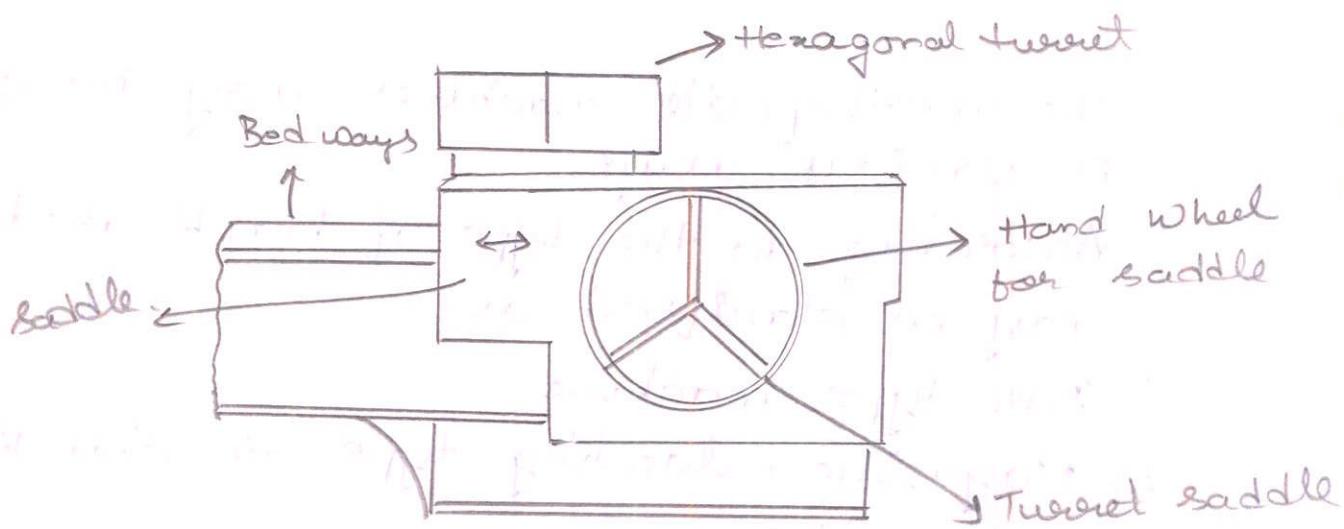
LH Turning
Tool (A)

turret stroke and an automatic ender. The machine is required for either bar or checking work where overhang of the work may be held to the minimum.



Saddle type

In this type of turret lathe the hexagonal turret is mounted directly on the saddle and the entire saddle moves back & forth on the lathe bed to apply feed. It is heavier in construction than arm type & is more suitable for work requiring long turning and boring cuts. The machine can accommodate longer workpieces than the Capstan lathe.



The multi-spindle automatic lathes are the fastest type of production lathe machines and are made in variety models with two, four, six or eight spindles.

Compared to the single spindle machine, where one turret face at a time is working one spindle the multi-spindle machine has all turret faces working on all spindles at the same time.

There production capacity is higher but the machining accuracy is lower.

Because of the longer setup time and increased tooling cost, the multi-spindle machine is less than single spindle and turret lathes. & more economical on longer runs.

on the single spindle machine, the time required to produce one component is the sum of all the turret operations.

Where as the time required to machine one piece on multi-spindle machine is the time of the longest cut.

The multi-spindle machines may be classified in various ways.

According to the type of blank used, they may be classified as -

- 1) Bar type machine
- 2) Magazine-loading type or chucking type machine.

Types of turret lathes

According to the direction of machine these are classified as-

- 1) Horizontal Turret lathe &
- 2) Vertical Turret lathe

Horizontal Turret lathe are further classified as

- a) Chucking machine &
- b) Bar machine.

a) Chucking Machine are employed for parts of irregular shape such as casting & forging which must be supported in suitable quick-acting chucks or special holding fixtures.

b) Bar Machines are employed for machining bar stock or individual parts of nearly symmetrical shape resembling bar stock.

Ram type or Capstan lathe

In this type of lathe, the hexagonal turret is mounted on a slide or ram, which moves back & forth on a saddle, that is permanently clamped to the bed. This machine is recommended for small work, since it is fast handling and easy operated machine. It is quickly and operated easily because the hexagonal turret can be moved back and forth without moving the entire saddle unit. The machine is light of construction and has a short

control turret for right

- In this type of lathe the hexagonal turret is mounted on a slide or ram, which moves back & forth on the saddle that is permanently clamped to the lathe bed.
- This is used for small jobs.
- The machine consists of light construction & has a short turret stroke & an automatic index on the turret.

