CHAPTER-1

CUTTING TOOLS AND CUTTING MATERIALS

INTRODUCTION

- Design of single point cutting tool is an important aspect of tool engineering. This unit deals with the design of tool shank, design of single point cutting tool, and various forces involved during machining of the workpiece.
- Strength and rigidity of tool is also taken into account while designing single point cutting tool.

Types of Tools

Single point cutting tool

One cutting tip is available

e.g. lathe machine tools, shaping tools, planning tools, etc.

Multi-point cutting tool

More than one tip is available

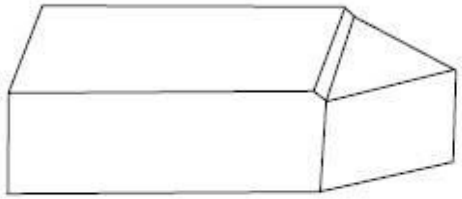
e.g. milling cutter, grinding wheel, drill, etc.

Types of Cutting Tools

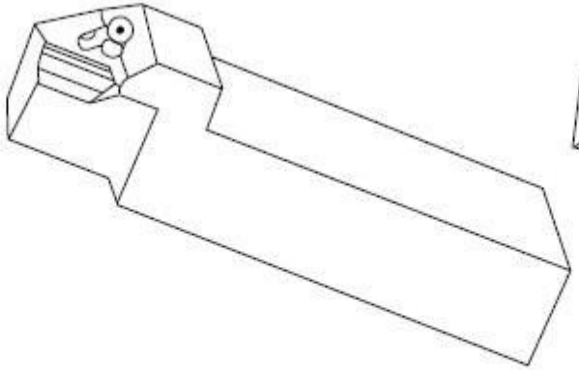
- Cutting tools performs the main machining operation.
- It is a body having teeth or cutting edges on it.
- They comprise of single point cutting tool or multipoint cutting tools.

Single point cutting tool : This type of tool has a effective cutting edge and removes excess material from the workpeice along the cutting edge.

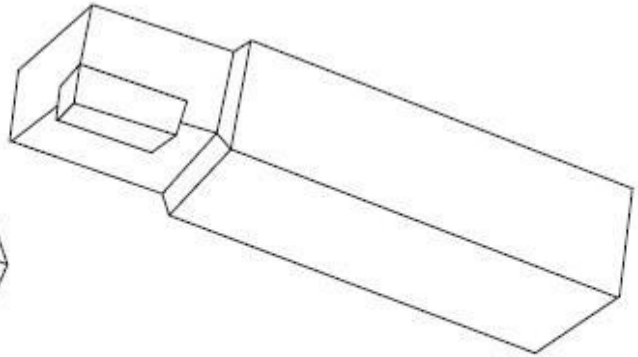
- These tools may be left-handed or right-handed.
- Again single point cutting tools classified as solid type and the tipped tool.
- Brazed tools are generally known as tool bits and are used in tool holders.
- The tipped type of tool is made from a good shank steel on which is mounted a tip of cutting tool material.
- Tip may be made of high speed steel or cemented carbide.
- Different types of carbide tips are generally used on tipped tool.



Solid type of single point cutting tool



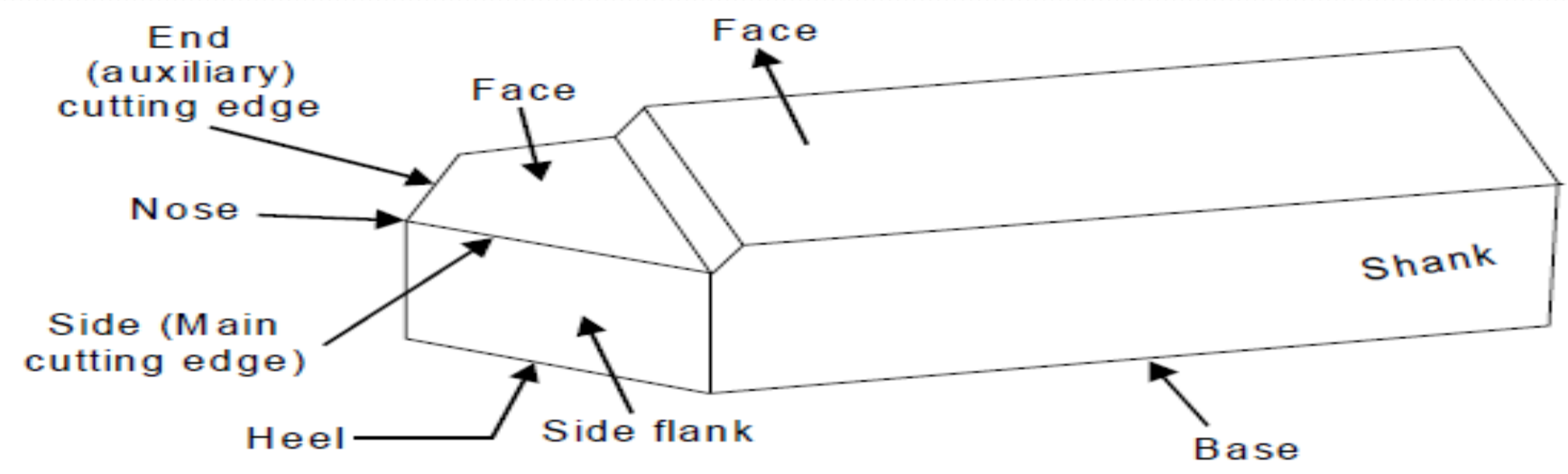
Tipped type single point cutting tool



Index-able insert type single point cutting tool

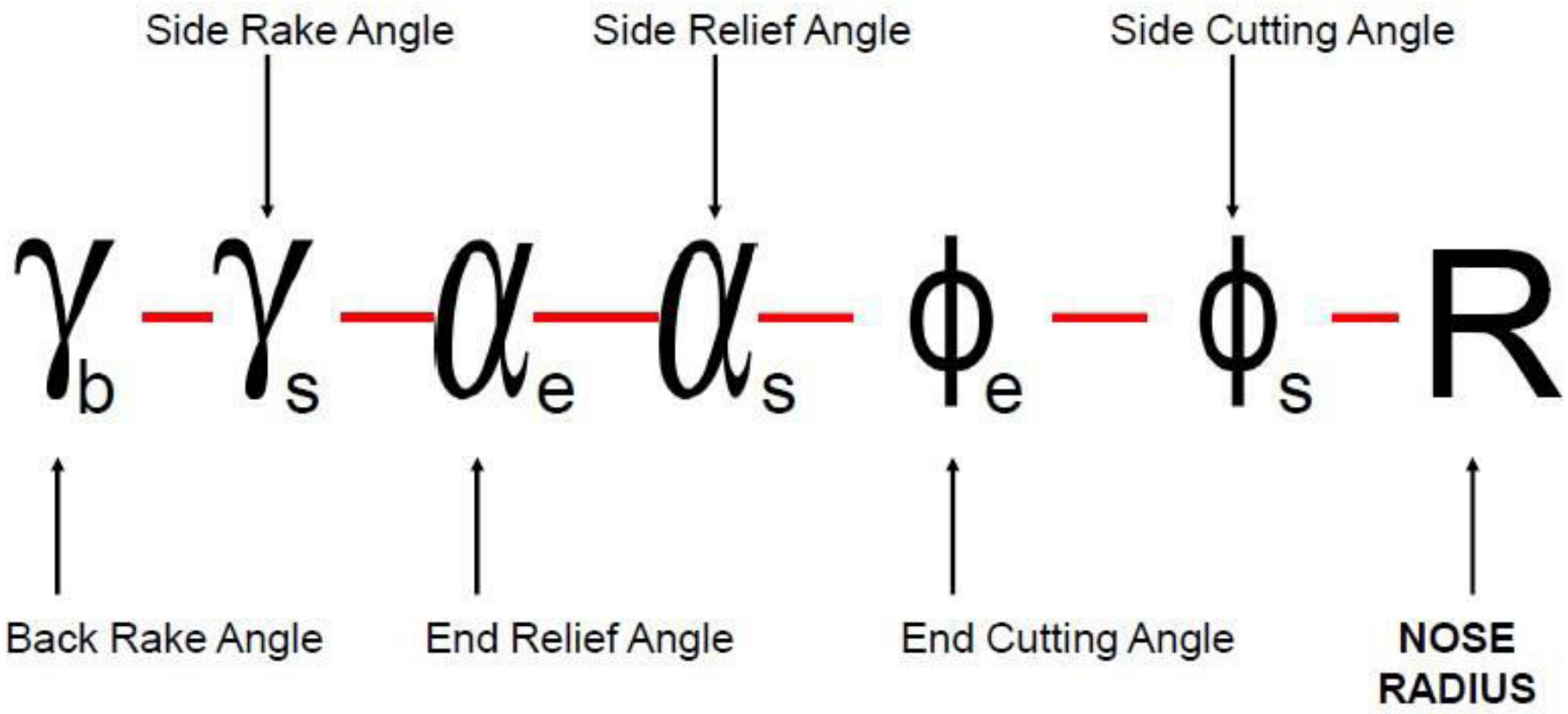
Geometry comprises mainly of nose, rake face of the tool, flank, heel and shank etc.

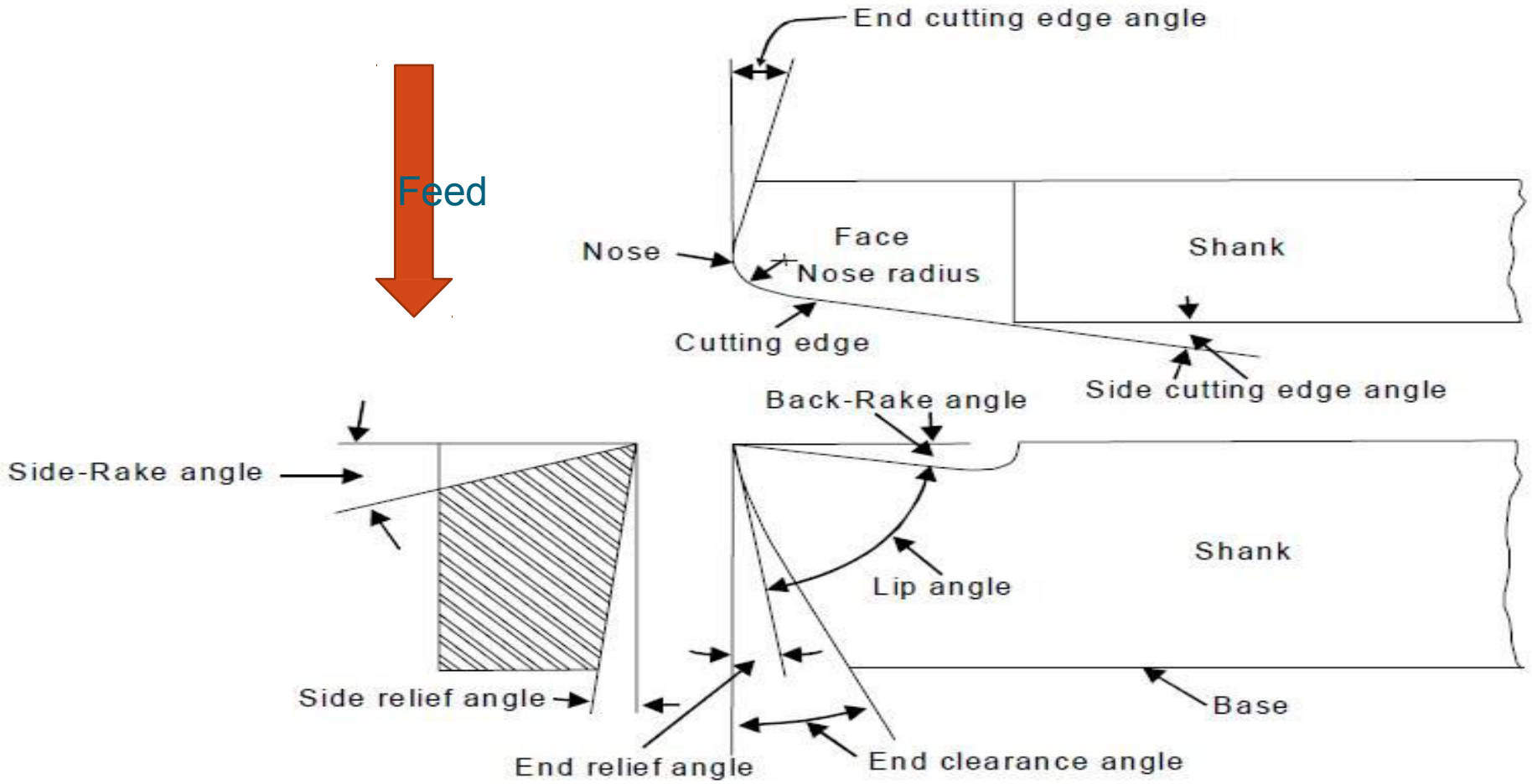
The nose is shaped as conical with different angles.



Single point Cutting Tool nomenclature

ASME (American Society of Mechanical Engineers) & ASA (American Standards Association) designates single point cutting tool as





Back rake angle (α_b)

It is the angle between the face of the tool and a line parallel with base of the tool measured in a perpendicular plane through the side cutting edge.

This angle helps in removing the chips away from the work piece.

- It is the angle by which the face of tool is inclined side ways.

- This angle of tool determines the thickness of the tool behind the cutting edge.

Side rake angle (α_s)

- It is provided on tool to provide clearance between work piece and tool so as to prevent the rubbing of work- piece with end flank of tool.

End relief angle

It is defined as the angle between the portion of the end flank immediately below the cutting edge and a line perpendicular to the base of the tool, measured at right angles to the flank.

It is the angle that allows the tool to cut without rubbing on the work- piece.

Side relief angle

It is the angle that prevents the interference as the tool enters the material.

It is the angle between the portion of the side flank immediately below the side edge and a line perpendicular to the base of the tool measured at right angles to the side.

End cutting edge angle

- It is the angle between the end cutting edge and a line perpendicular to the shank of the tool.

- It provides clearance between tool cutting edge and work piece.

Side cutting edge angle

- It is the angle between straight cutting edge on the side of tool and the side of the shank.

- It is also known as lead angle.

- It is responsible for turning the chip away from the finished surface.

Tool Signature

Convenient way to specify tool angles by use of a standardized abbreviated system is known as tool signature or tool nomenclature.

The seven elements that comprise the signature of a single point cutting tool can be stated in the following order:

Tool signature 0-7-6-8-15-16-0.8

1. Back rake angle (0°)
2. Side rake angle (7°)
3. End relief angle (6°)
4. Side relief angle (8°)
5. End cutting edge angle (15°)
6. Side cutting edge angle (16°)
7. Nose radius (0.8 mm)

Properties of cutting tool materials

1. **Red hardness or Hot Hardness:** It is the ability of a material to retain its hardness at high temperature
2. **Wear resistance:** It enables the cutting tool to retain its shape and cutting efficiency
3. **Toughness:** It relates to the ability of a material to resist shock or impact loads associated with interrupted cuts

Classification tool materials

1. Carbon-Tool Steels:

- 0.6-1.5% carbon + little amount of Mn, Si, Cr, V to increase hardness.
- Low carbon varieties possess good toughness & shock resistance.
- High carbon varieties possess good abrasion resistance

2. High Speed Steels (HSS):

- High carbon+ little amount Tungsten, Molybdenum, Cr, V & cobalt to increase hardness, toughness and wear résistance.
- High operating temperatures upto 600^{o}C.

- Two types of HSS i.e, is T-type and M-Type
- Vanadium increases abrasion resistance but higher percentage will decreases grindability.
- Chromium increases hardenability
- Cobalt is added to HSS to increase red hardness.

3. Cast Cobalt Base Alloys:

- It is a combination of W, Cr, carbon and Cobalt which form an alloy with red hardness, wear resistance and toughness. It is prepare by casting.
- Used for machining Cast iron, alloy steels, non-ferrous metals and super alloys

4. Cemented Carbides:

- These are carbides of W, Titanium and tantalum with small amount of cobalt produced by means of powder metallurgy route.
- Two types i.e, Straight Tungsten Carbide Cobalt Grade and Alloyed Tungsten Carbide Grade

Alloyed Tungsten Carbide Grade: All grades of steel at 3 to 4 times more speeds than HSS

5. Ceramic Tools:

Straight Tungsten Carbide Cobalt Grade : Cast iron, non ferrous alloys, plastics, wood, glass etc.

- Aluminium Oxide, Silicon Carbide, Boron Carbide, Titanium Carbide, Titanium Boride
- High speed, longer tool life, superior surface finish, No coolant is required.

6. Diamond Tools:

- More abrasion resistance
- Used for turning grinding wheels
- Used to produce mirror surface finish.
- Diamond abrassive belts are used to produce TV screens
- Poly crystalline diamond inserts are brazed into cutting edges of circular saws for cutting construction materials like concrete, refractories, stone etc.

CHAPTER-2

LATHE MACHINE

Lathe Machines

Lathe is a machine, which removes the metal from a piece of work to the required shape &size

- Lathe machines or Turning machines

1. Cylindrical Surfaces
2. Flat Surfaces

Lathe Operations:

(1) Facing

(2) Turning

(3) Taper turning

(4) Chamfering

(5) Knurling

(6) Grooving or Necking

(7) Threading

(8) Parting

Other Operations:

Drilling

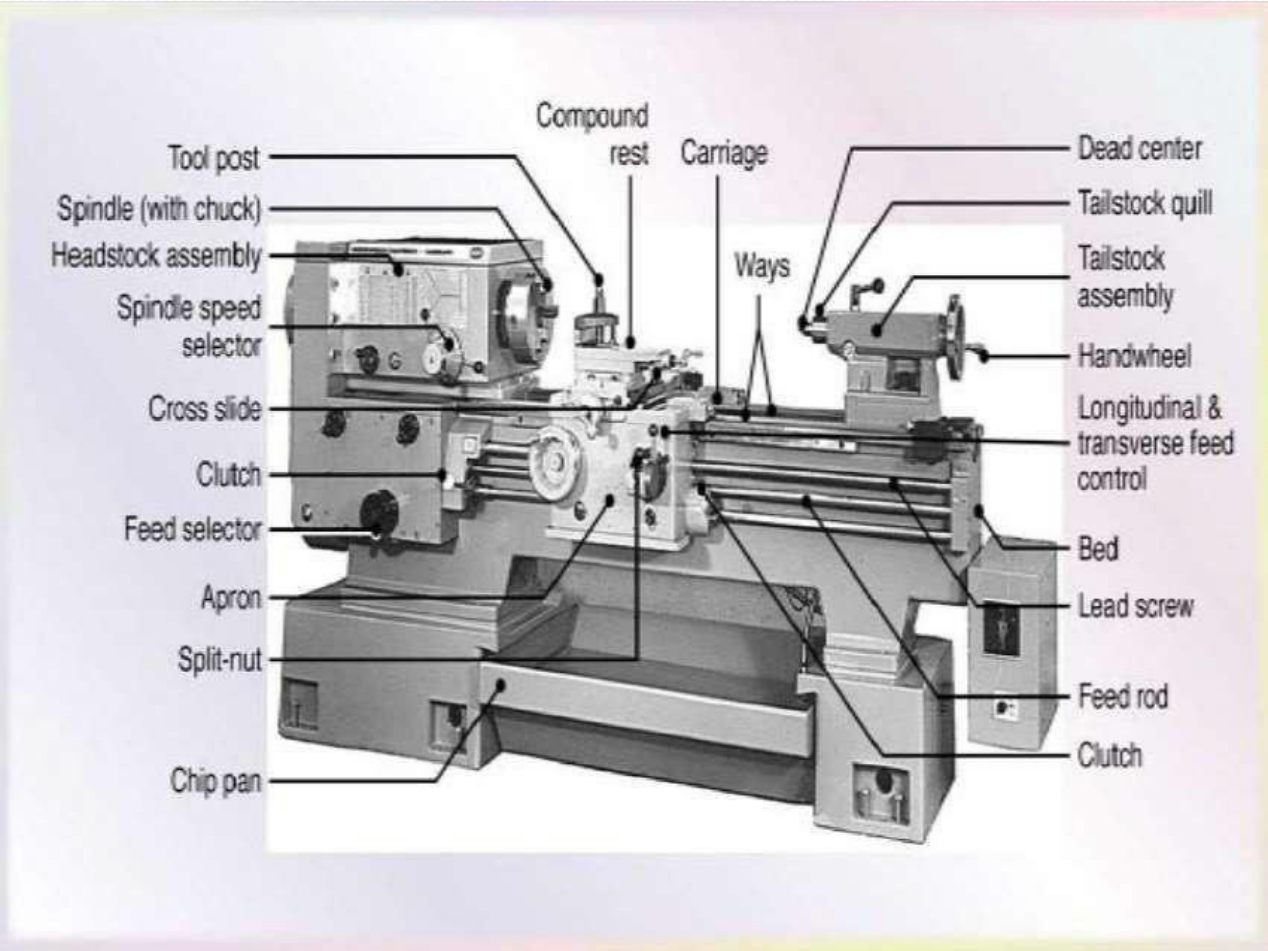
Boring

Reaming

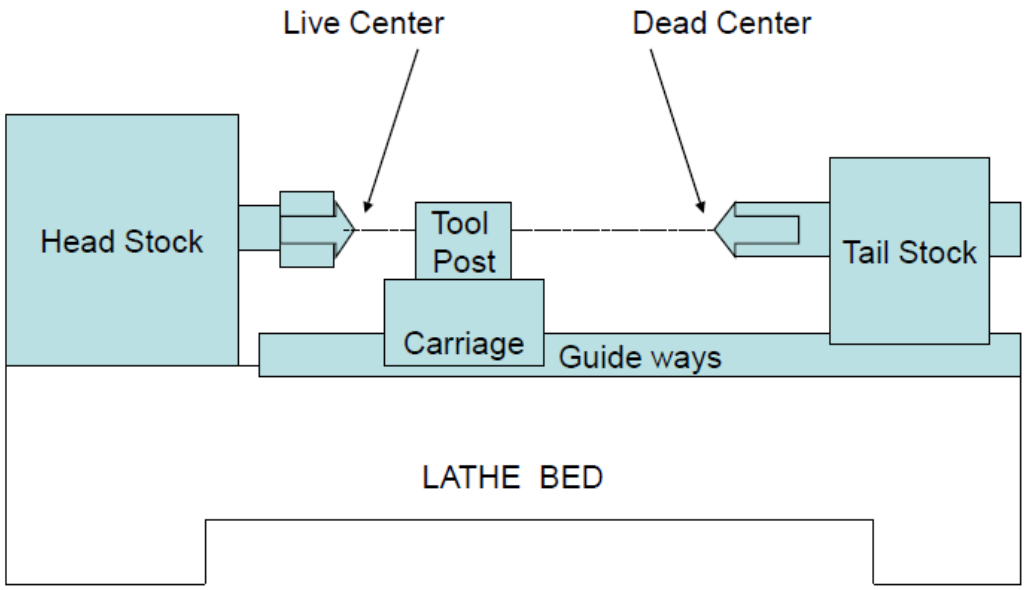
Milling

Grinding

Pictorial View of Lathe (with various parts marked)