Saddle type or turret lathe

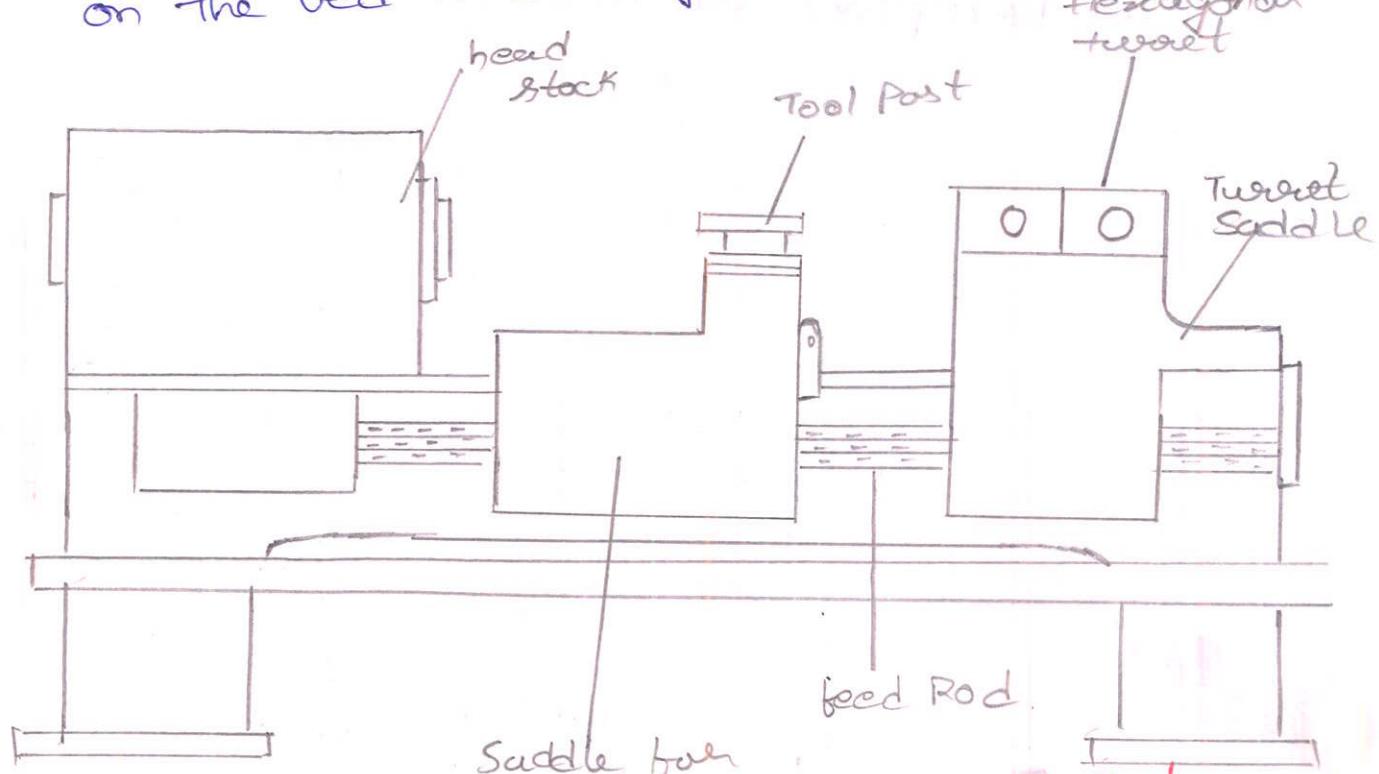
- The main difference b/w Saddle & Ram type lathe is that it has heavier construction compared to Ram type or Capstan lathe.
- It has a long turret stroke & a rigid turret mounting.
- These are used for large jobs.
- This machine can accommodate longer workpieces than that in a Capstan lathe.

Cross Slide & Saddle - (P) go about algorithms

- In Small capstan lathes, hand operated cross slide & saddle are used which are clamped on the lathe bed at the required position.
- These have two types of carriages.
 - 1) Conventional type Carriages.
 - 2) Side hung type Carriages.

The Conventional type Carriages is supported on the front and rear bedways and is equipped with four station type tool post at the front and one rear tool post at the back of the Cross slide.

The Side hung type Carriages is generally fitted with heavy duty turret lathes where the saddle slides on the top & bottom guide ways on the front of the lathe bed. The longitudinal movement of each tool may be regulated by using stop bars set against the stop fitted on the bed & carriage.



Principle parts of a Capstan & turret lathe

→ The turret lathe has the same parts as the engine lathe

Bed-

The bed is a long box like Casting provided with Accurate guideways upon which the Carriage and turret saddle are mounted. The bed supports the whole construction.

Head Stock-

The head stock of a turret lathe is large Casting located at the left of the bed. The function of the head stock is to control the spindle speeds. It has also chucks which is used for holding purpose also. The head stock of a capstan or turret lathe may be of the following.

- 1) Step Cone pulley driven head stock
- 2) Driven electric Motor driven head stock
- 3) All geared head stock
- 4) Preselective (or) preselective head stock.

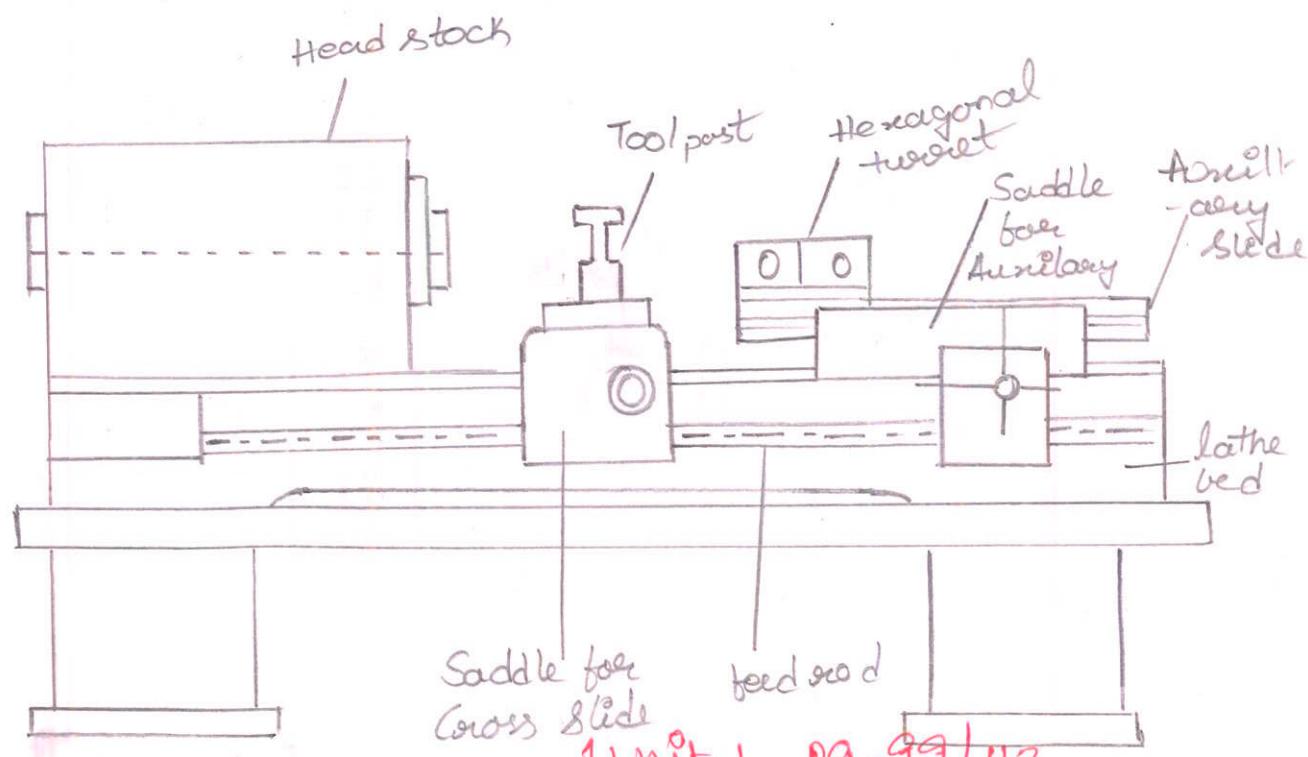


Fig 1.56 shows a typical single point tool. The most important features are the cutting edges & adjacent surfaces.

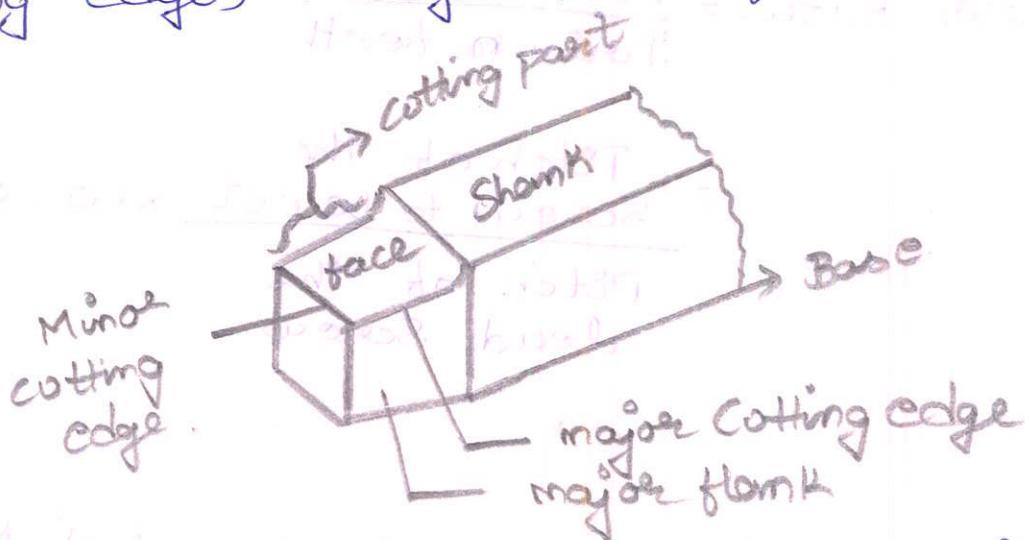
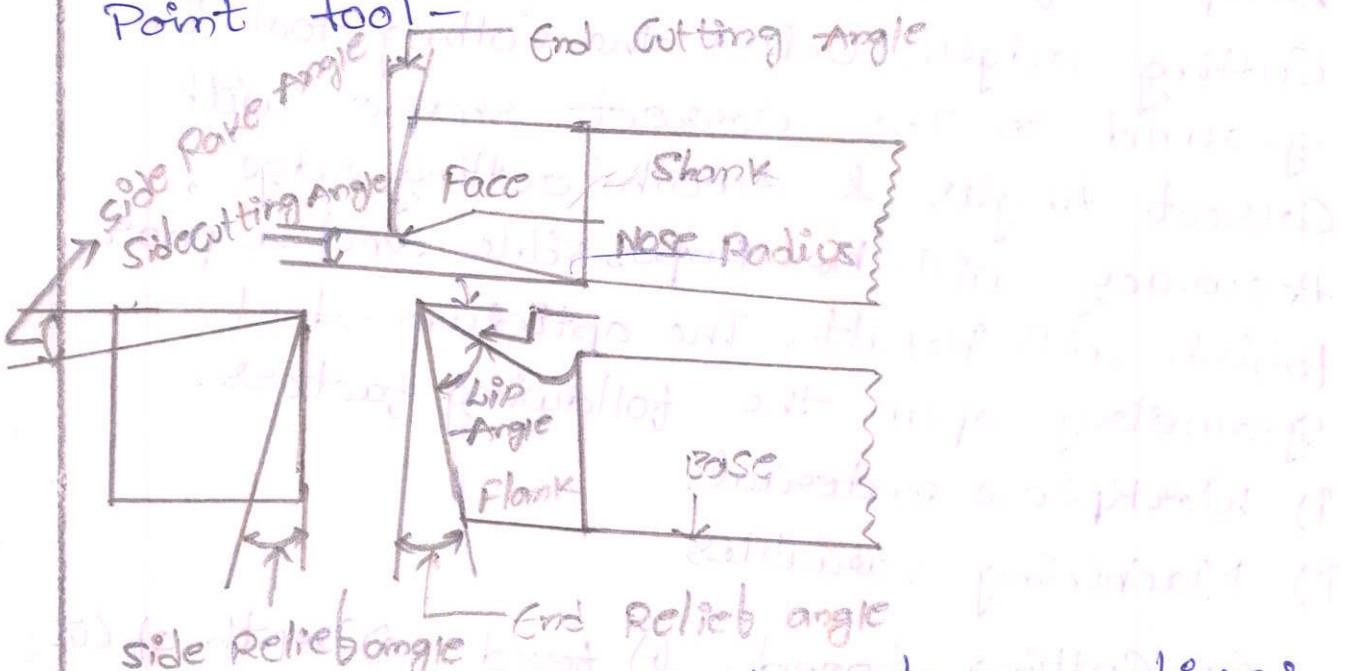