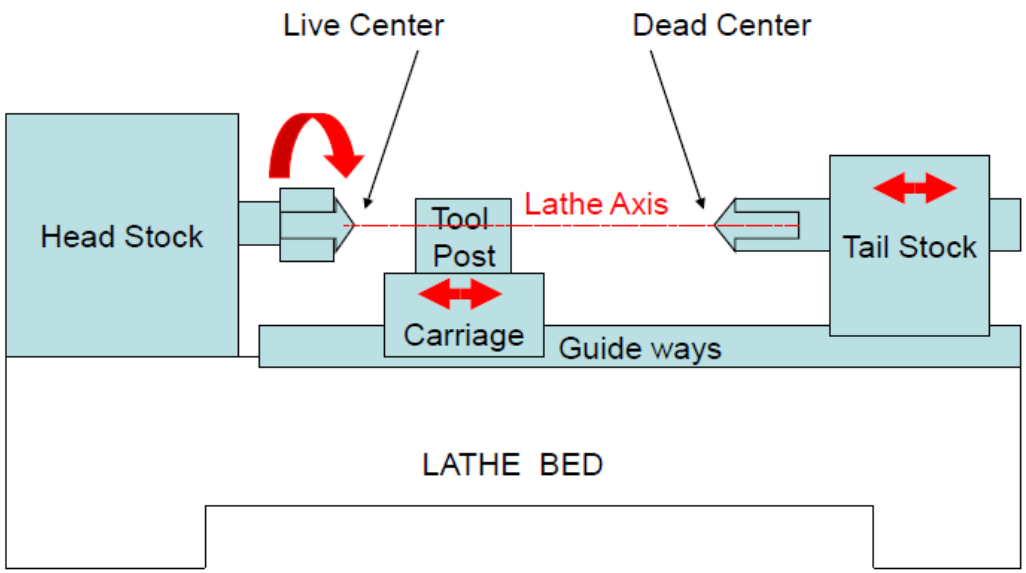


Lathe – Turning Machine

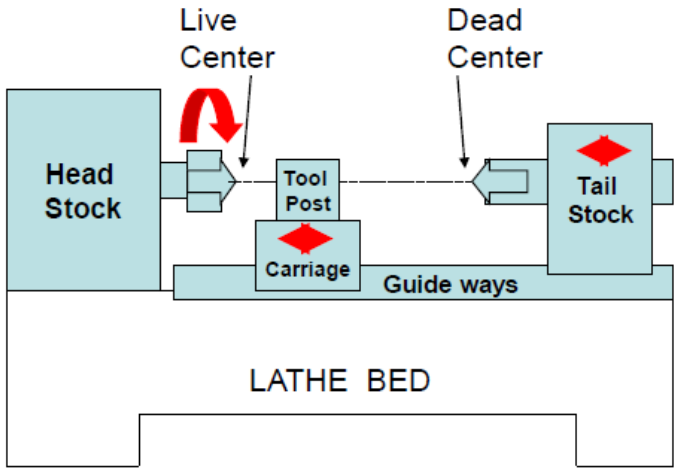


Center: A tapered metal part with a pointed end ant it supports the work piece as it turns between the centres.

Lathe – Turning Machine



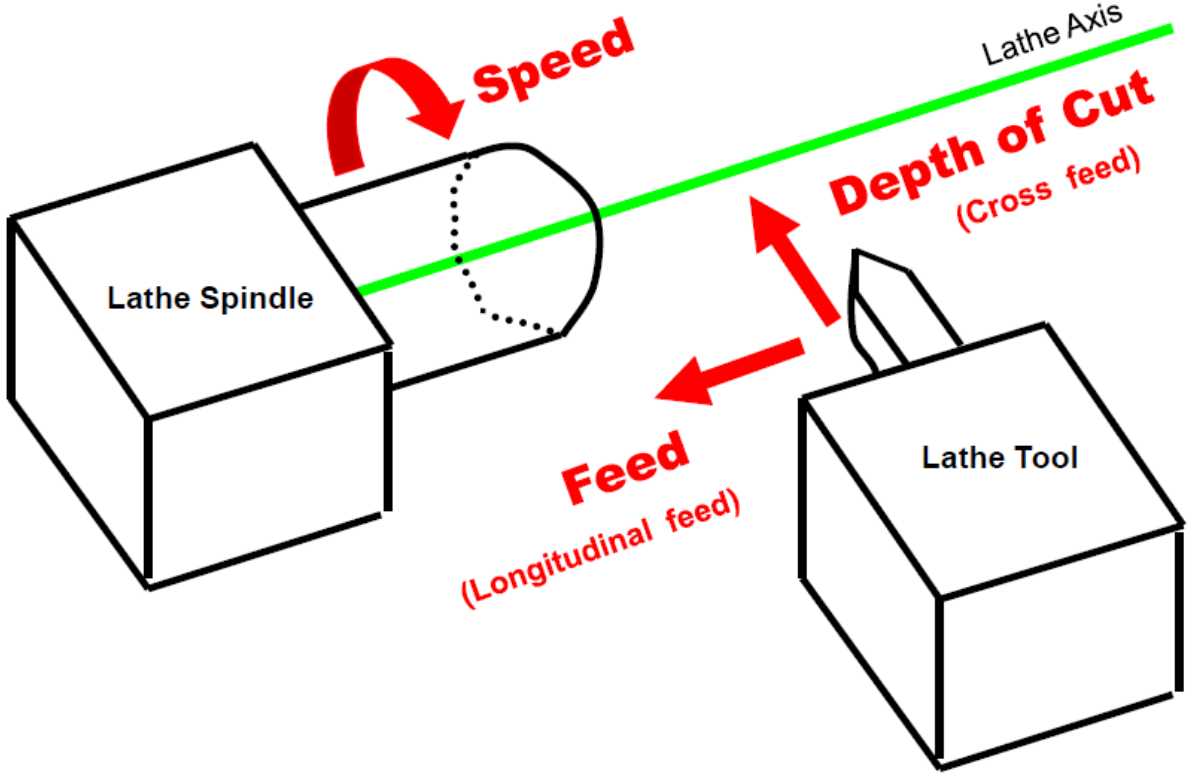
Lathe – Turning Machine



Main Parts of a LATHE

1. Lathe Bed
2. Guide ways
3. Head Stock
4. Tail Stock
5. Carriage
6. Tool Post
7. Feed Mechanism
8. Thread Cutting Mechanism

Lathe – Turning Machine



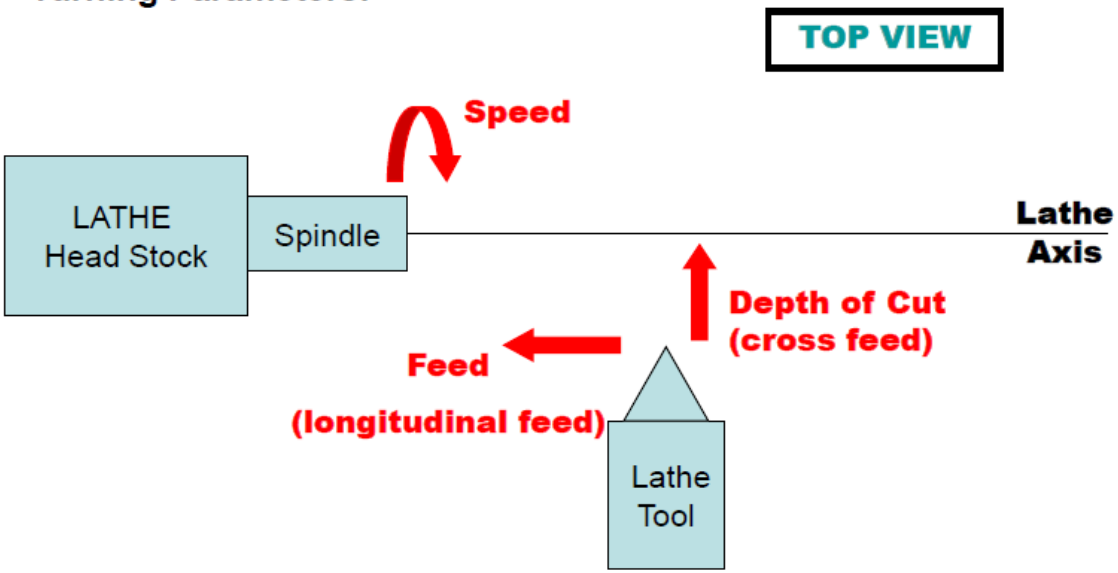
Lathe – Turning Machine

Turning Parameters

1. Speed
2. Feed
   - Longitudinal Feed
   - Cross Feed
3. Depth of Cut

Lathe – Turning Machine

Turning Parameters:

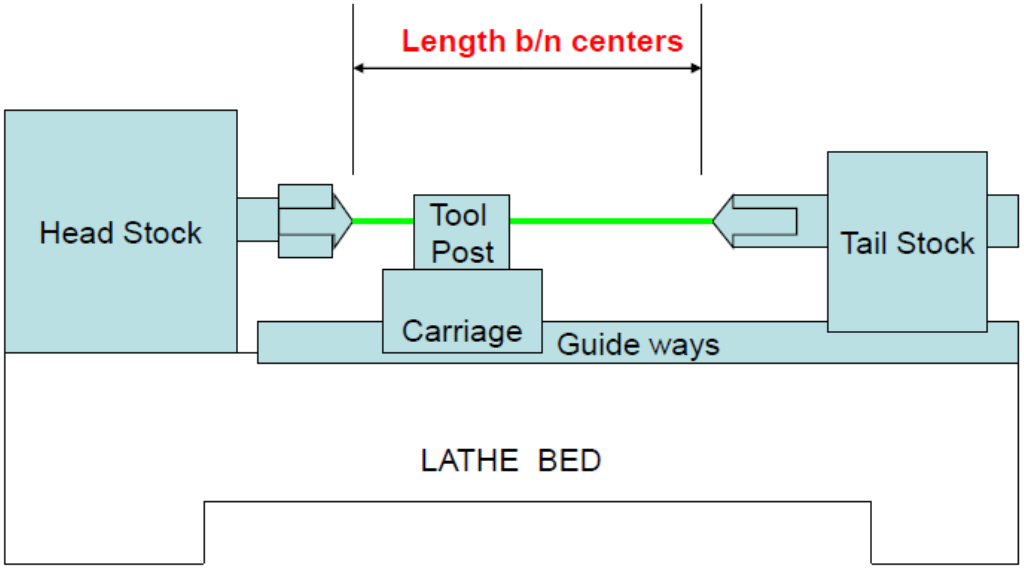


Lathe Specifications

Main Specifications of a LATHE

1. Length between the centers
2. Height of the centers
3. Swing diameter over the bed
4. Swing diameter over the carriage
5. Maximum bar diameter

Lathe – Turning Machine



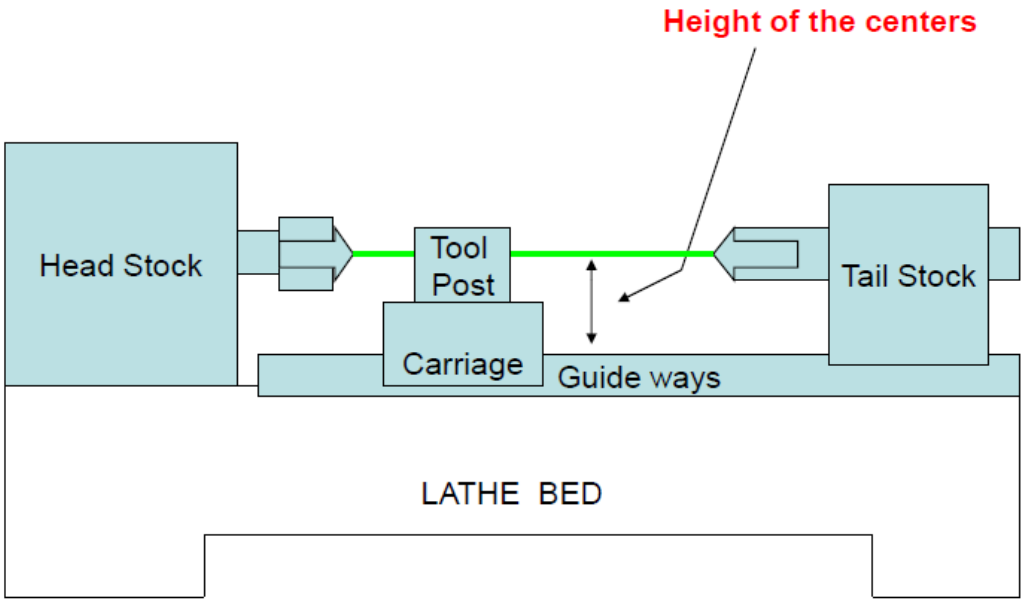
Lathe Specifications

Main Specifications of a LATHE

1. Length between the centers

"It is the measure of the maximum length of the work piece that can be fixed between the lathe centers".

Lathe – Turning Machine



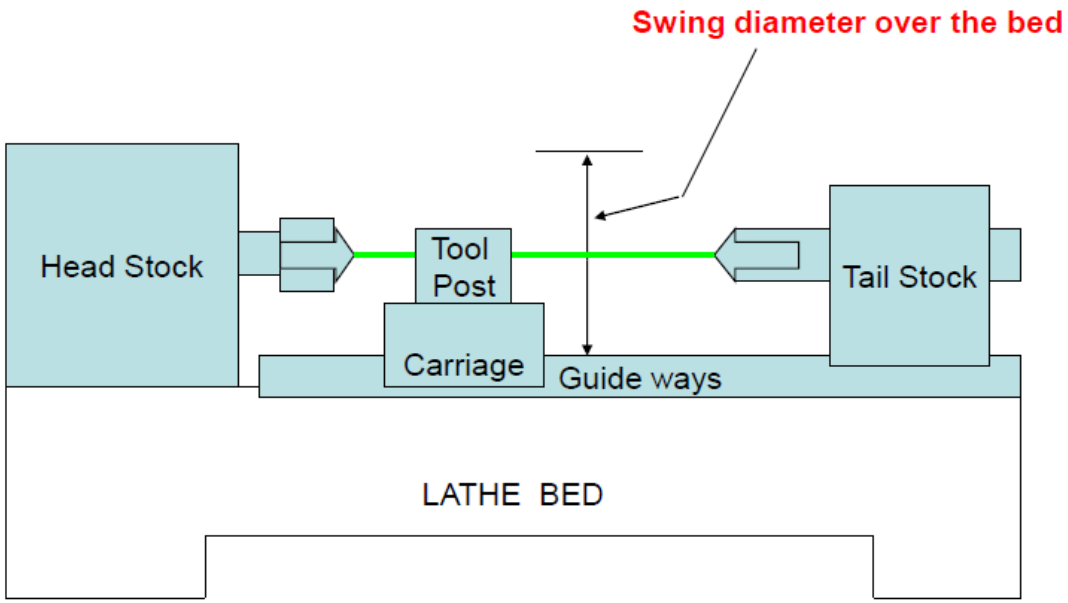
Lathe Specifications

Main Specifications of a LATHE

2. Height of the centers

"It is the distance between the lathe axis and the lathe bed".

Lathe – Turning Machine



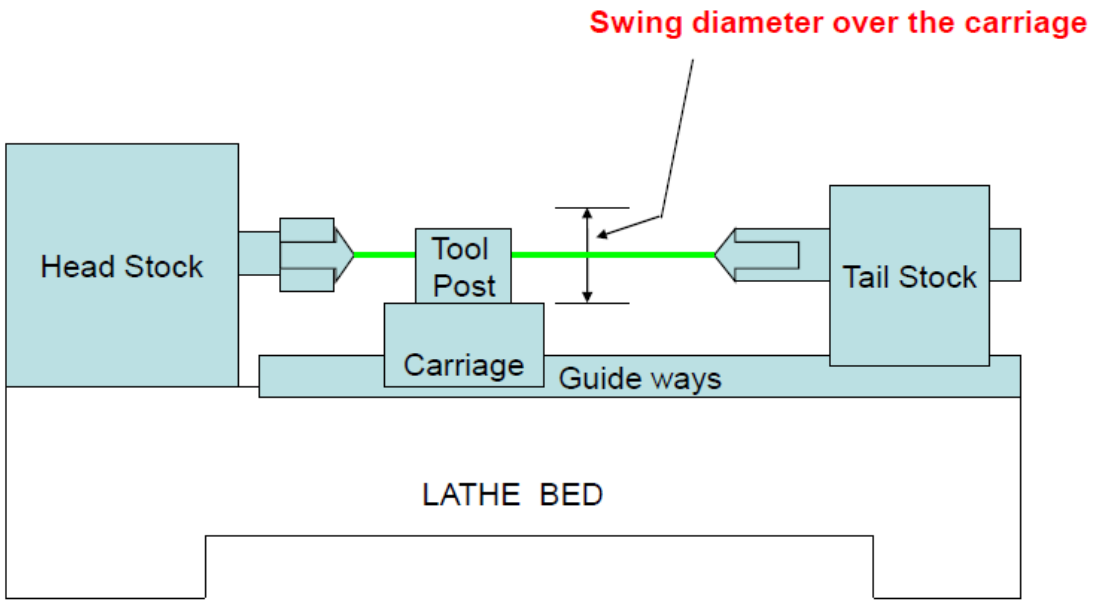
Lathe Specifications

Main Specifications of a LATHE

3. Swing diameter over the bed

"It is the maximum diameter of the work piece that can be turned on a lathe without hitting the lathe bed".

Lathe – Turning Machine



Lathe Specifications

Main Specifications of a LATHE

4. Swing diameter over the carriage

"It is the maximum diameter of the work piece that can be turned on a lathe without hitting the carriage".

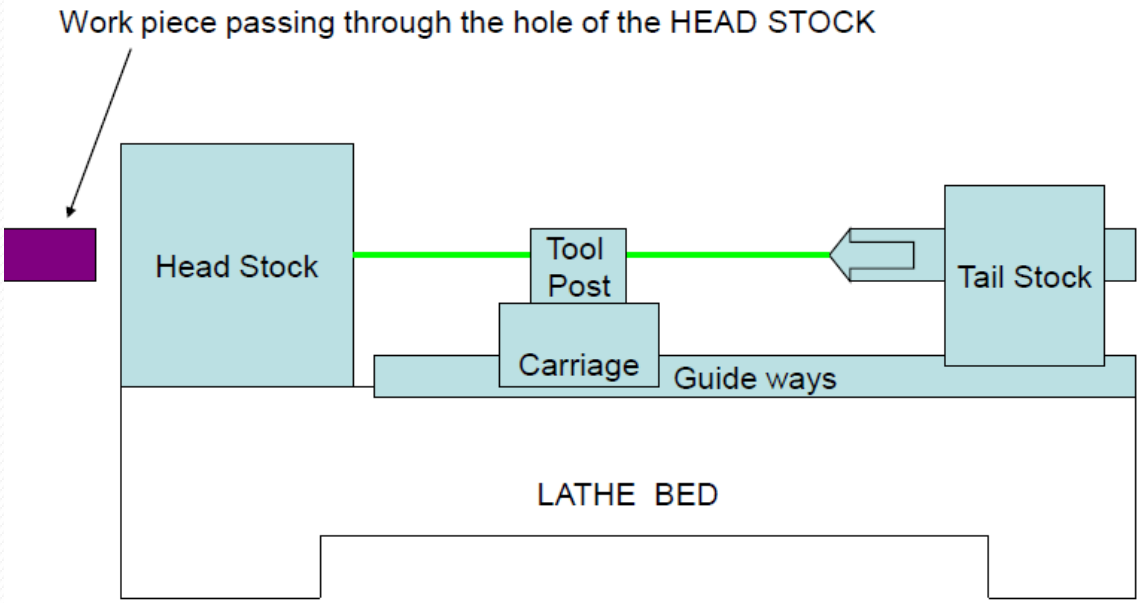
Lathe Specifications

Main Specifications of a LATHE

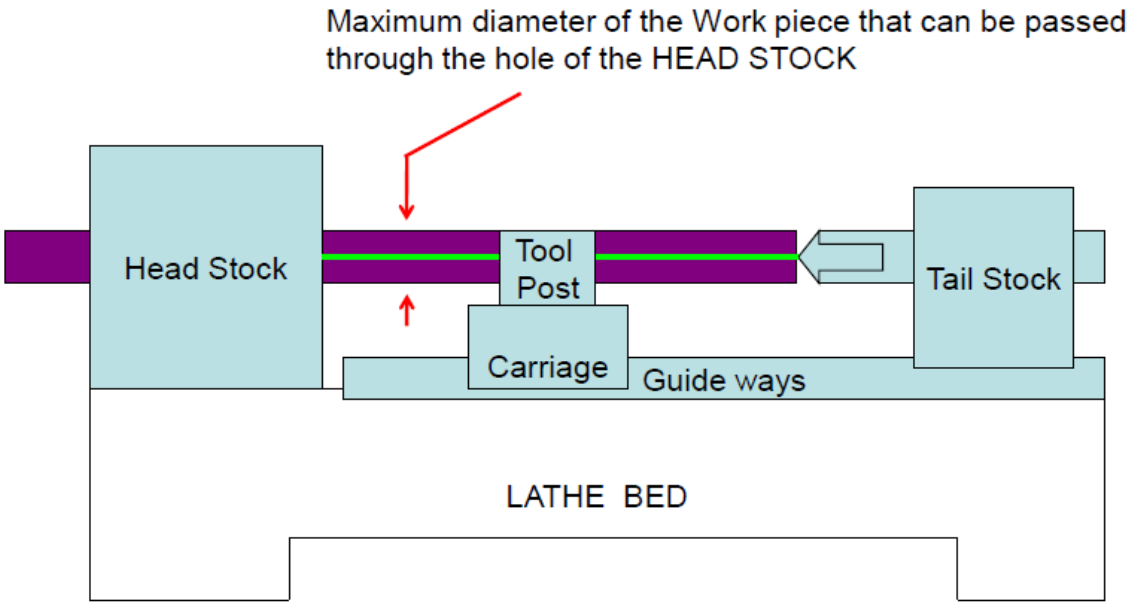
5. Maximum bar diameter

"It is the maximum diameter of the work piece that can be passed through the hole in the head stock".

Lathe – Turning Machine



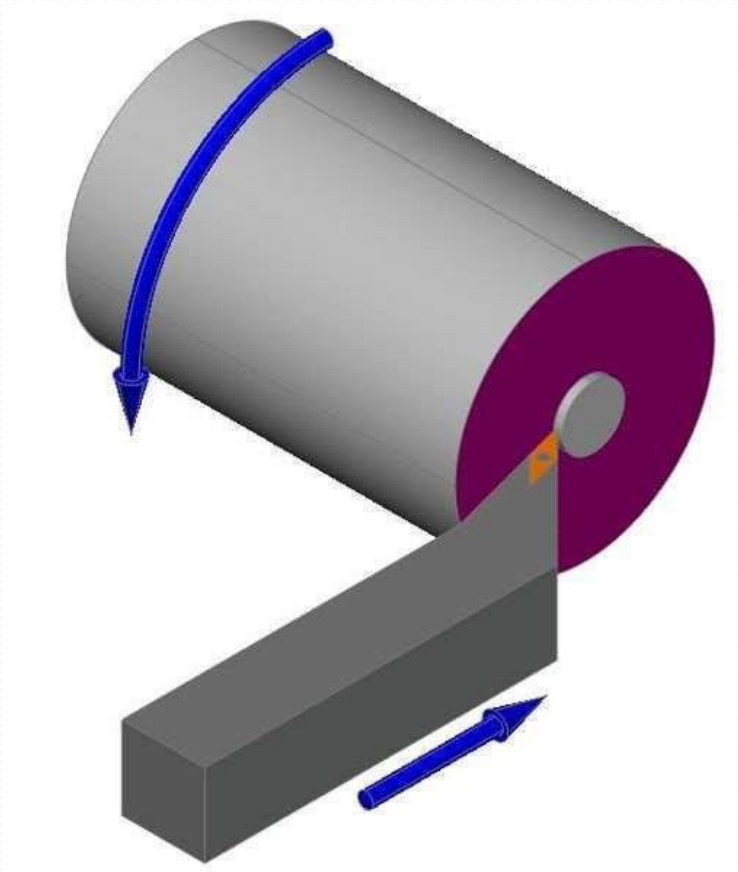
Lathe – Turning Machine



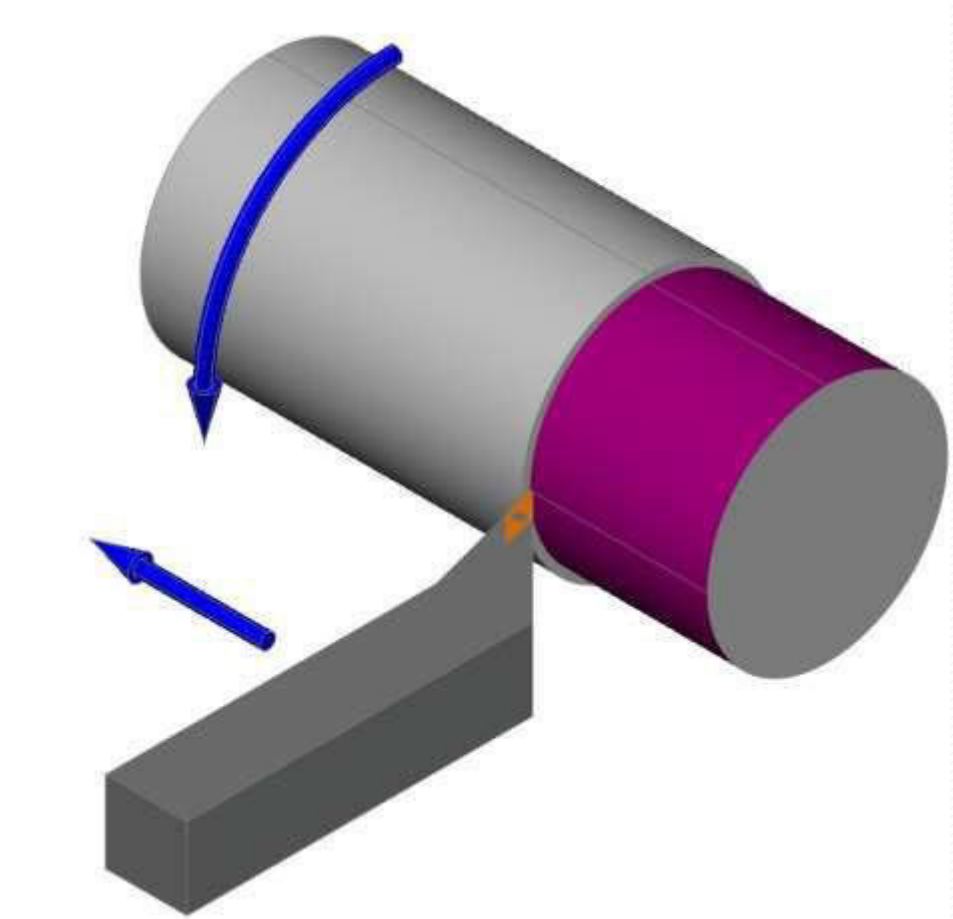
Lathe Operations

- Straight Turning
- Taper Turning
- Profiling
- Turning & External grooving
- Facing
- Face Grooving
- Cutting with form tool
- Boring & Internal grooving
- Drilling
- Cutting off *or* Parting off
- Threading
- Knurling

- **Facing**: To produce a flat surface at the end of the part (i.e. at the face)

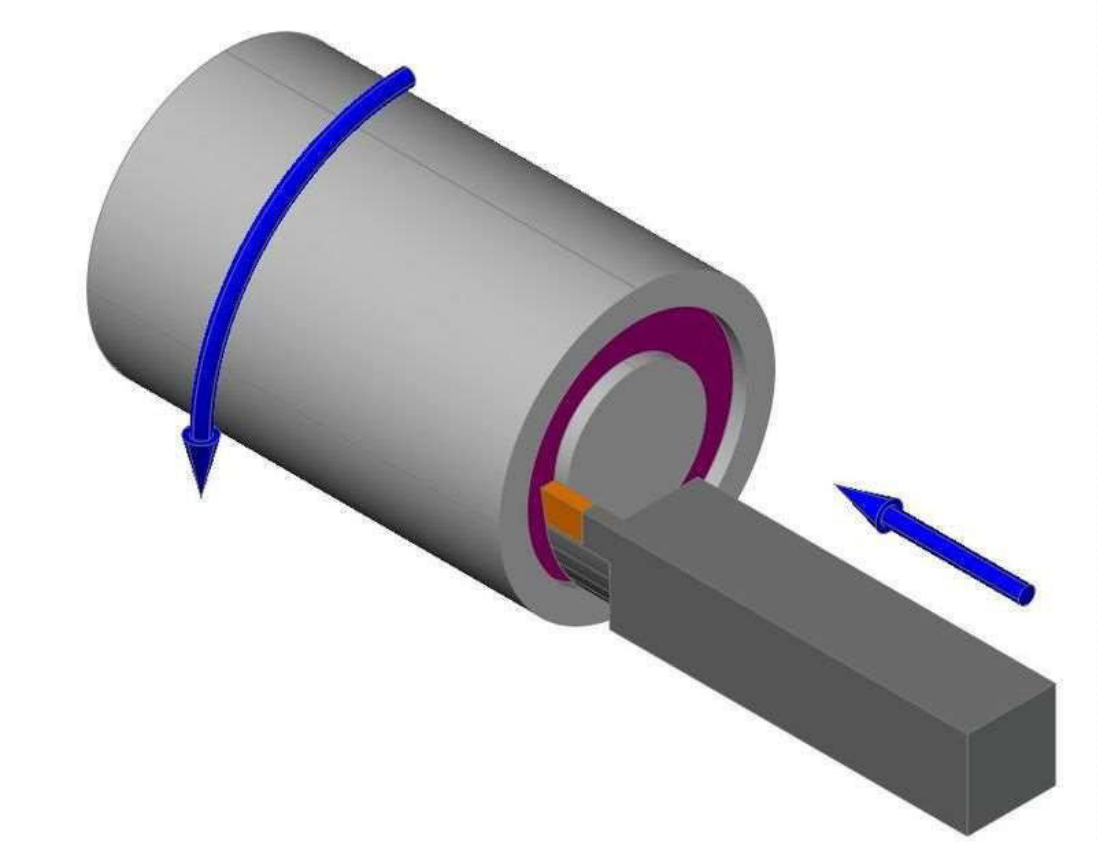


- **Turning:** To produce cylindrical or conical surfaces

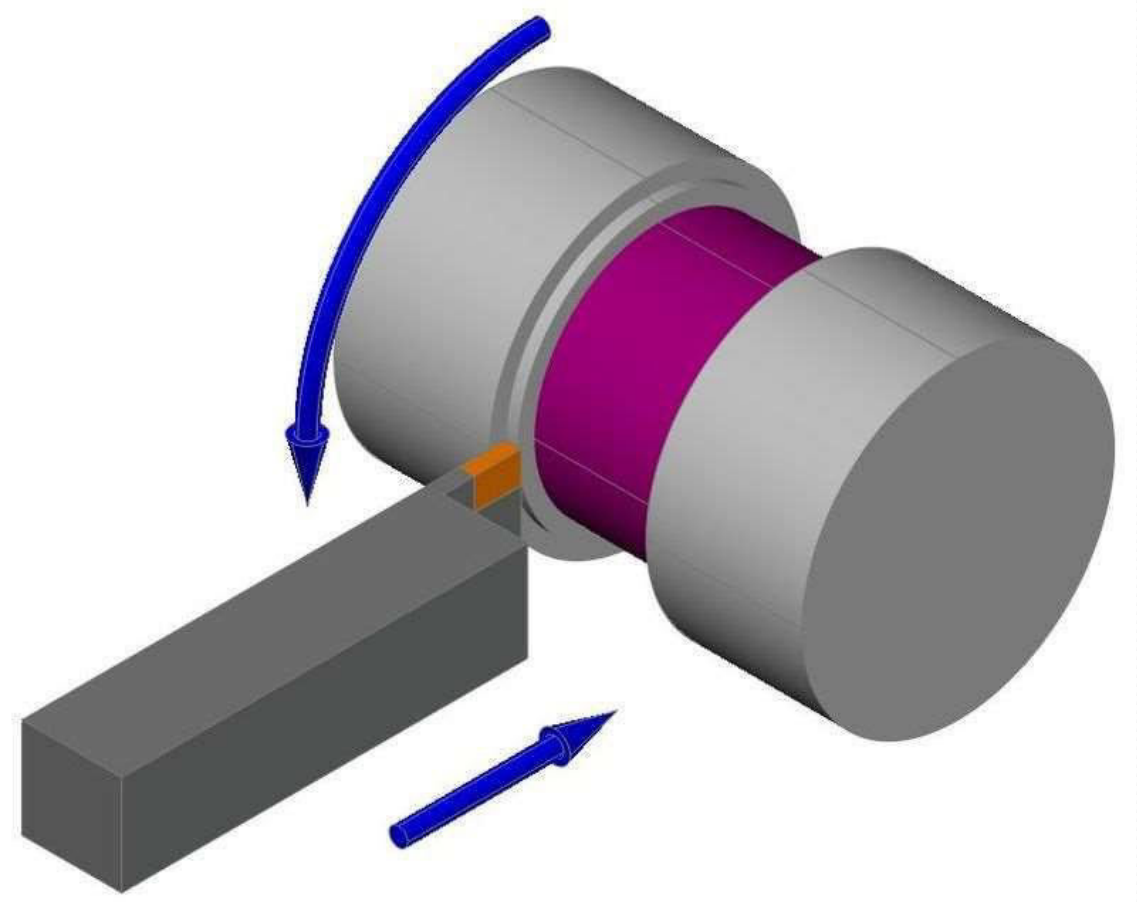


- **Knurling:** To produce cylindrical surfaces with some surface roughness

Face grooving: T o cut groove on face of the job



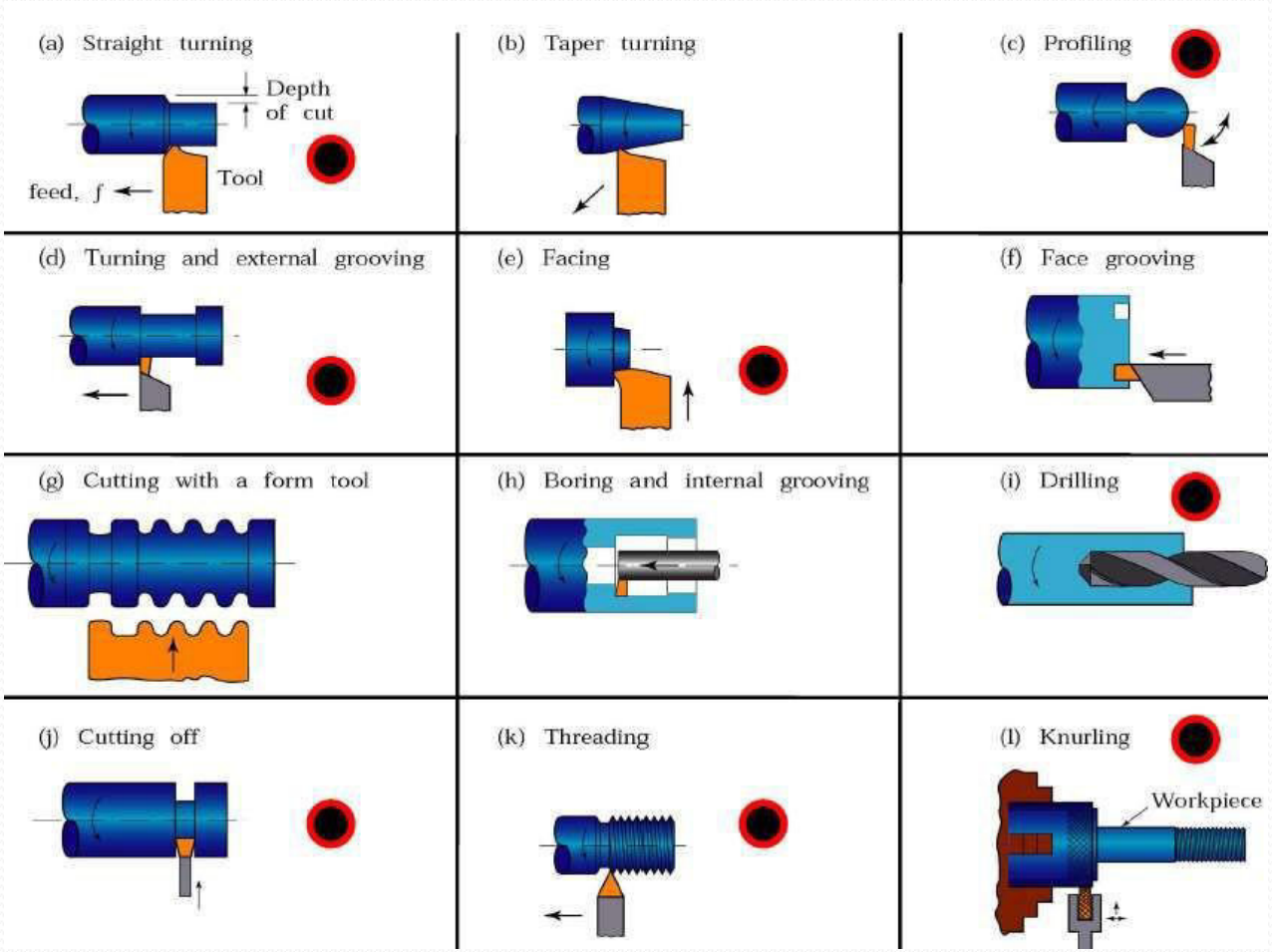
Grooving or Necking: To reduce the diameter at desired portion



Lathe Operations

- **Turning:** To produce cylindrical or conical surfaces
- **Facing**: To produce a flat surface at the end of the part (i.e. at the face)
- **Drilling:** To produce a hole by fixing a drill bit and drill chuck assembly in the tailstock
- **Boring:** To enlarge a hole made by a drilling process
- **Threading:** To produce external or internal threads
- **Knurling:** To produce cylindrical surfaces with some surface roughness

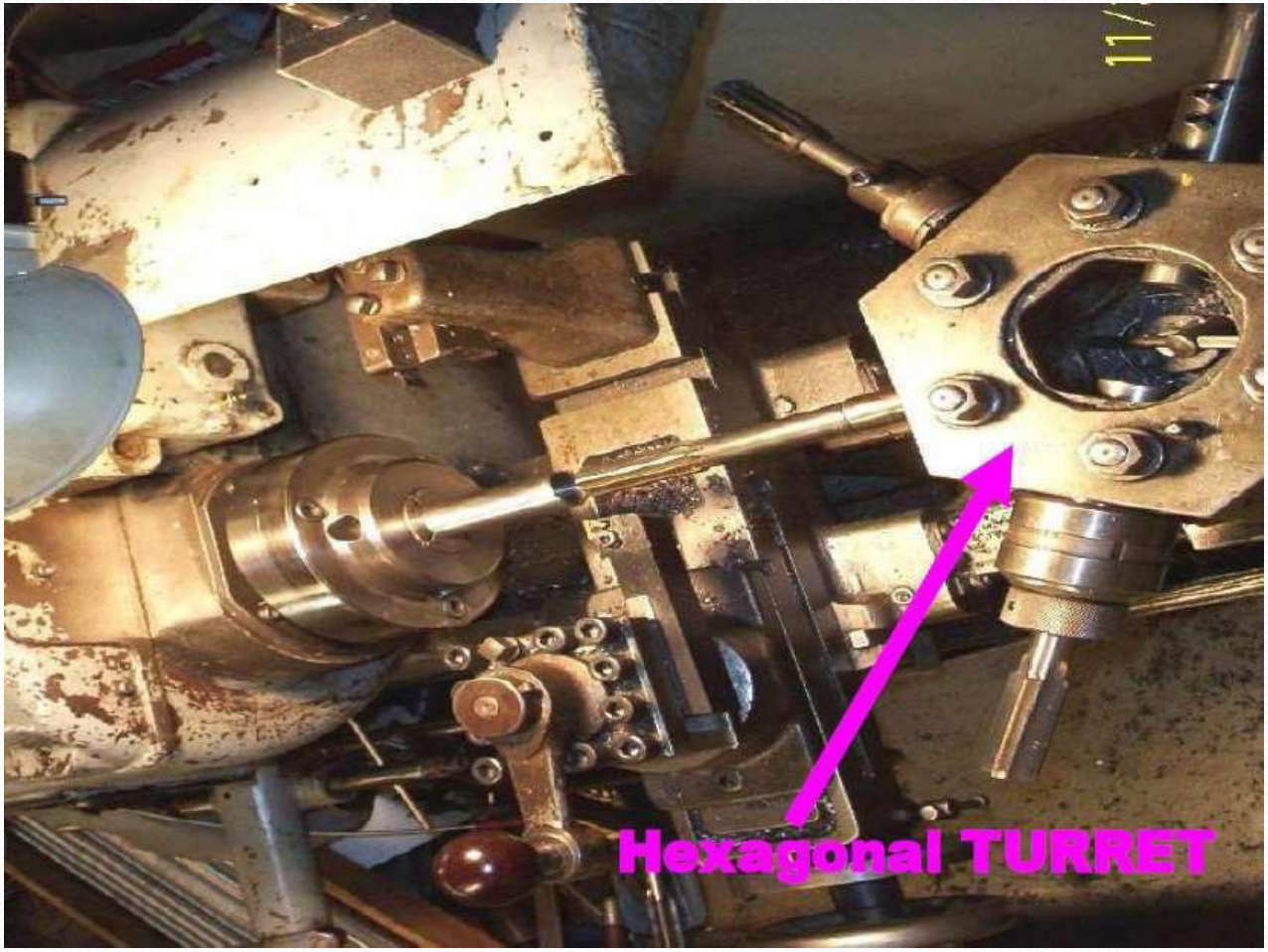
Schematic Representation of Various Lathe Operations



Lathe – Turning Machine

- Types of Lathe:
    1. **Speed Lathe**
    2. **Centre lathe or Engine Lathe**
    3. **Bench lathe**
    4. **Tool room lathe**
    5. **Capstan & Turret Lathe**
    6. **Special purpose lathe**
    7. **Micro Lathe**
    8. **Automatic lathe**