Fig 1.57 shows the geometry of a single point tool -



In lathe work, different operations require different types of tools.

The tool bits are shaped for various lathe operations such as straight turning, taper turning, Drilling, Reaming, Boiling, Threading etc.

Further more the cutter bits may be shaped for either rough turning or finish turning, or they may be shaped

The gear ratio, of change gears can be calculated as,

$$\text{Gear Ratio} = \frac{\text{Driver teeth}}{\text{Driven teeth}}$$

$$= \frac{\text{Pitch of the Screw to be cut} \times \text{no. of starts}}{\text{Pitch of the lead Screw}}$$

Tool geometry refers to the tool angles shape of the tool face & form of the cutting edges. Unless the cutting tool is ground to the correct shape with correct angles & smooth cutting edge, accuracy will be impossible and a poor finish will result. The optimum tool geometry upon the following factors.

- i) Workpiece material.
- ii) Machining variables
 - a) Cutting speed b) feed c) Depth of cut
- iii) Material of the tool point
- iv) Type of cutting.

For general purpose work, the tool used in a lathe is a single point tool but for special operations multi point tools may be used.

Tool Signature-

Tool Signature is a Sequence of listing various Angles & size, shape of Cutting tool which is Posted at tool post.

The numerical identification has been Standardised by American Standard Association [A.S.A]

The Seven important elements stated as follows These are measured in degrees & mm.

Rake Angle - 8°

Side Rake Angle - 14°

End Relief Angle - 6°

Side Relief Angle - 6°

End Cutting edge Angle - 6°

Side " " " - 15°

& Nose Radius - 4mm

Production lathe-

→ Production lathe are development of the engine lathe.

→ An engine lathe is not preferred for batch and mass production because it takes large amount of time for setting various tools for various operations

→ A skilled person is maintained at a production lathe

→ In production lathes, several tools are mounted in a such a manner that the tool can be used for various operation simultaneously.

The production lathes are ~~not~~ Turret lathe, Automatic, & Semi Automatic lathe Also Saddle lathe.

Turret lathe -

- The turret lathe are the modification of the engine lathe
- The turret lathe reduces time and Production is made with In the time period tremendously.
- In turret lathe the tailstock is replaced by multiple face rotating tool holder or turret
- Turret may have five, six, eight, ten faces
- All the faces can hold different types of tools such as drilling, Reaming, Boring, chamfering tool etc.
- The Main characteristics of the turret lathe is that it enables us to perform many operation at the time
- These are mainly used in mass Production
- These can be seen in many plywood carpentry, Industries etc.
- It reduces man work, time Increases the production

2. Automatic bar Machines -

- Are designed for machining Components from bars or pipe stocks.
- These machines are chiefly used for the manufacture of fasteners (Screws, nuts, studs), shafts, handles and other parts, usually made of bar or pipe stock.

Depending upon the no. of Spindles these are classified as

- 1) Single Automatics &
- 2) Multi spindle Automatics.

Again According to the Arrangement of Spindle automatic are classified -

- 1) Horizontal machine
- 2) Vertical machine.

Types of Single Spindle Automatics.

1) Automatic cutting off machines-

"The front cross slides are used for turning & forming operations. Rear tool slide is used for facing, undercutting and cutting off operations".

The stock is held b/w the collet chock of the rotating spindle. The machining is done by the tool held in slides operating only in cross-wise direction.

"The form tool held on the front cross slide produces the required shape of the component. The parting off tool in the rear slide is used to cut off the component after turning. **Unit-1, pg-104/113**

2) Swiss type automatic Screw Machine -

The machine is also known as Sliding head Screw machine or movable head stock machine because the head stock is movable & tools are fixed.

These machines are used for long holes of small diameter.

The main characteristic is that it can replace special attachments to form various operations such as Knurling, boring, chamfering, cutting off etc. with the special attachment mounted on the right hand side of the bed, Centering, Reaming drilling operation can also be performed.

Automatic lathes-

- Automatic or Autonatic machines are those in which both the workpiece handling & the metal cutting operations are performed automatically.
- Once the feed is given to the machine then the production will start automatically without need of worker.
- All the one thing to do is inspect the mechanism, whether the work-piece is renewed in shape or not.
- He has also to look after damages occurred in the machine if more heat is produced in the machine.
- And the main is that to inspect is whether it is given dimension product or not.

Advantages of Automatic lathes-

- 1) Greater production within time period.
- 2) More economy in floor space
- 3) Accurate than the turret lathe
- 4) Constant flow production
- 5) Scrap loss is reduced by eliminating operator error
- 6) Reduces man work
- 7) The operator has no risk he is free to operate or control the system.

operations of Capstan & turret lathes -

The Capstan or turret lathe consists of a bed, headstock & a saddle on which a four station tool post is mounted to hold four different tools. A tool post fitted at the rear end of the carriage holds a Parting in an inverted position. The work-Piece are held in collet or chucks. The hexagonal turret is mounted on a slide can hold 6 or more no of different tools. The longitudinal cross feed movement is adjusted or regulated by adjustable stops.

Advantages of Capstan & turret lathes -

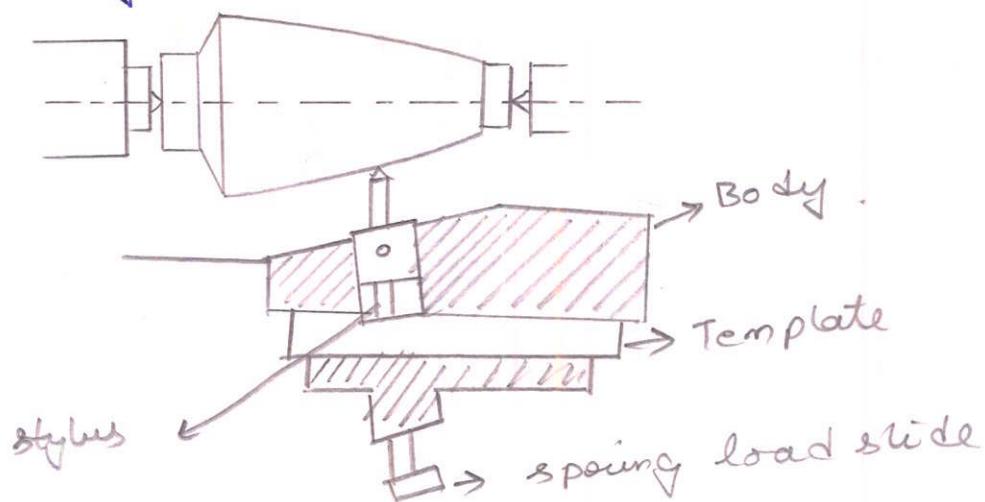
- 1) A large no of tools can be permanently set up in the machine in the proper sequence of their use.
- 2) Each cutting position is provided with a feed stop, which ensures identical cuts on successive pieces.
- 3) Multiple cuts & combined cuts can be taken at the same time.
- 4) The turret lathe can be fitted with various attachment such as for taper turning, thread chasing & duplicating.
- 5) A less skilled operator is required.

There are two common types of copying lathe.

- 1) Mechanical type
- 2) Hydrolic type.

Mechanical type-

A simple mechanical type copying turning attachments is mounted on the saddle after removing the cross slide from the template the reciprocating the job profile is desired. The job is clamped at a suitable position on the bed the stylus is fitted in the spring and loaded tool slide & the saddle will travel longitudinal direction according to the direction of the template.