Turret Lathe



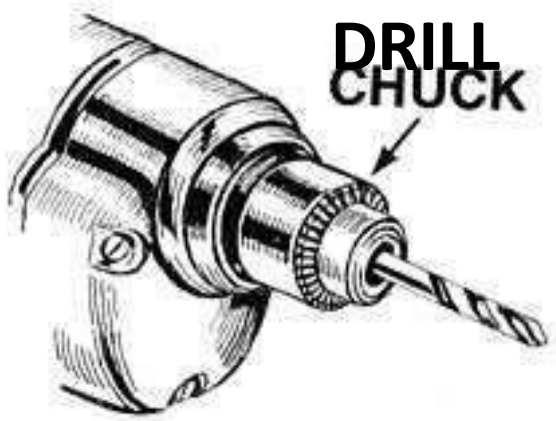
Work-Holding Devices

- Chucks
- Mandrels
- Rests
- Centres

CHUCKS

Work Holding Devices

- CHUCKS
  - 3-Jaw self centering
  - 4-Jaw self centering
  - 4-Jaw Independent
  - 4-Jaw Combination (self & Independent)
  - Magnetic
  - Face plates
- MANDRELS
- RESTS
- CENTERS

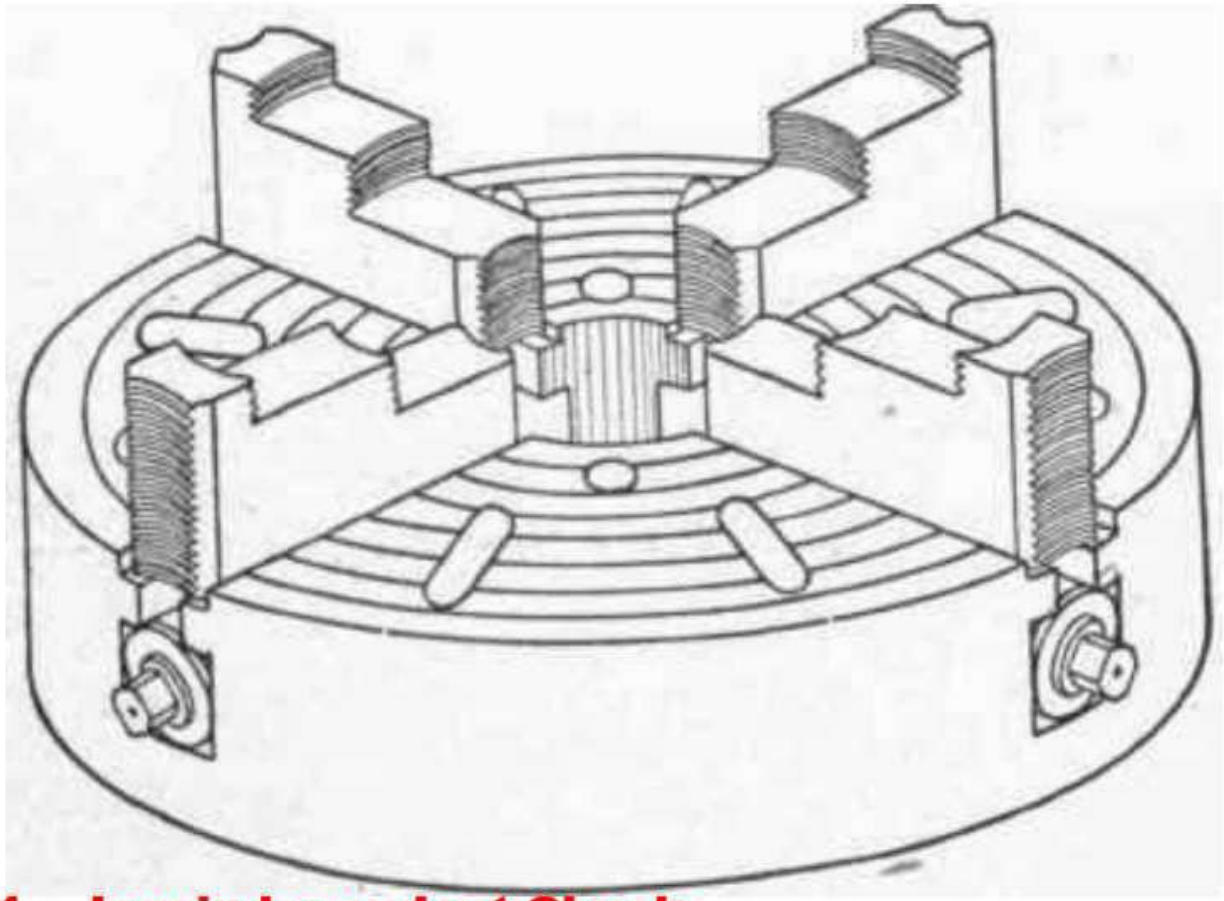


Chuck: Type of clamp used to hold an object

3 – Jaw Self centering Chuck

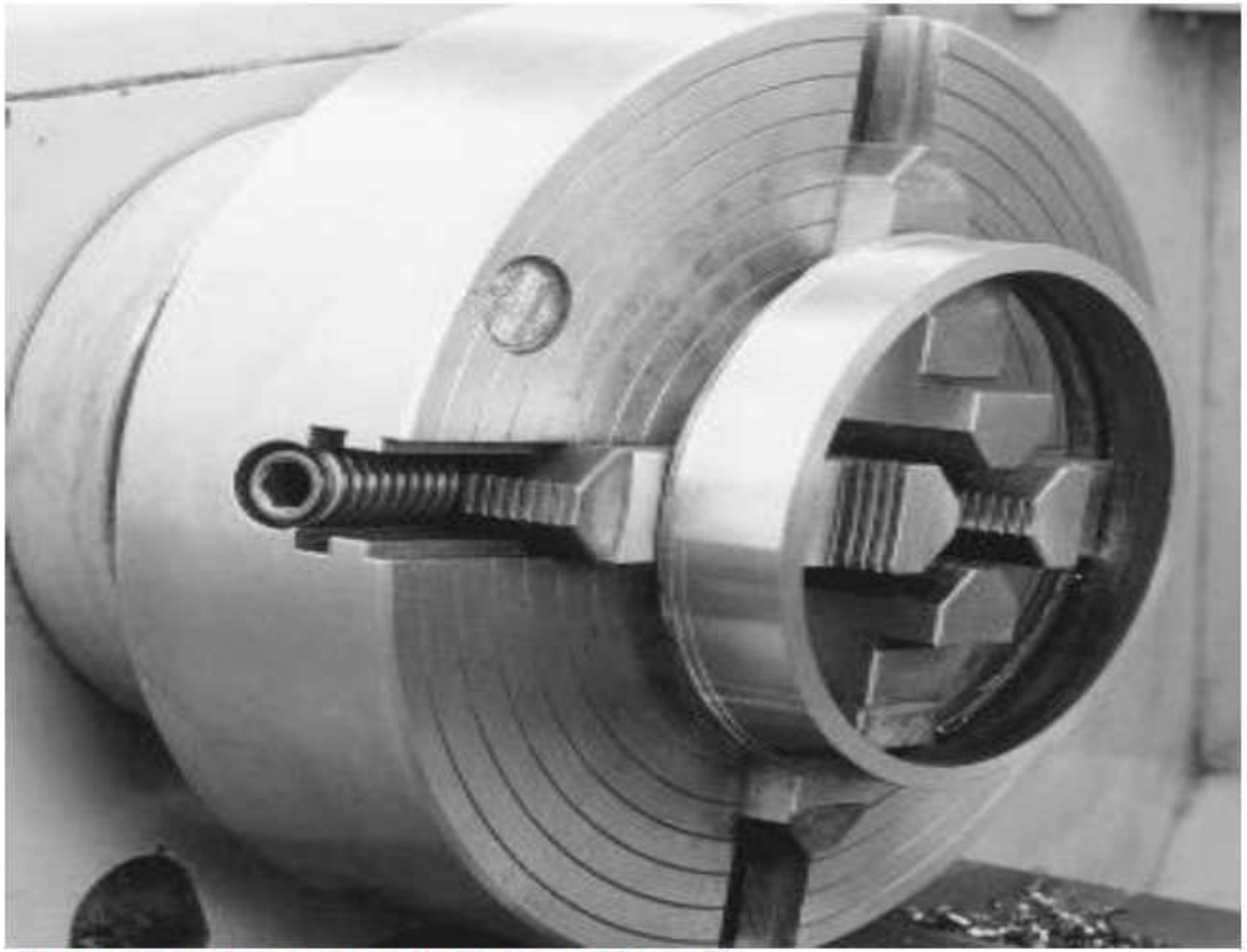
Used for holding symmetrical work pieces

Three jaws move together



4 – Jaw independent Chuck

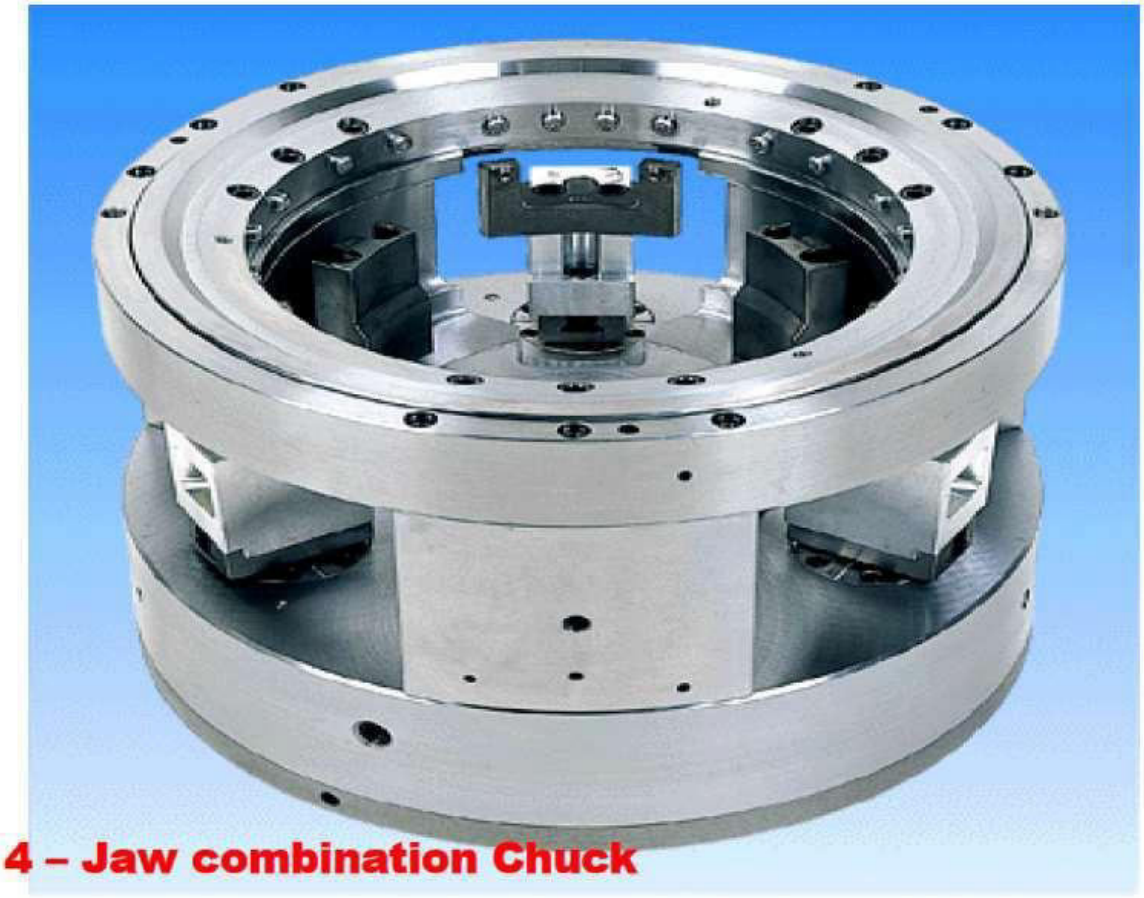
Used for holding Non-symmetrical and complex work pieces



4 – Jaw Self centering Chuck

Six-Jaw Chuck

More jaws grip the work piece more securely



Independent jaw movement

Movement of all the jaws simultaneously

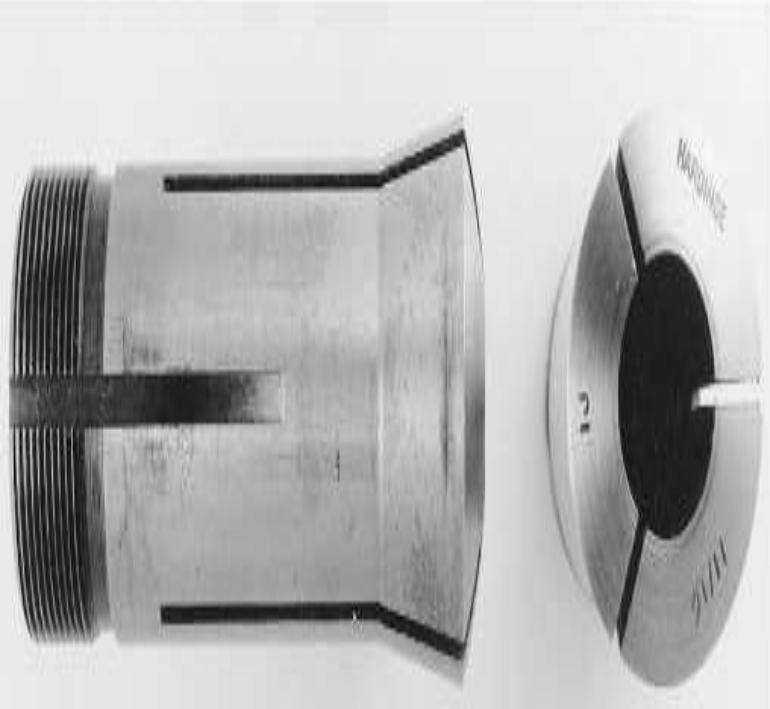
Magnetic Chuck

Magnetic Chuck used in Surface Grinder

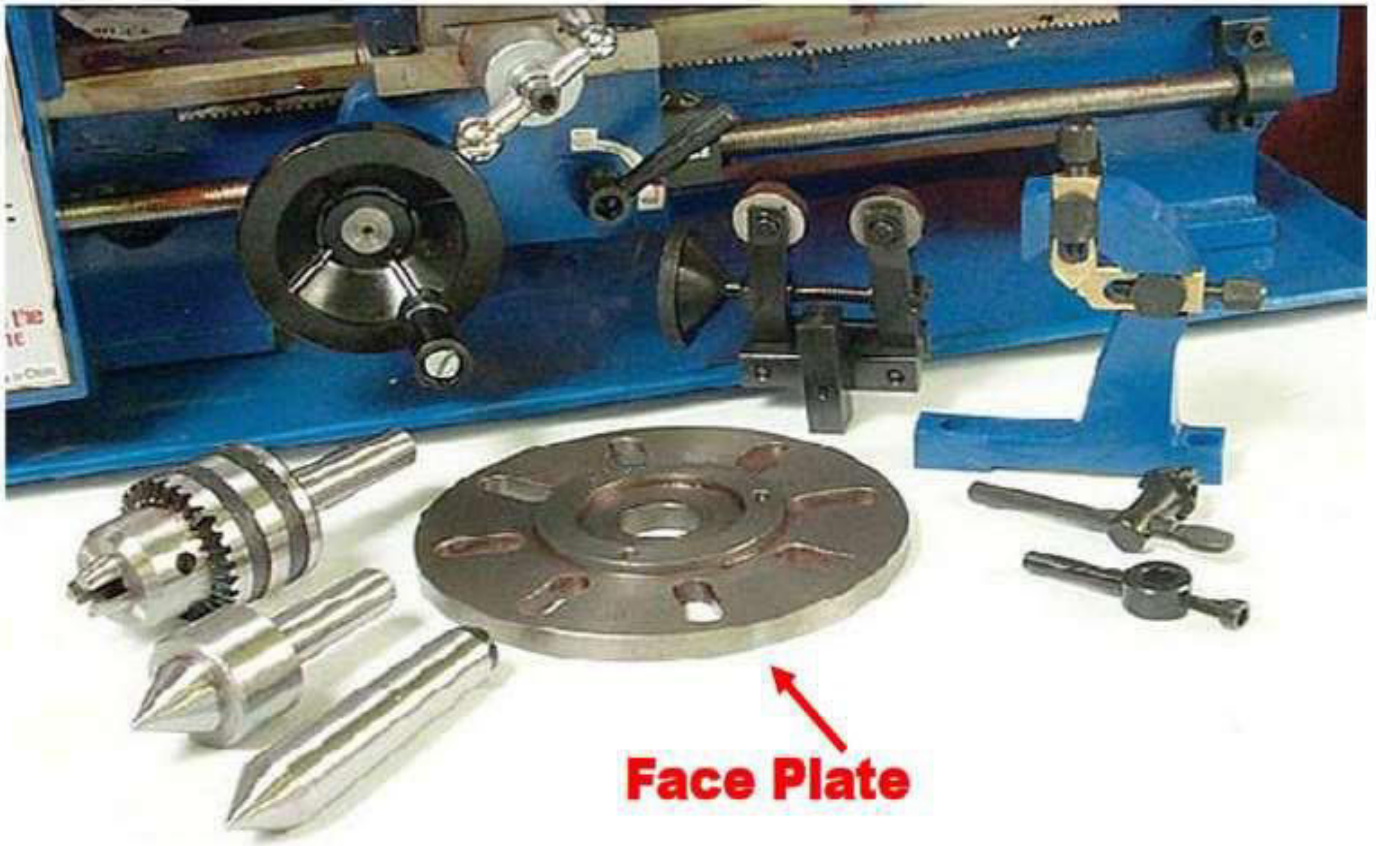
Used for holding: 1) Thin jobs

2) Ferro-magnetic work pieces

Collet Chuck

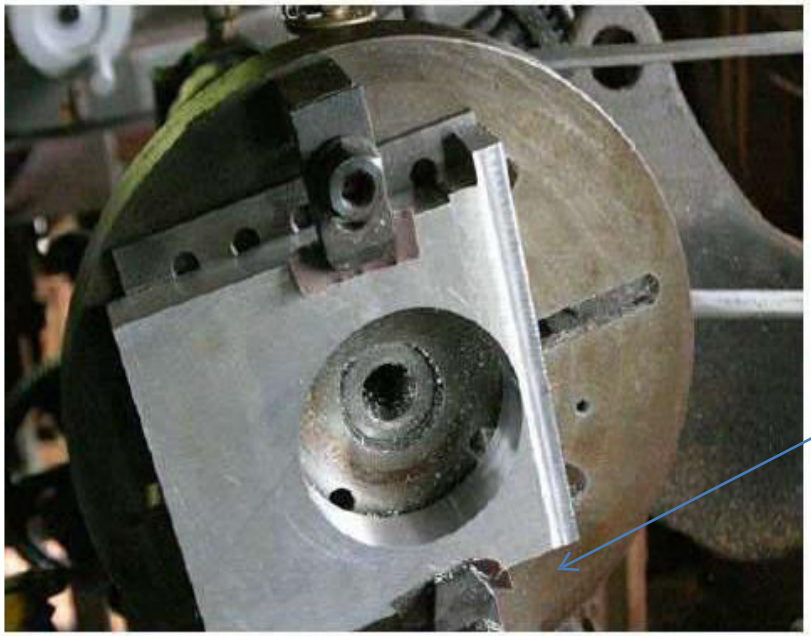


Used to hold small work pieces


Face Plate

Face Plate fixed on the lathe chuck

Face plate: Screwed on spindle nose



Work piece fixed on a Face Plate upon the lathe chuck

Face plate: Used for holding jobs of irregular shape

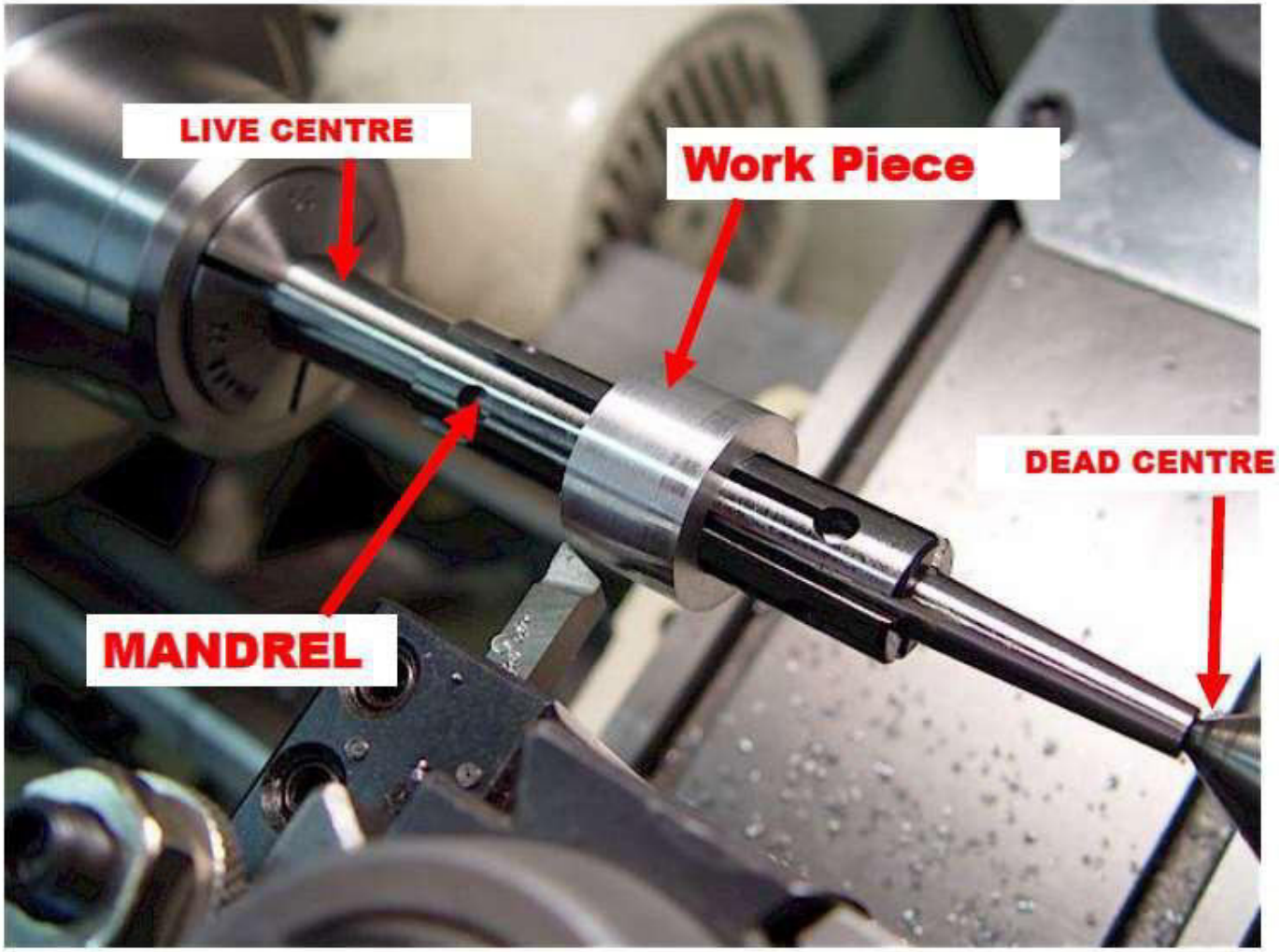
Job is fixed with bolts, nuts and straps