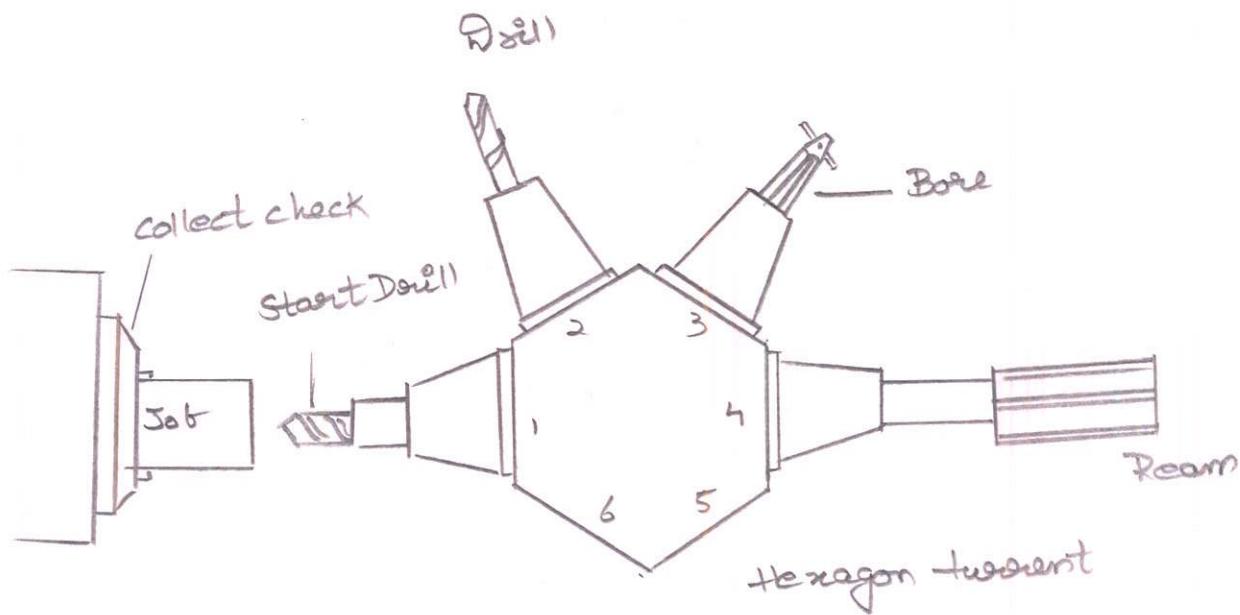


Hydrolic copying attachments

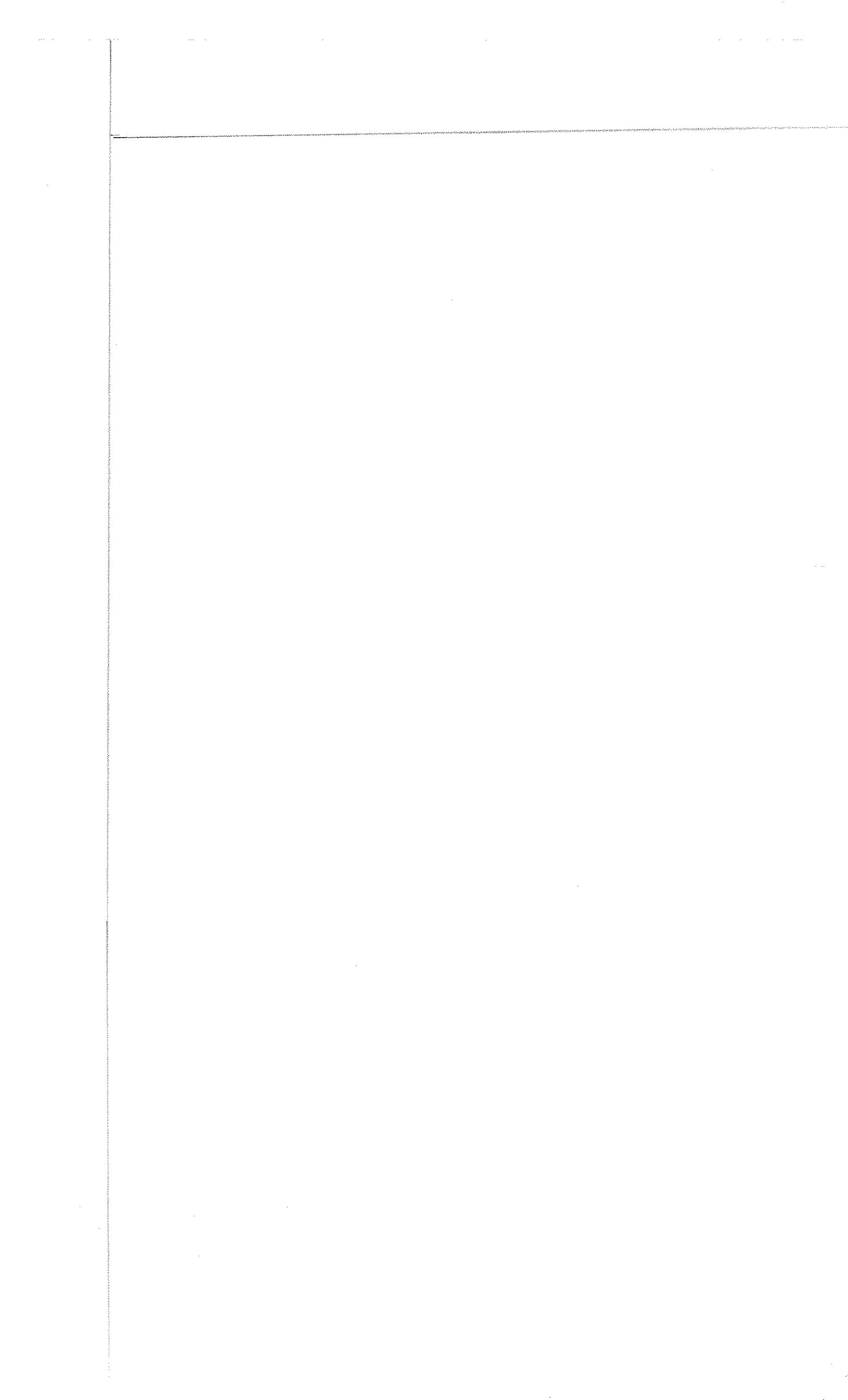
The mounting & working principle for profile turning in centre lathe. Here also a stylus moves along the template profile to replicate to one job.

Turret lathe-

- The turret lathes are modification of the engine lathe
- In a turret lathe tailstock of an engine lathe is replaced by a multiple face rotating tool holder or turret which may have four, five or six faces.



- The longitudinal & cross feed movement of the turret saddle & across slide are regulated by adjustable stops.
- The special characteristics of a turret lathe



Cutting Speed, Feed & Depth of Cut

Cutting -

- The Cutting speed of a tool is the speed at which the metal is removed by the tool from the job.
- The lathe speed is expressed in m/min

For example, in lathe work, a workpiece of Diameter D rotates at a speed N rpm then the cutting speed (V) is given by the relation

$$V = \frac{\pi DN}{1000} \text{ m/min}$$

2) Feed -

The feed of cutting tool in a lathe work is the distance the tool advances for each revolution. Increased feed reduces cutting time but increased feed greatly reduces the tool life. Coarser feed are used for roughing & finer feeds for finishing cuts.

3) Depth of cut -

Depth of cut (t) is the distance measured from the machined surface to the uncut surface of the workpiece. It is the thickness of the layer of metal removed in one cut or pass measured in direction perpendicular to the machine surface.