Face Plate fixed on the lathe chuck

MANDRLES

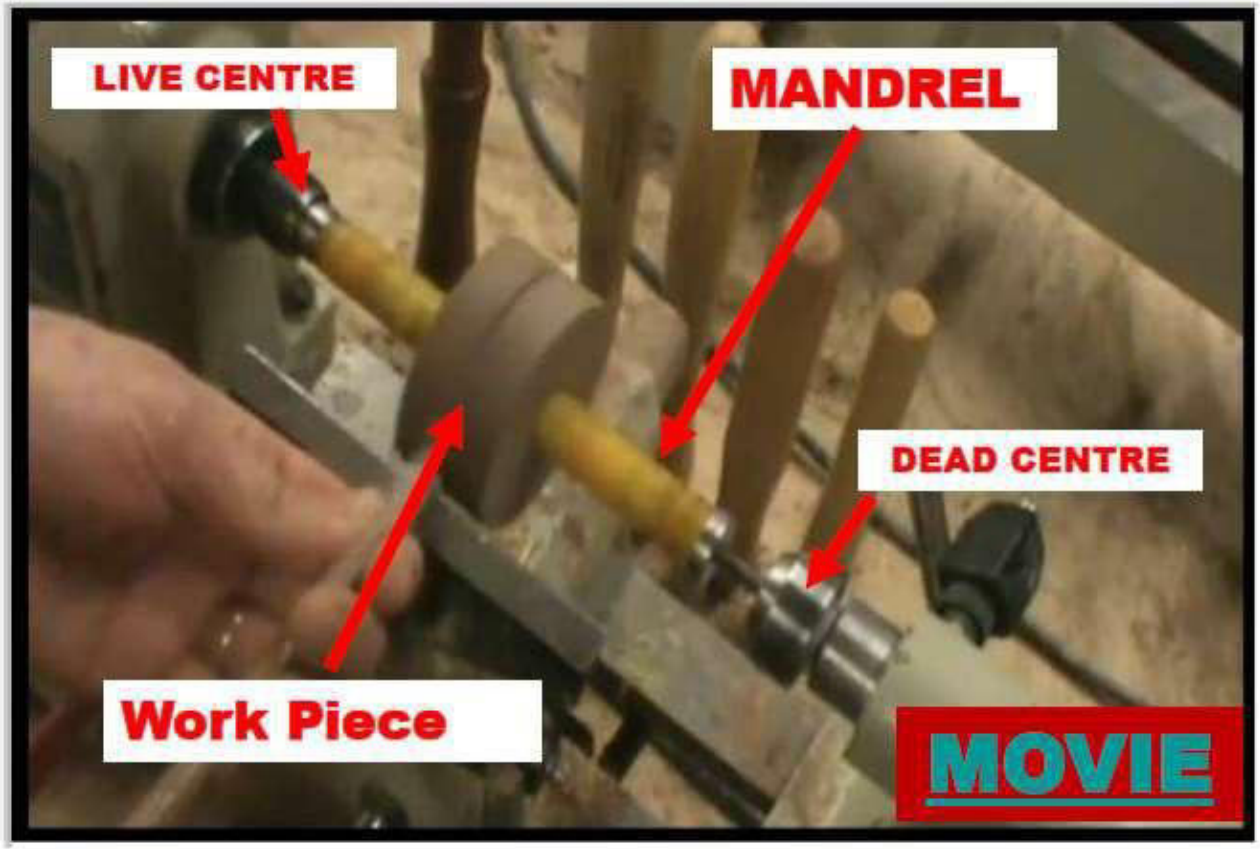
Work Holding Devices

- CHUCKS
- MANDRELS →
  - Plain mandrel
  - Stepped mandrel
  - Screw mandrel
  - Cone mandrel
  - Gang mandrel
- RESTS
- CENTERS



Mandrel: Used for holding a work piece with central hole

Examples: gear blanks, Pulleys, etc.

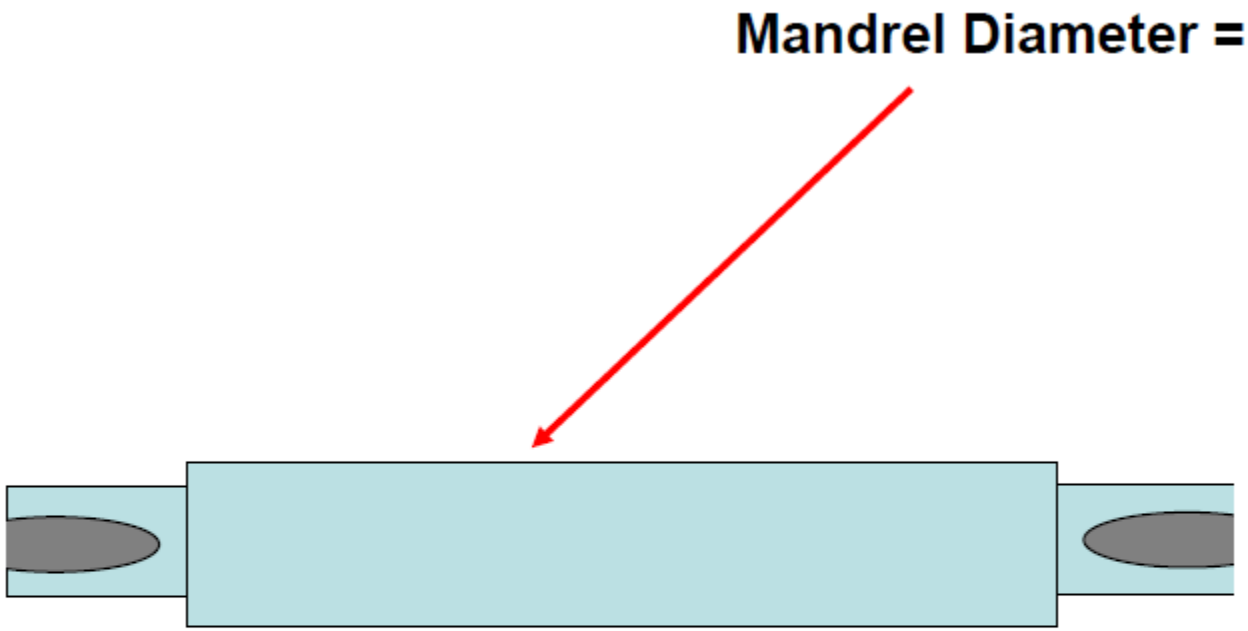


Mandrel: Solid hardened bar and usually tapered

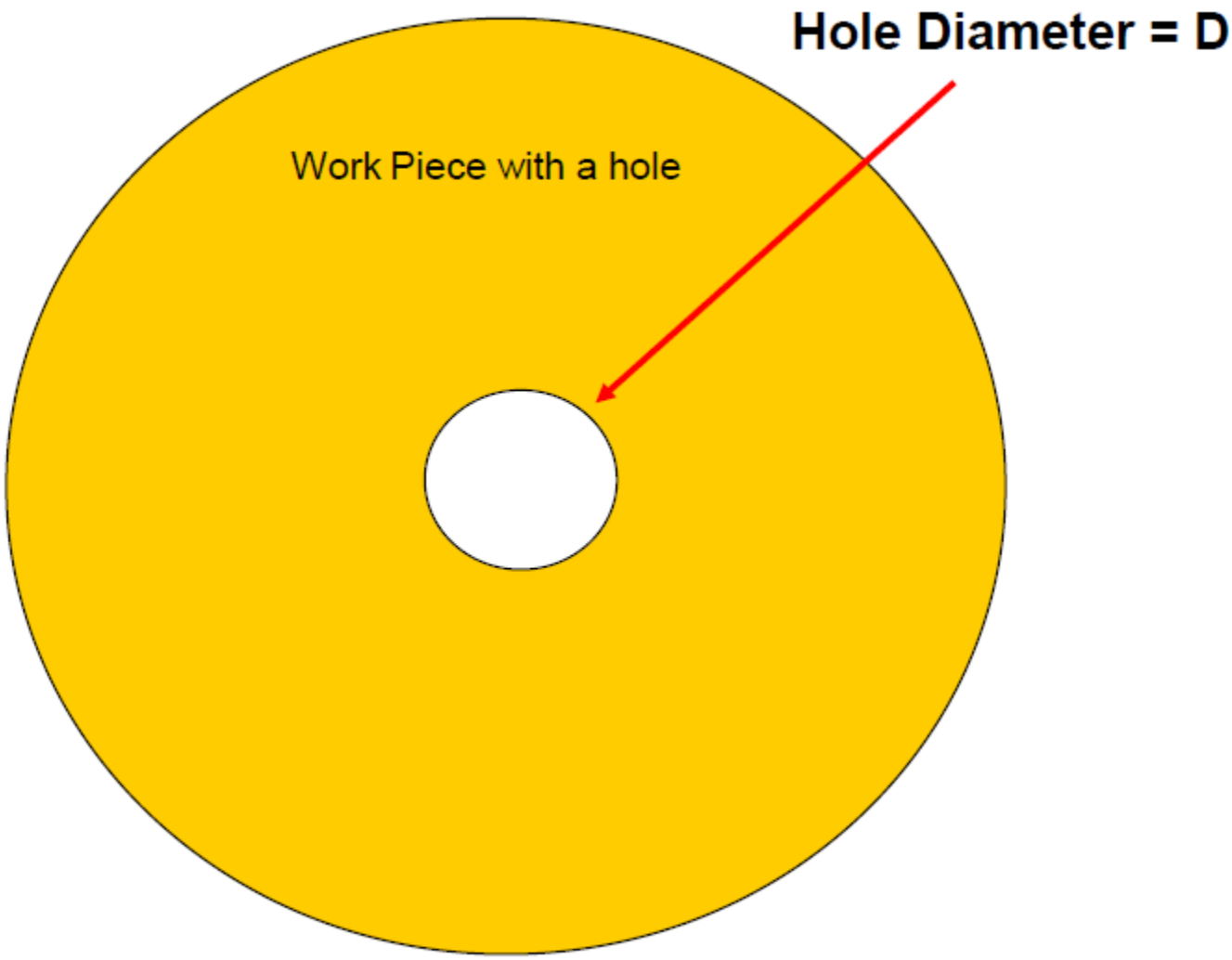
Taper: About 0.005 mm per cm. length

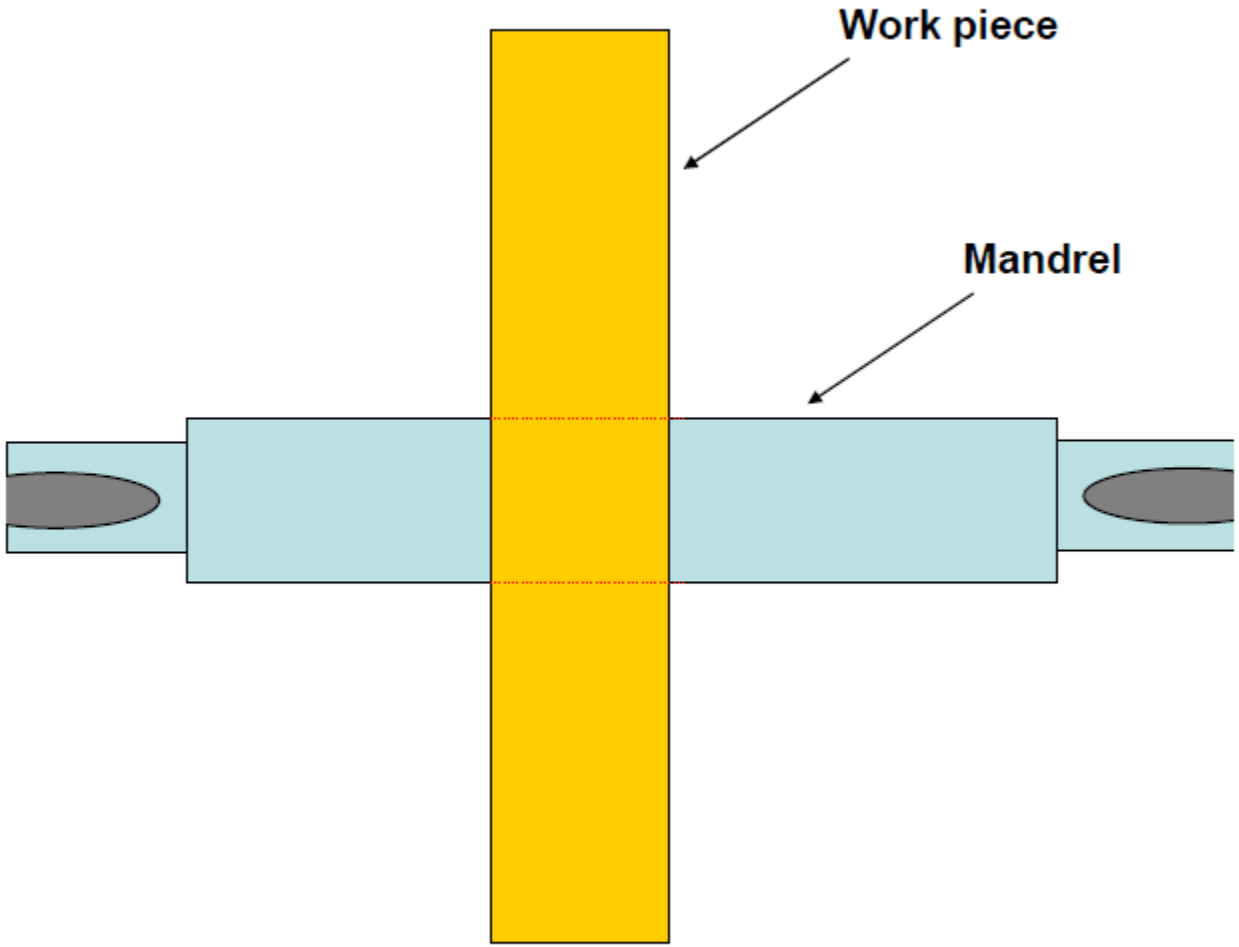
Plain Mandrel

LATHE MANDRELS



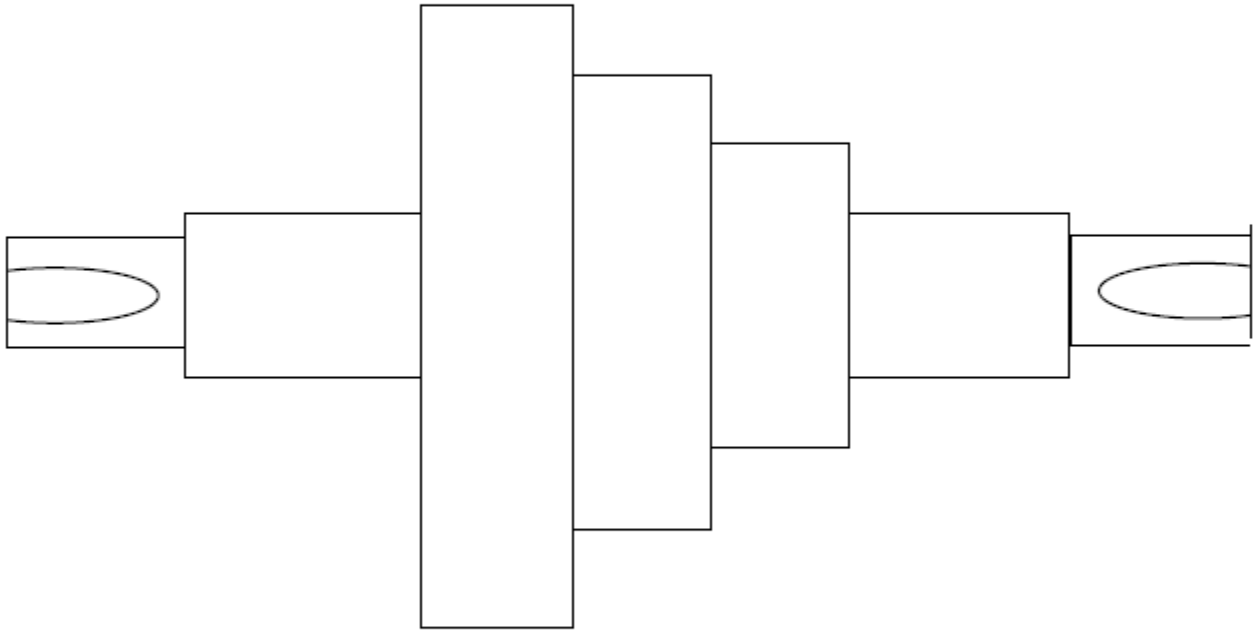
Plain Mandrel


Hole Diameter = D
Work Piece with a hole

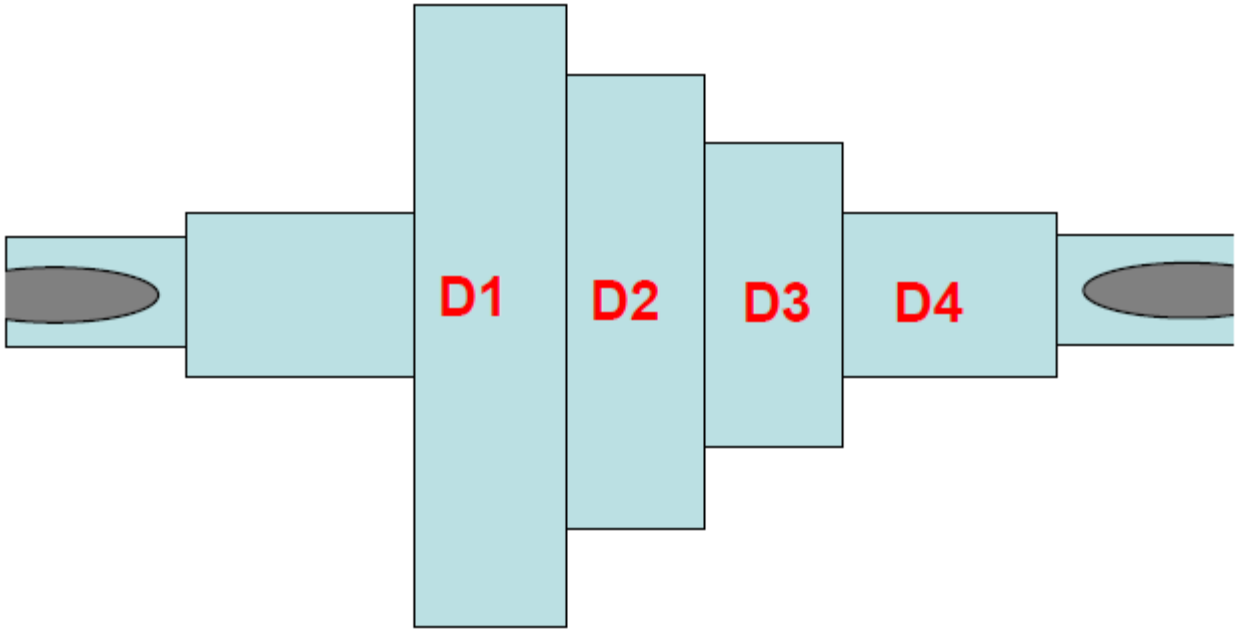


Work Piece fixed on a Plain Mandrel

Work piece placed on plain mandrel

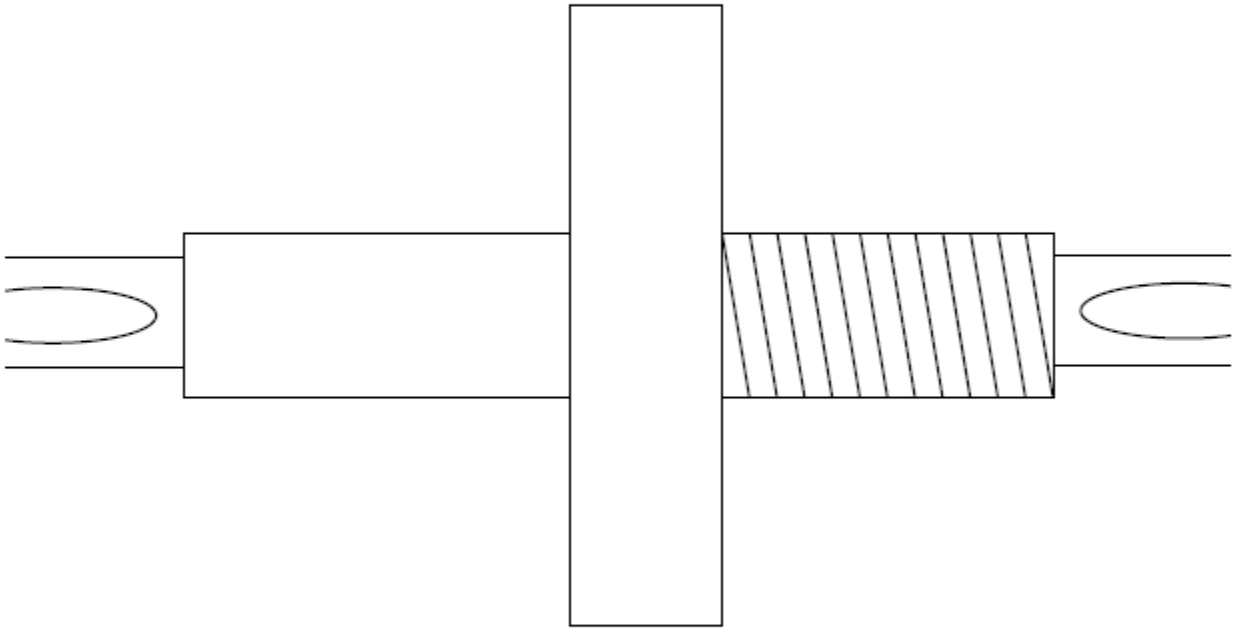


Stepped Mandrel

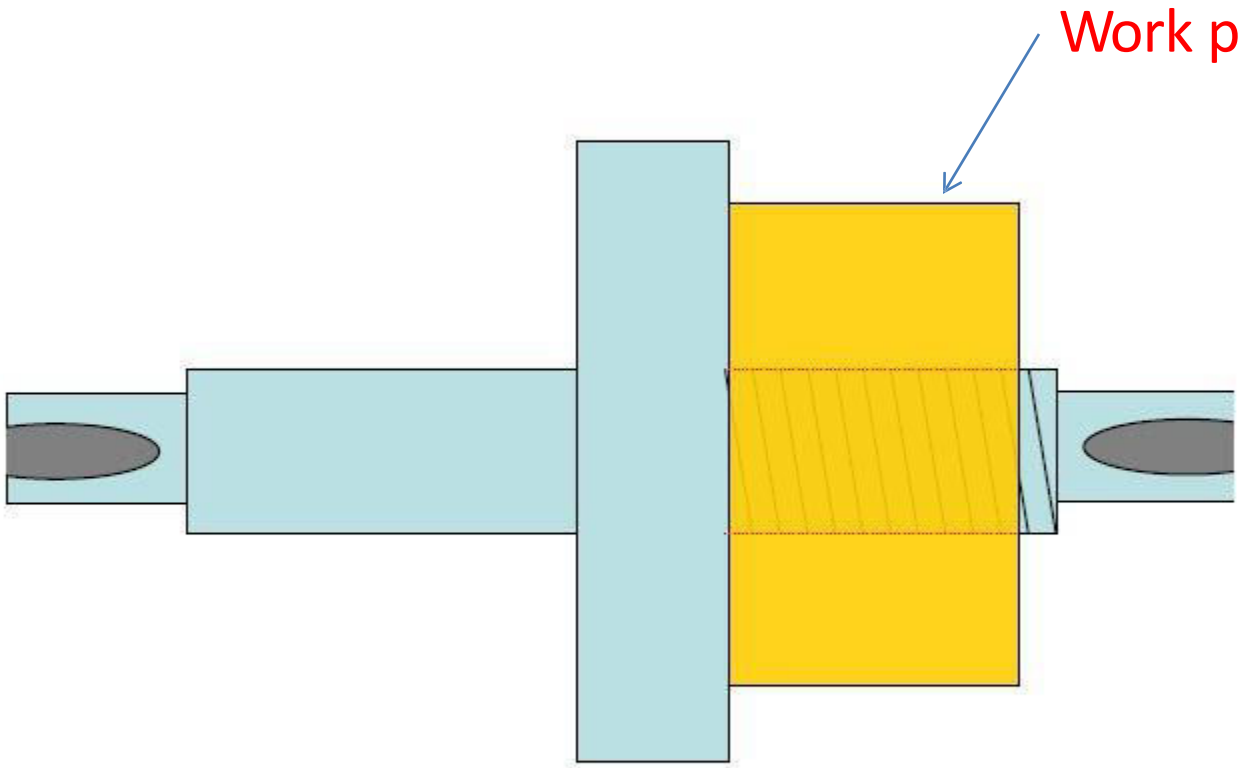


Stepped Mandrel

Stepped Mandrels

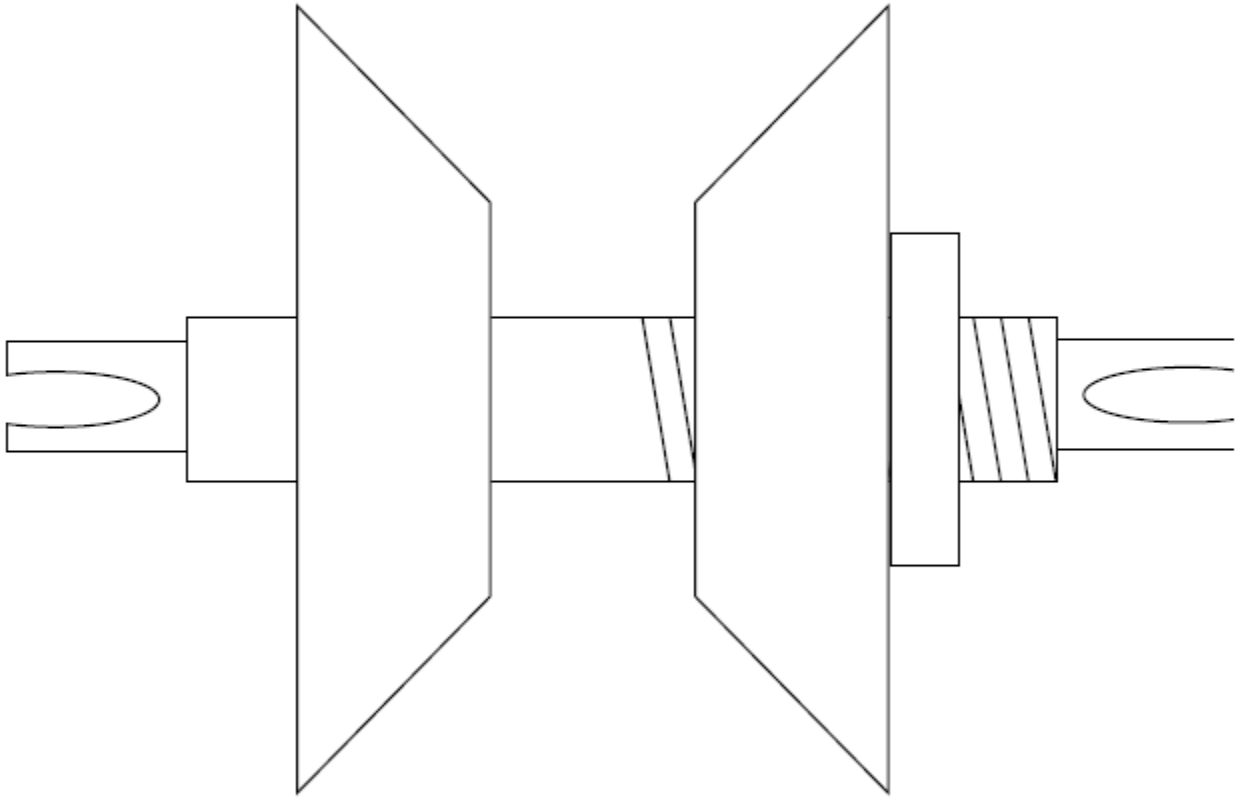


Screw Mandrel

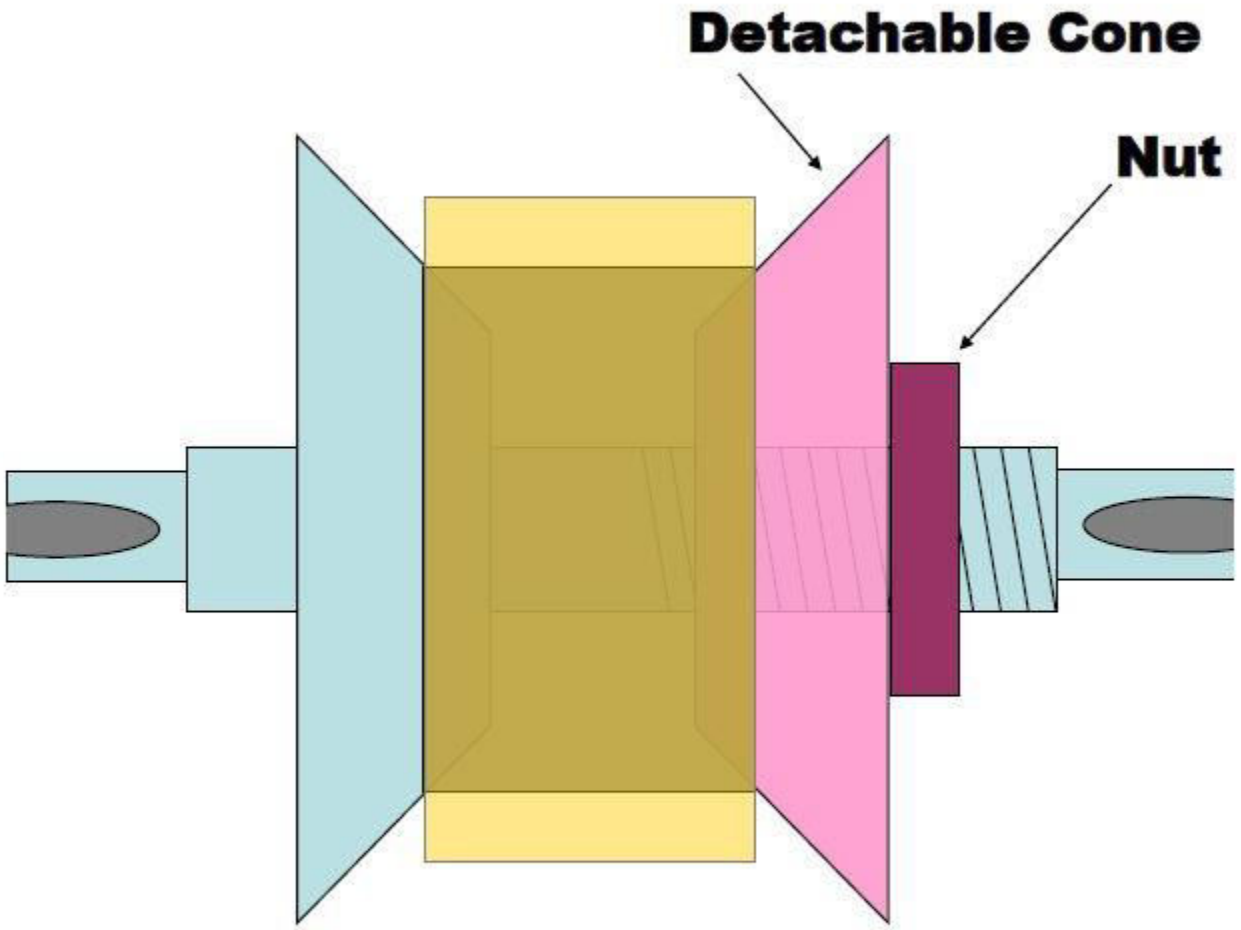


Work piece having internal threads fixed using a Screw Mandrel

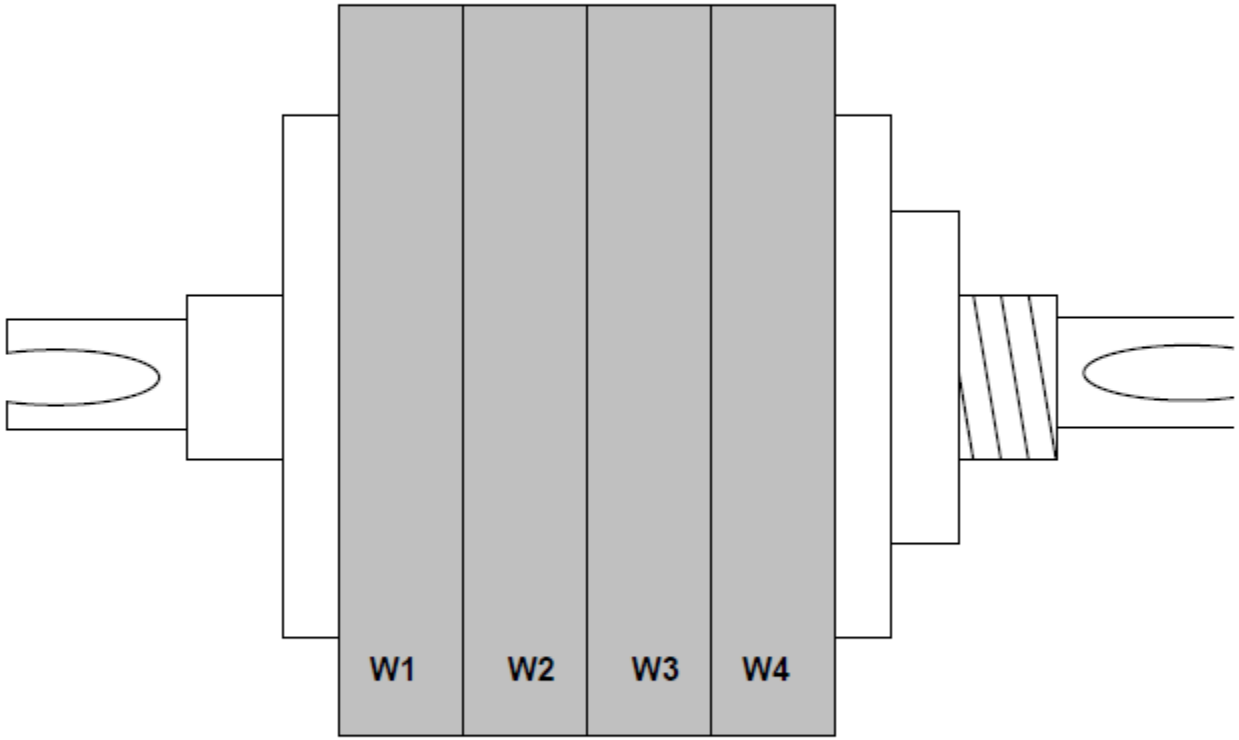
Screw Mandrels



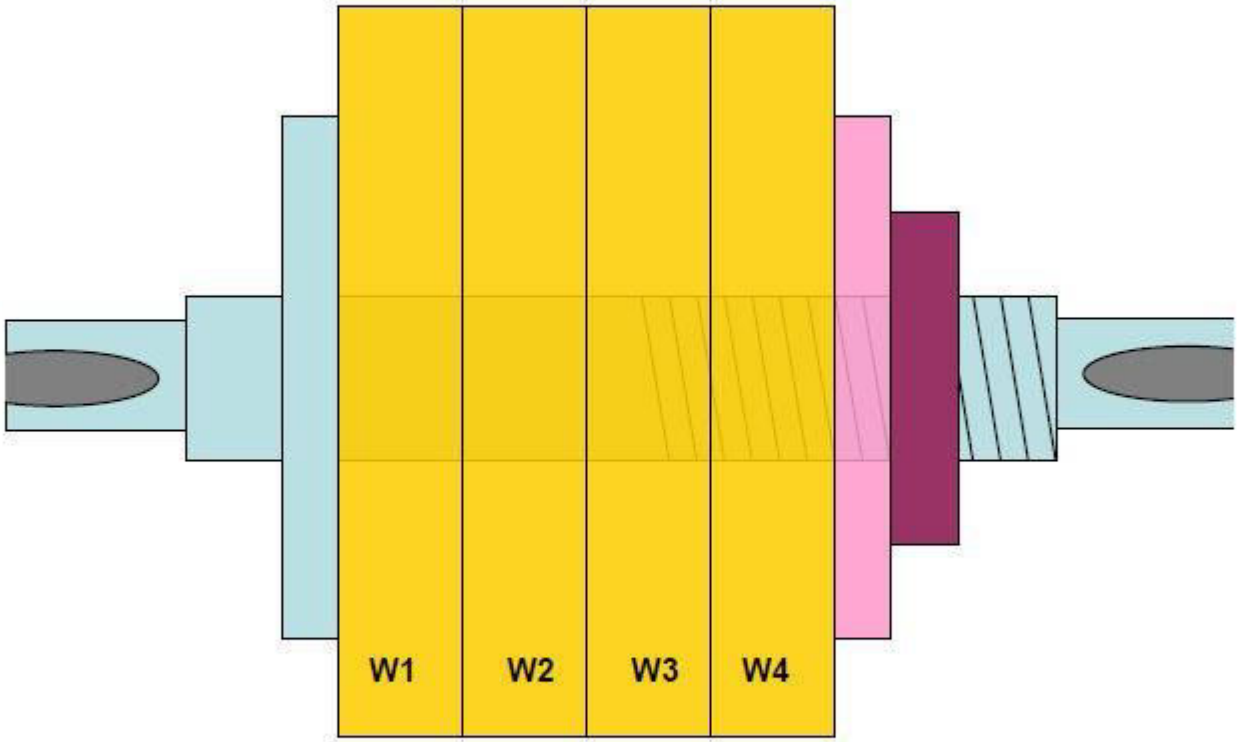
Cone Mandrel



Work piece with large internal hole is fixed using a cone Mandrel



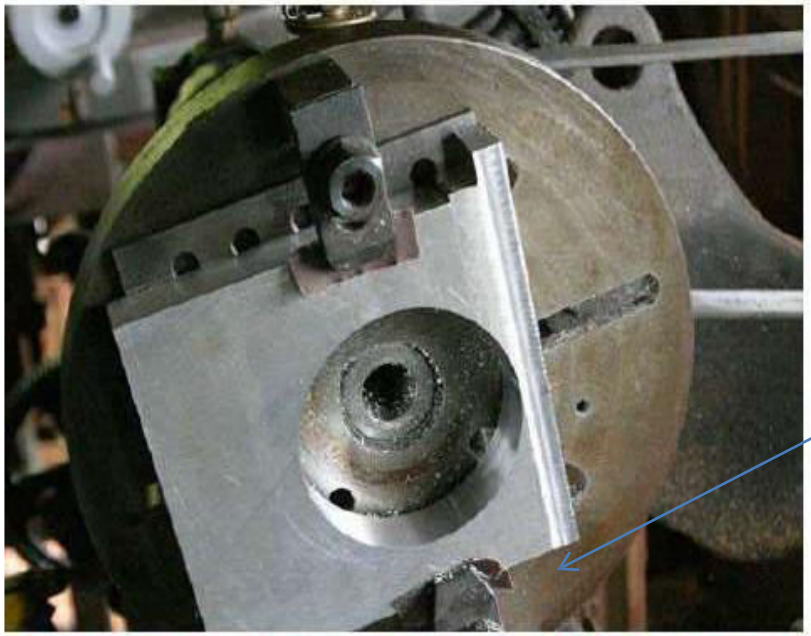
Gang mandrel



Several work pieces of the same internal & external diameters fixed using a gang mandrel

Face Plate fixed on the lathe chuck

Face plate: Screwed on spindle nose



Work piece fixed on a Face Plate upon the lathe chuck

Face plate: Used for holding jobs of irregular shape

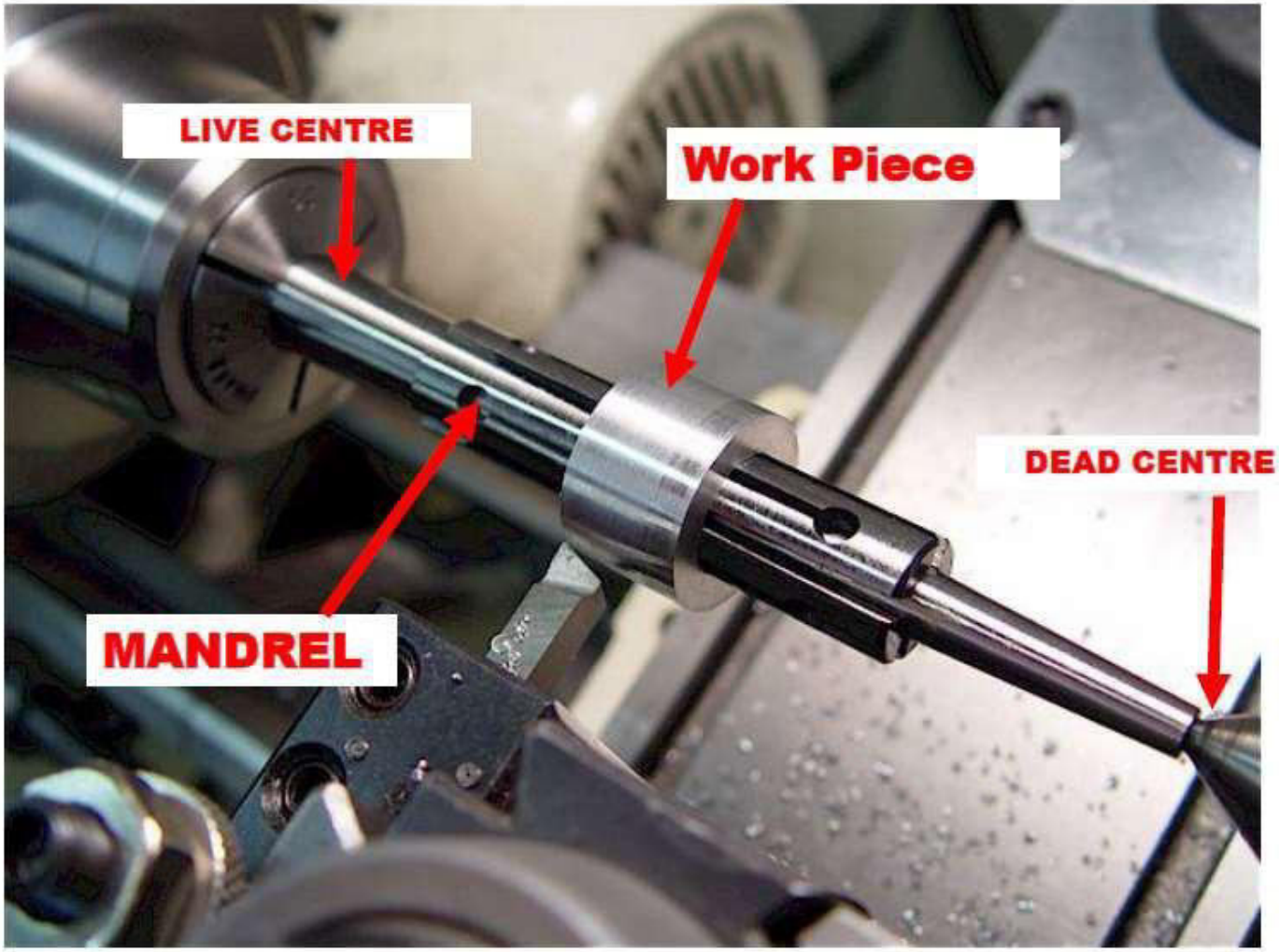
Job is fixed with bolts, nuts and straps