Depth of Cut is expressed

$$t = \frac{D_1 - D_2}{2} \text{ mm.}$$

D_1 = Diameter of the workpiece surface before machining

D_2 = Diameter of the machined surface.

Tool signature

This numerical method of Identification has been standard by the American Standard Association (A.S.A). The Seven important elements comprise the signature of the Cutting tool & are always stated in the following order.

Rake Angle = 8°

Side Rake Angle = 14°

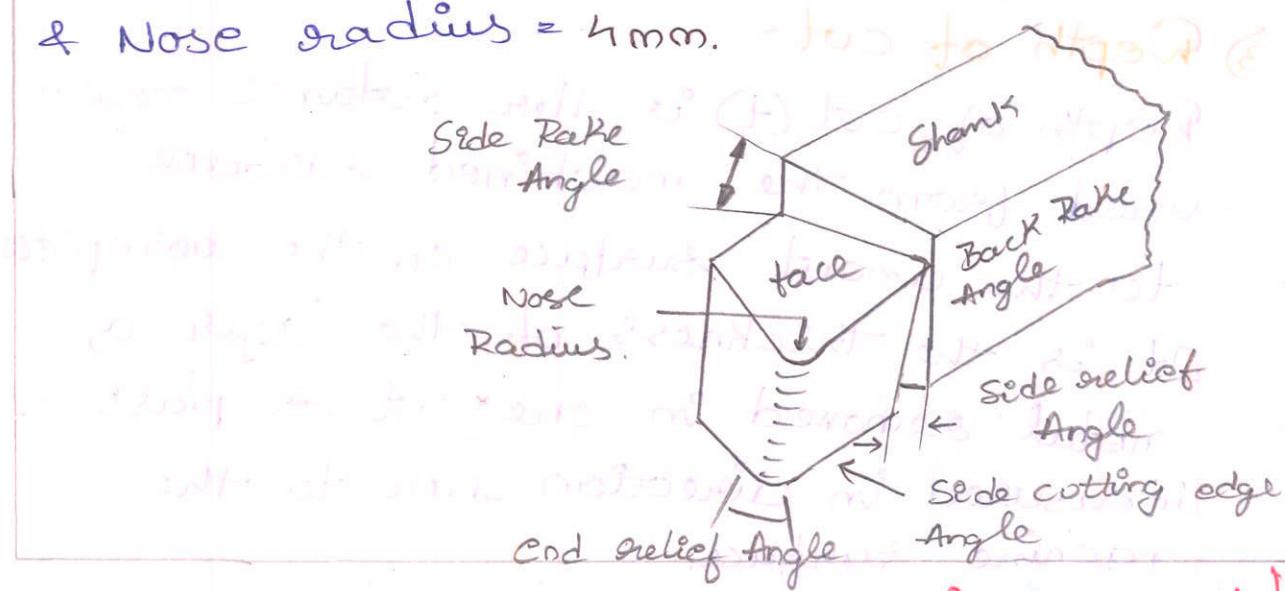
End Relief Angle = 6°

Side Relief Angle = 6°

End Cutting edge Angle = 6°

Side " " " " = 15°

& Nose radius = 4mm.



tools for drilling, reaming, threading, etc. All the operations are performed automatically.

The Swiss type automatic screw machines are used for machining slender parts of small diameter. They have a capacity to machine components of 2 to 25 mm diameter. They differ from the above machines in that the longitudinal feeds are obtained by moving the headstock with the bar instead of the tools.

Another useful form of single spindle automatics is the automatic screw machine, which is nothing but a fully automatic bar type turret lathe. They are employed for manufacturing screws, bolts and pins, etc. from bar stock. About 10 different tool can be mounted at a time. The collet, bar feed mechanism, cross-slide, and turret slides, etc. are controlled and operated automatically.