Face Plate fixed on the lathe chuck

MANDRLES

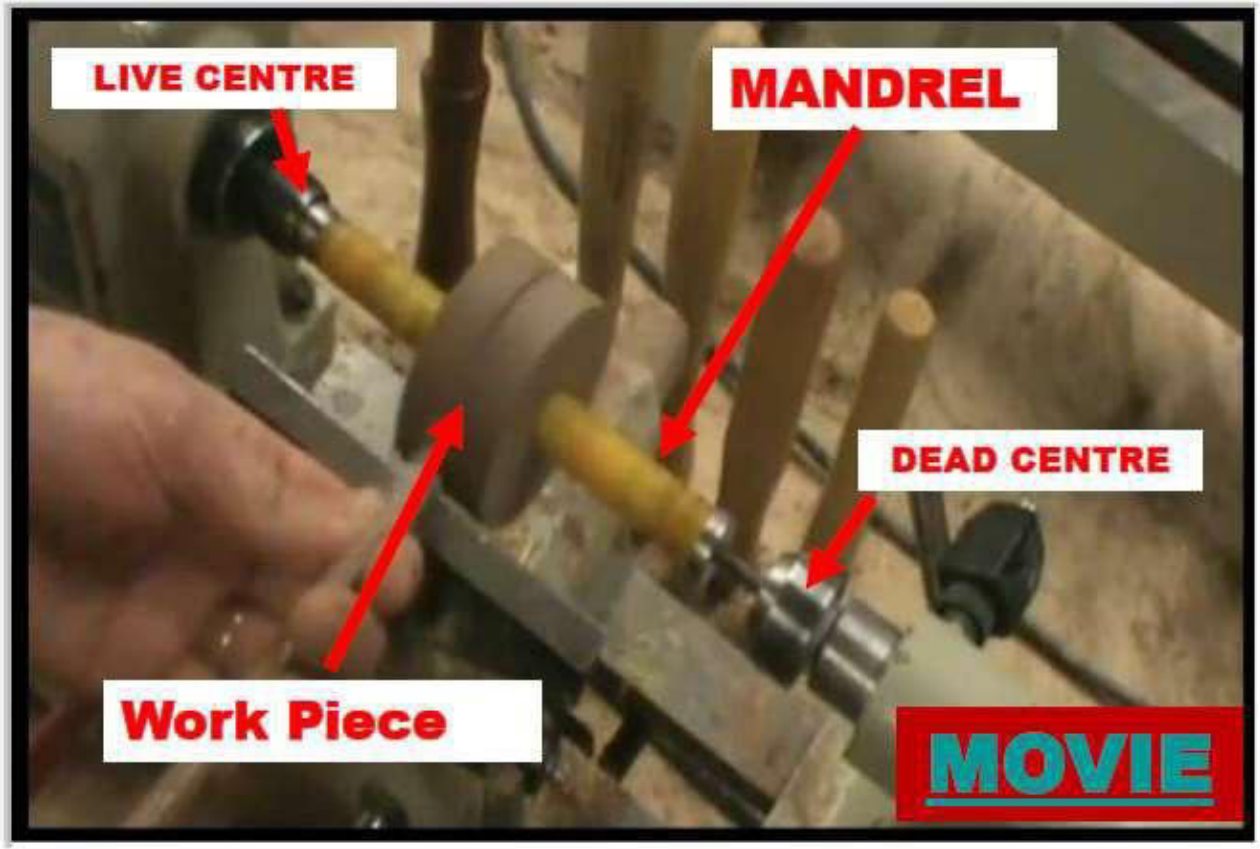
Work Holding Devices

- CHUCKS
- MANDRELS →
  - Plain mandrel
  - Stepped mandrel
  - Screw mandrel
  - Cone mandrel
  - Gang mandrel
- RESTS
- CENTERS



Mandrel: Used for holding a work piece with central hole

Examples: gear blanks, Pulleys, etc.

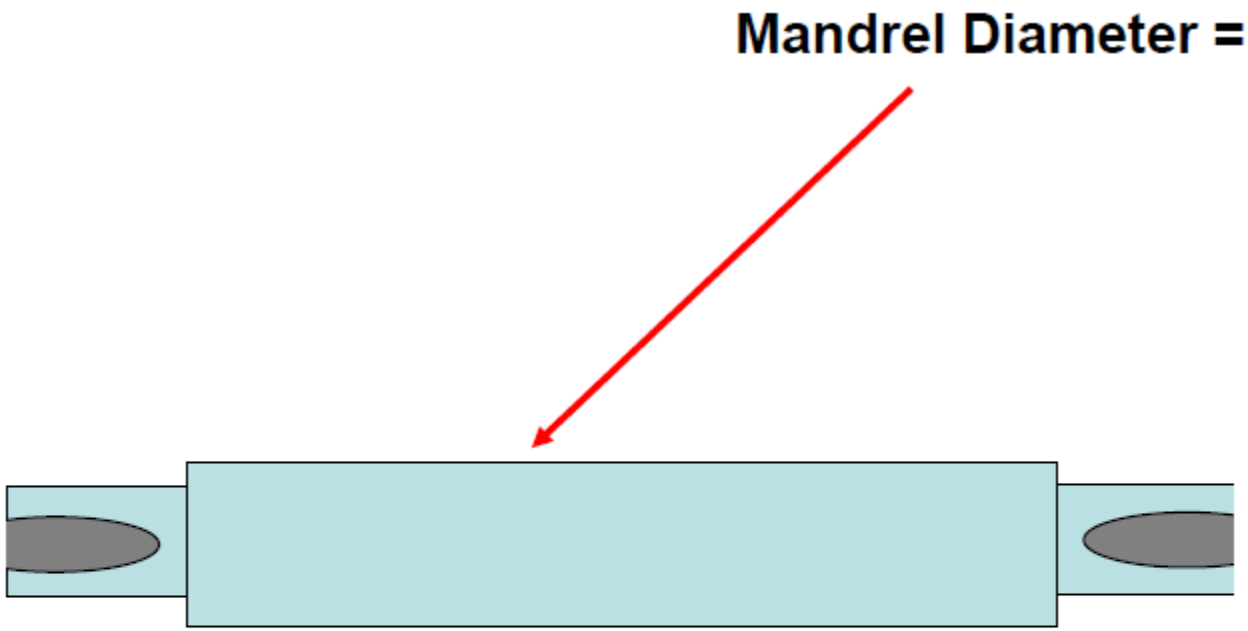


Mandrel: Solid hardened bar and usually tapered

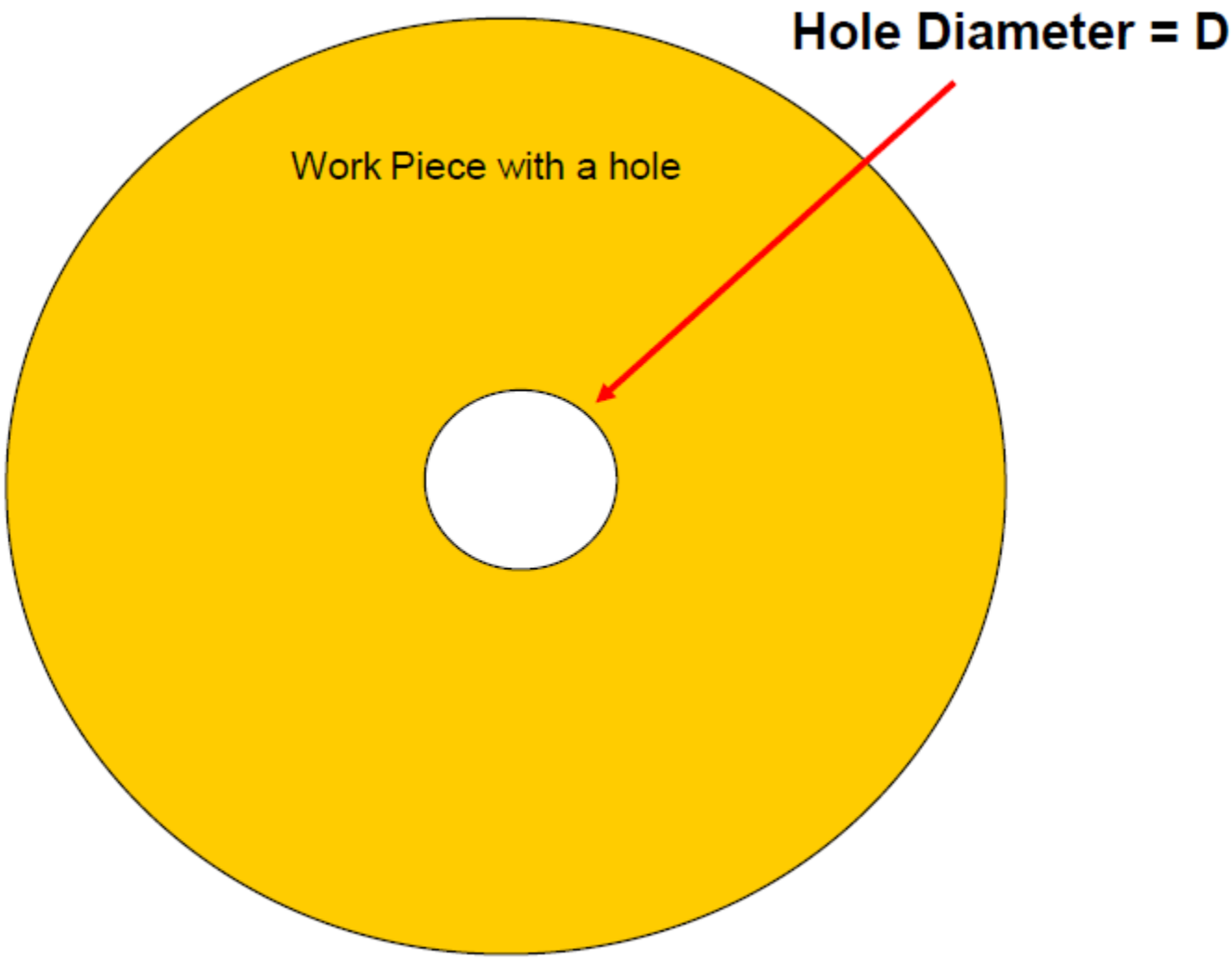
Taper: About 0.005 mm per cm. length

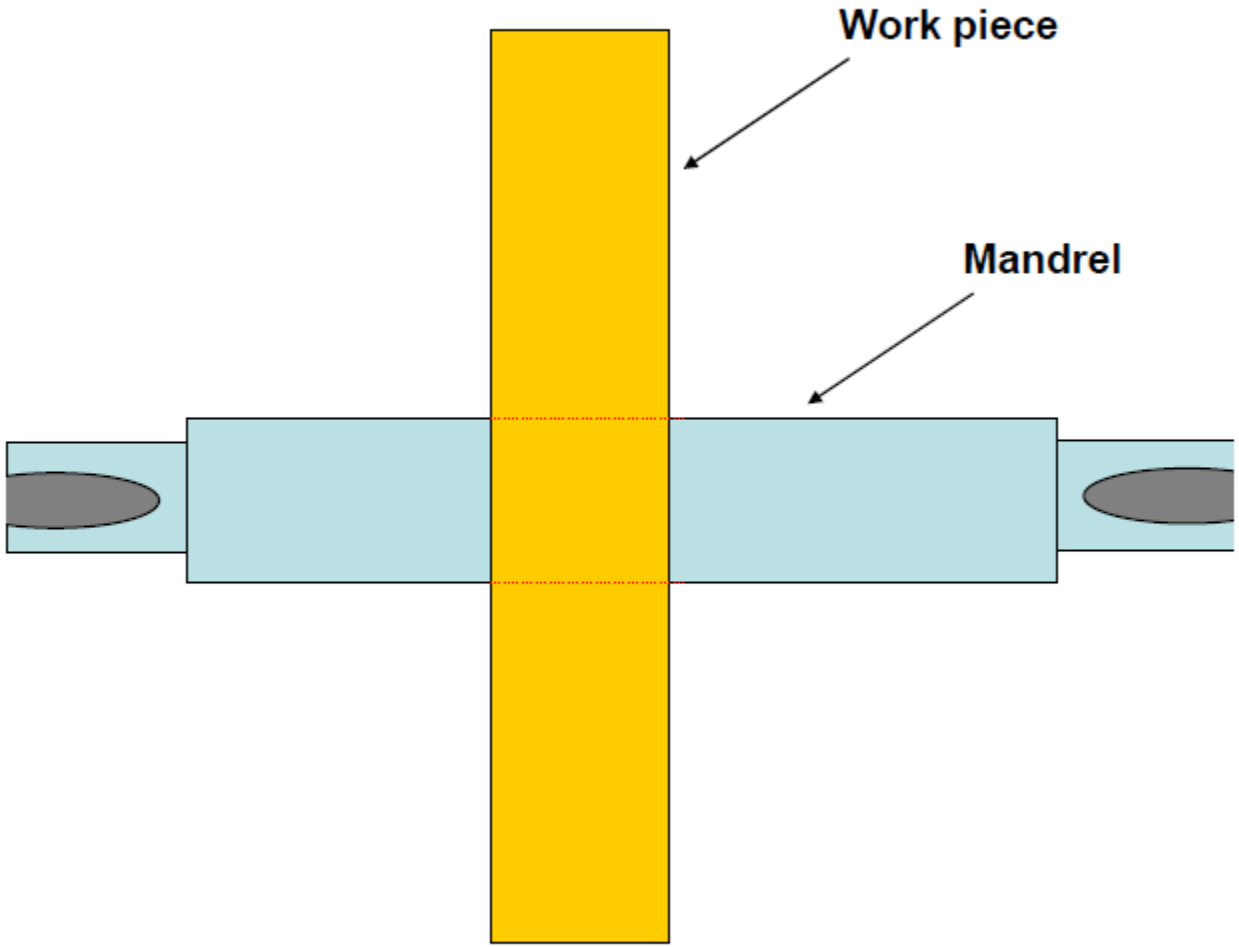
Plain Mandrel

LATHE MANDRELS



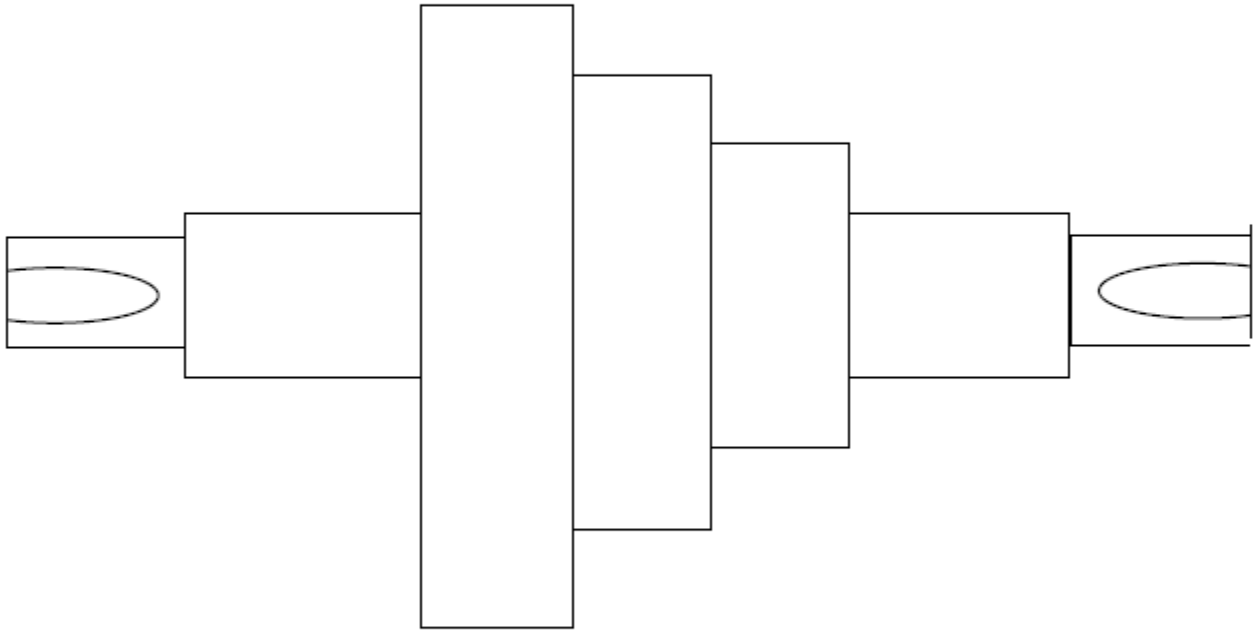
Plain Mandrel


Hole Diameter = D
Work Piece with a hole



Work Piece fixed on a Plain Mandrel

Work piece placed on plain mandrel

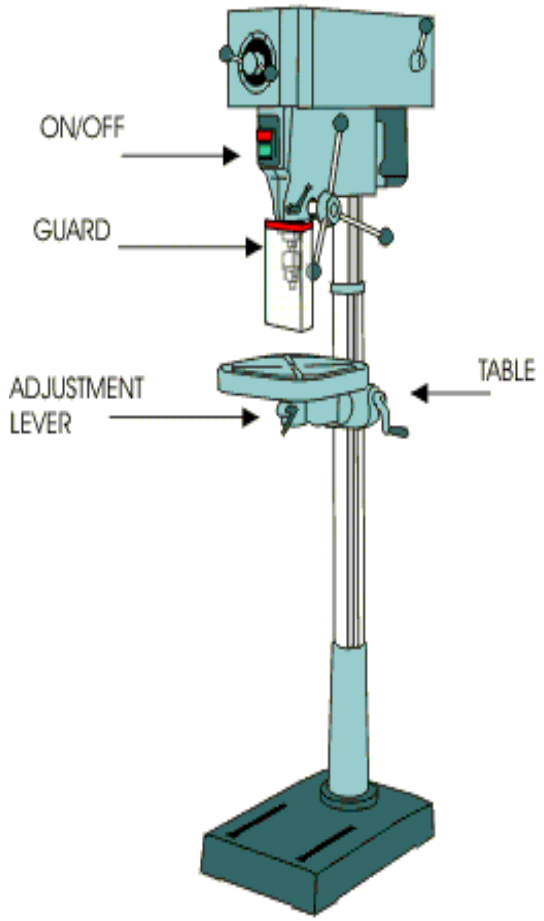


Stepped Mandrel

CHAPTER-3

DRILLING MACHINES

Drilling Process



- Drilling is the process of cutting holes in metals by using a drilling machine as shown
- Drills are the tools used to cut away fine shavings of material as the drill advances in a rotational motion through the material.
- Drilling is done by forcing a rotating drill into stationary job as on a drilling machine or by forcing stationary drill in a rotating workpeiece as on a lathe.
- Drilling also done by milling machine with a drilling attachment. In this case the job is fed onto rotating drill.

Classification of Drilling Machines

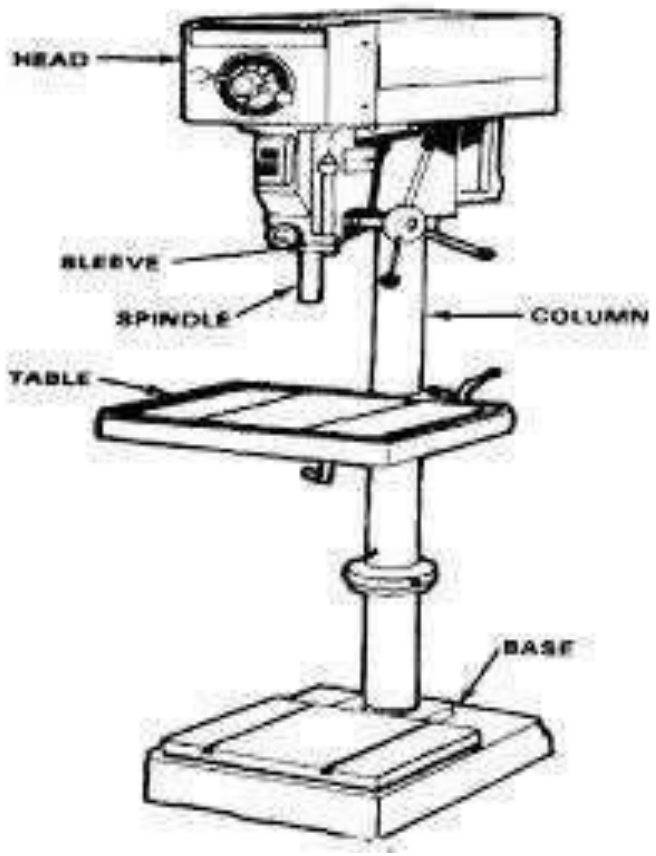
- **Drilling machines are classified according to their construction into the following categories:**

1. Portable drilling machine
2. Sensitive drilling machine
3. Radial drilling machine
4. Gang drilling machine
5. Multi-spindle drilling press
6. Automatic drilling machine
7. Turret drilling machine
8. Numerically controlled drilling machine
9. Upright drilling machine

Portable Drilling machine

- This type of drilling machine is can carried anywhere in shop.so it is called portable.
- The machine can be used for creating holes with work piece in any position which is not possible with standard drilling machines.
- The entire machine is quite compact and handy.
- Most of the portable drilling machines are operated by individual motors contained in the machine. Some small machines can be operated by hand.