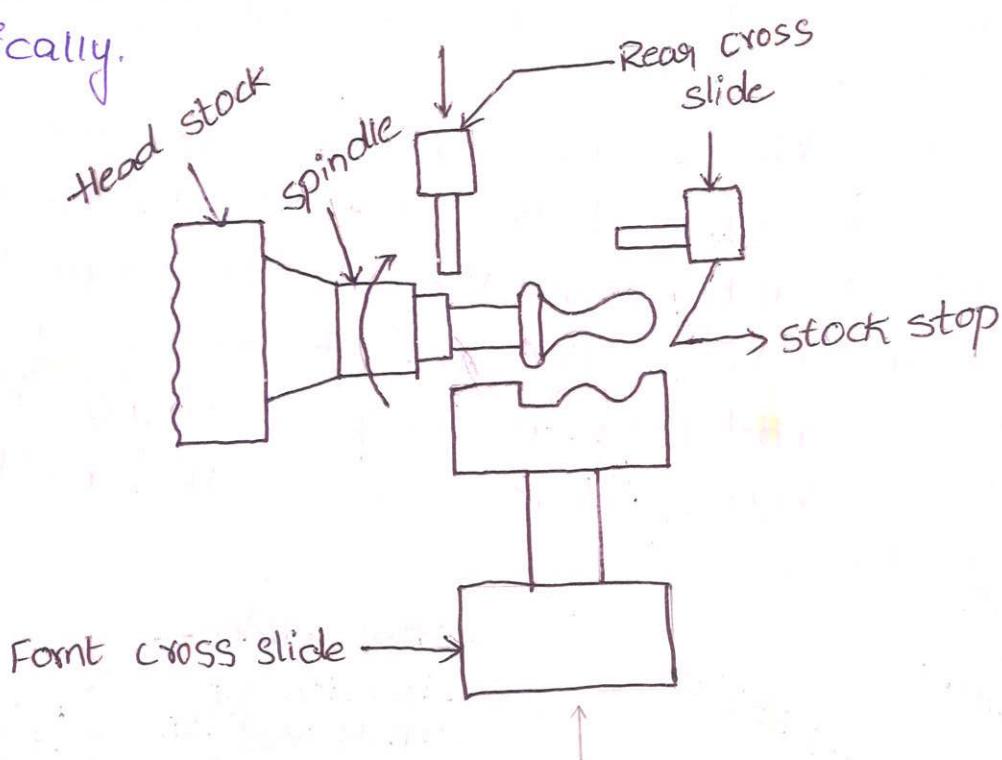
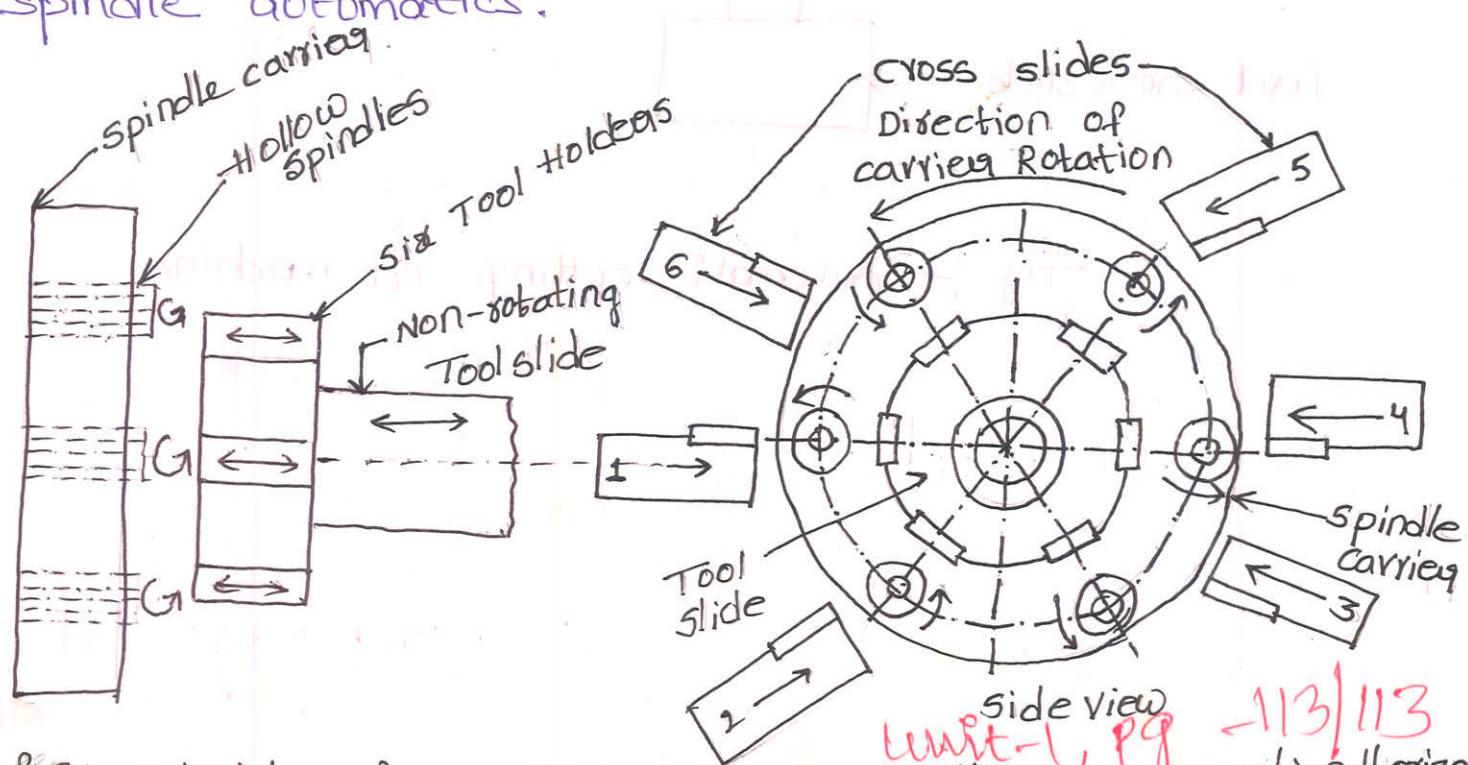


fig :- Automatic cutting - off machine.

* Multi-spindle automatics

These machines are the improved types of single spindle automatics. They are made to have 2 to 8 spindles but 4 and 6 spindles are very commonly used. The spindles are arranged in a carrier which is periodically indexed from position to position. The indexing takes place through 90° to 60° , depending upon whether there are 4 or 6 spindles. A gear is centrally mounted in the carrier, which drives all the spindles, which are free to rotate in the carrier. This gear rotates independent of the carrier. At each position, called the station, the work machined by tools from two sides; the cross-slide and the main or longitudinal slide. The spindle rotates at a constant speed in all the positions.

Operating parts of the machines are controlled by means of cams mounted on a cam shaft. However, it is important to note that the rate of production certainly increases with the use of multi-spindle machines, but the machining accuracy of single spindle automatic lathes is higher than that of the multi-spindle automatics.



-Fig:- principle of operation of a six-spindle progressive action horizontal

unit-1, pg -113/113