Sensitive Drilling Machines



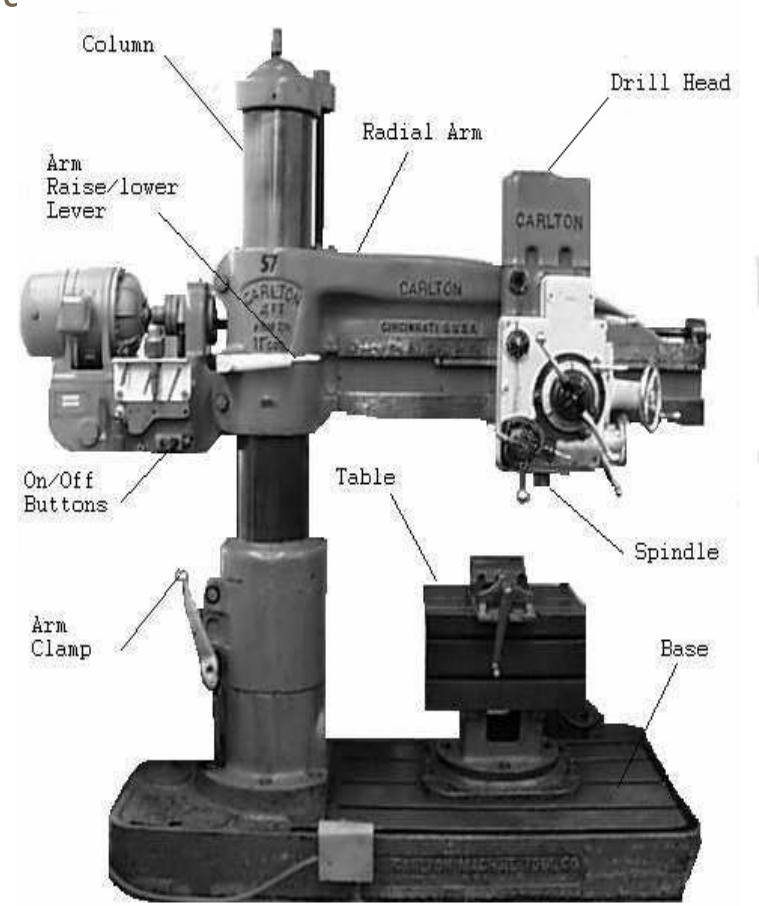
- These are small machines designed for drilling holes at high speed in light work pieces.
- As shown in figure the machine consists of a vertical column, a horizontal table, a machine head mounted on the column to support the driving motor, and mechanism for driving and feeding the tool.
- While feeding the operator can sense the cutting action and adjust the feed rate so it is called sensitive drilling machine.
- the machine can be fitted on a table or the floor.

Working of Sensitive Drilling Machine

- Work piece with the exact location marked on it with the center punch is clamped rigidly on the work table.
- spindle axis and center punch indentation are in same line.
- Machine is started and drill bit is lowered by rotating feed handle.
- Drill bit touches the work and starts removing material.

Radial Drilling Machine

The arm can be moved up and down the column and swiveled about the column and drill head also can be moved along the radial arm



- The motion of head along with the drill spindle permits positioning of holes in a circle with a radius almost as large as the length of radial arm so this is called radial drill machine.
- The rotating spindle can be moved up and down relative to the arm through the feed mechanism.
- Radial drilling machines are convenient for heavy jobs which cannot be moved around easily and for drilling a numbers of holes in a job.
- Power feeding is also available in radial drilling machine.

Gang Drilling Machine

- A Gang drill machine has a number of drill heads arranged with a common base and table.
- Each drill head has its own power unit and carries a tool to perform an operation on a job in sequence.
- The spindle may be set up with drills of different diameter or other tools as required.
- The job is moved from one spindle to the other spindle for performing various operations.
- Gang drilling machines are useful when several different machining cuts with different tool are to be taken on sufficiently large number of work pieces.

Multi-spindle Drilling Machine

- Multi-spindle drilling machines with two or more spindles driven by a common head.
- This machine are used for drilling a numbers of holes simultaneously in a worpiece.
- They may be built as specific jobs with their spindles fixed in specific positions or as general purpose machines in which the relative distance between the spindles can be changed within a range.
- Multi-spindle machines are high production rate machines and lead to considerable saving for large quantity jobs.

Automatic Drilling Machine

- These are high performance automatic machine designed for variety of operations being done on the work piece.
- A number of machines are arranged in series to perform variety of different operations on the worpiece at successive work stations.
- After one operation is completed at one workstation the work piece is automatically transferred to the next work station.
- Because all operation are done automatically the preciseness is higher and production time is lower.

Upright Drilling Machine

- The column may be round or of box section.
- It can be raised or lowered along the pillar depending upon the height of the job clamped in position for rigidly.
- The table in the case can be rotated about its own axis and clamped in position.
- The swivel of the table about the pillar and rotation of the table about its center permits easy location of the job under the drill.

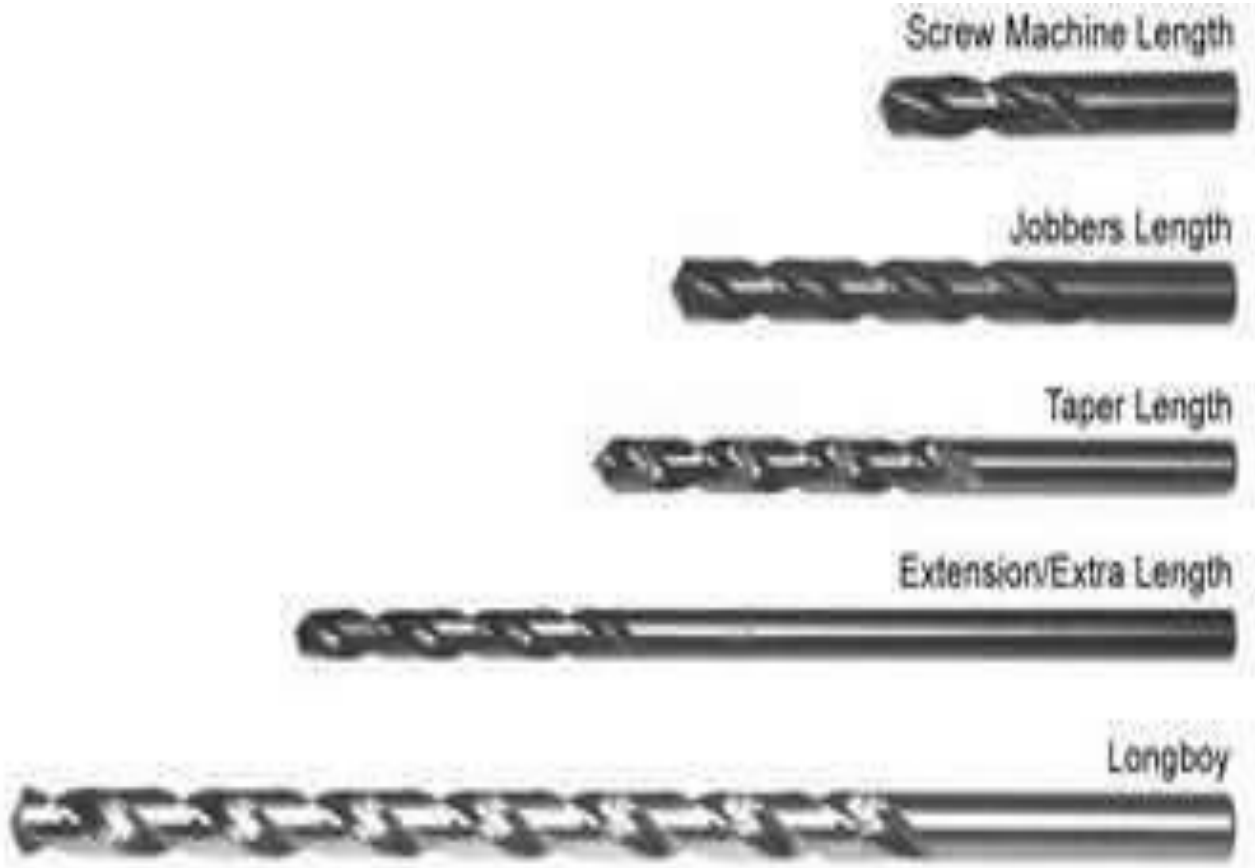
Drill Machine Specifications

- The specification of size of the drilling machine varies with type of machine.
- A portable drilling machine is specific by the maximum diameter of the drill that it can be hold.
- Sensitive and upright drilling machine are specified by the diameter of the largest work piece on the center of which a hole can be drilled; also by the maximum size of the drill held in steel or cast iron.
- The size of radial machine is specified by the diameter of the column and length of arm.
- Other particular of the machine that may sometimes be specified are the table size, maximum spindle travel, spindle speeds and feed available, power of the machine, floor space required etc.

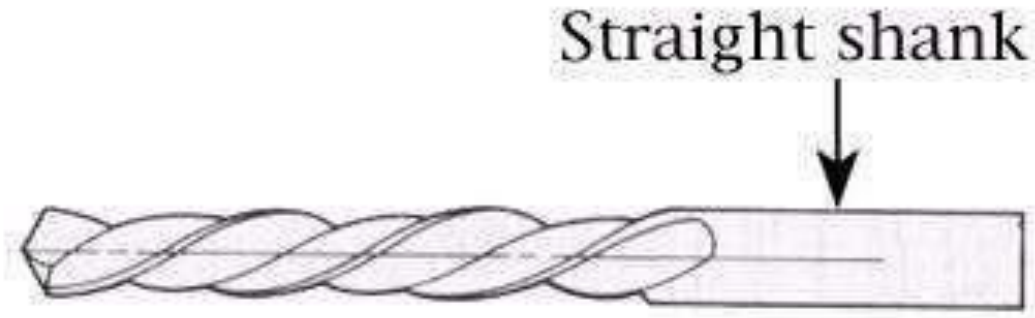
Drill Bits

- A drill bit is a multi-point tool and typically has a pointed end. A twist drill is the most common type used.
- Twist drills are available with parallel shanks up to 16mm diameter and with taper shanks up to 100mm diameter and are made from high-speed steel.
- Standard lengths are known as jobber-series twist drills, short drills are known as stub series, and long drills as long series and extra long series.
- Different helix angles are available for drilling a range of materials.
- Flutes are incorporated to carry away the chips of metal and the outside surface is relieved to produce a cutting edge along the leading side of each flute.

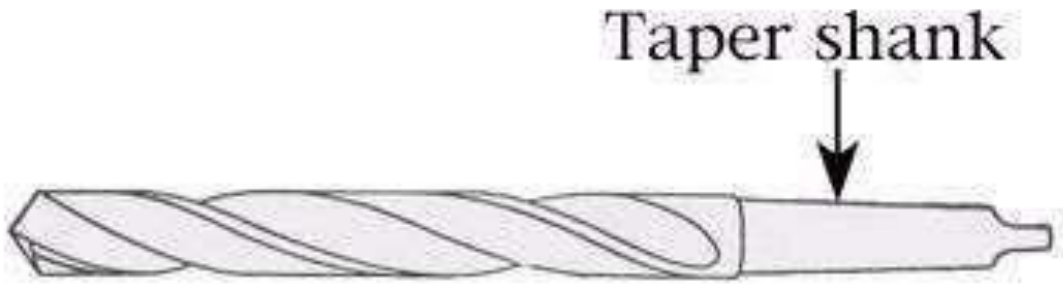
Drill Bits


Screw Machine Length
Jobbers Length
Taper Length
Extension/Extra Length
Longboy

Drill Bit Features

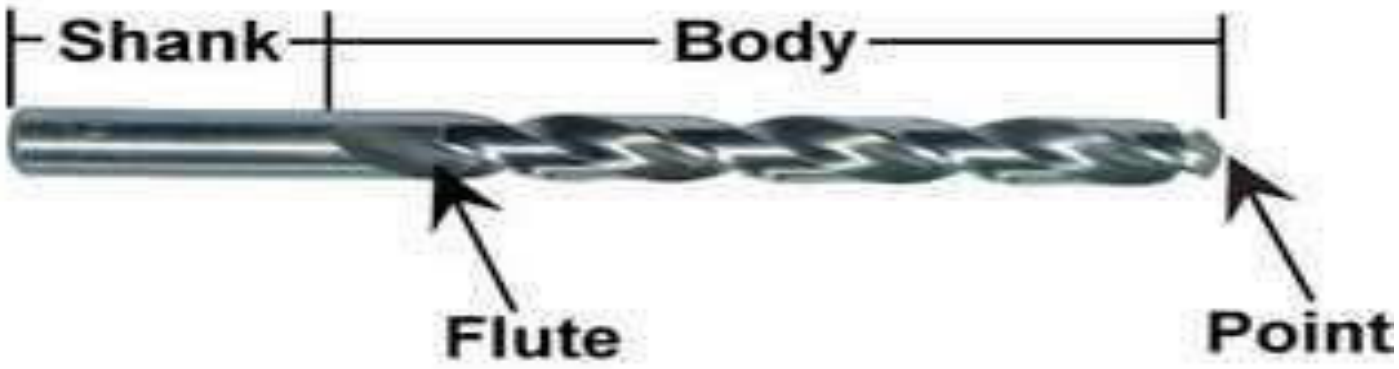


Fit in chuck



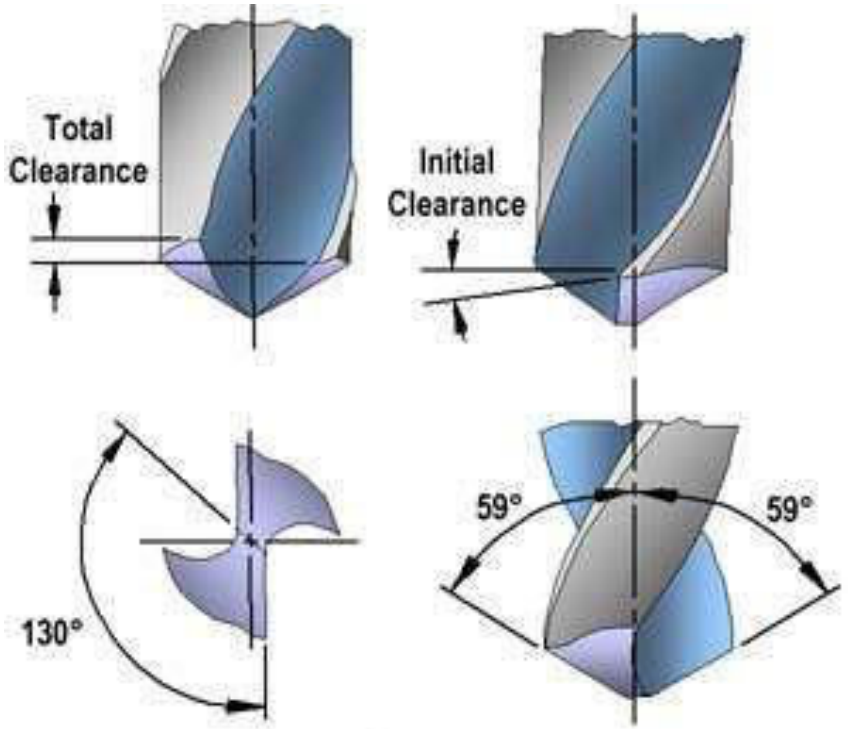
Fit direct into spindle

Drill Bit Features

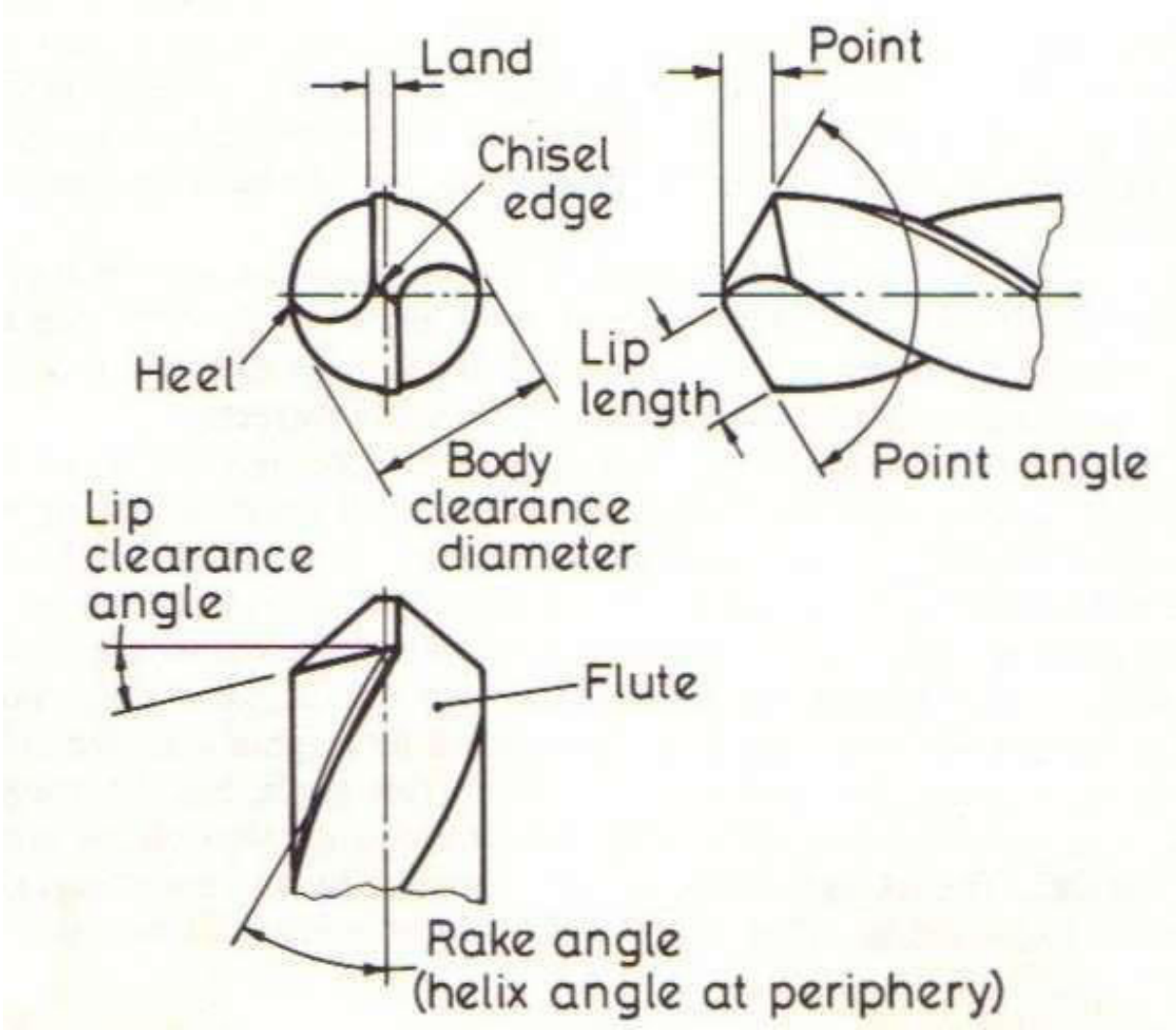


Drill Bit Features

- The point of the drill is ground to an angle of 118 degrees
- each side is ground back to give " relief " of about 12 degrees to each cutting edge as shown



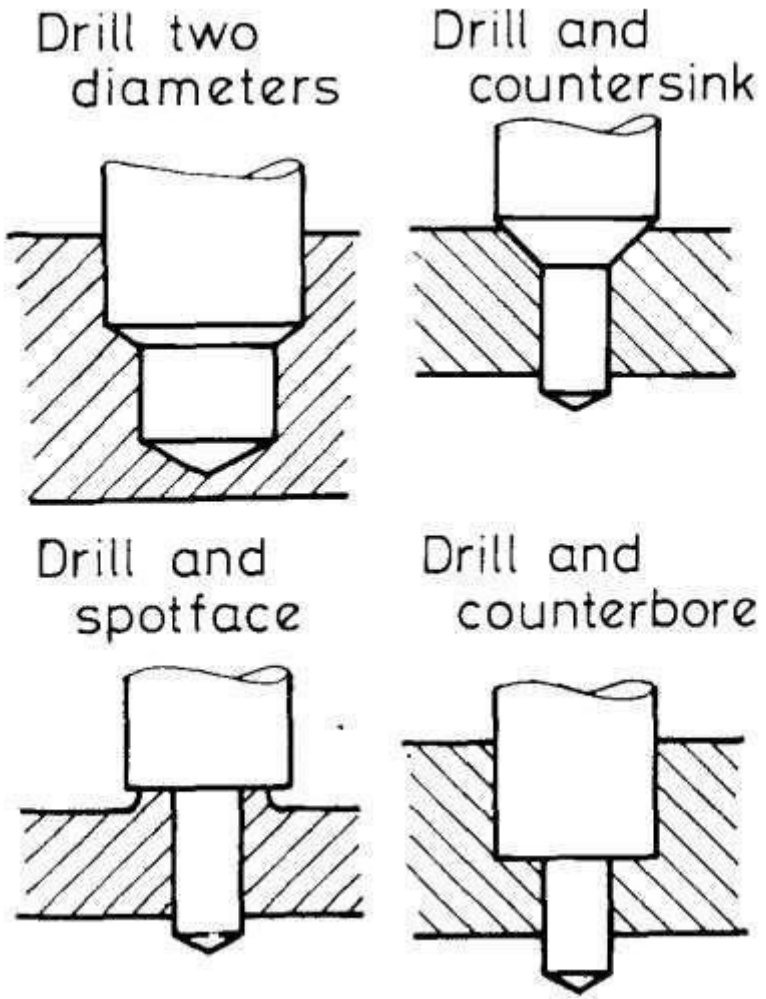
The Nomenclature of The Twist Drill



Subland Drills

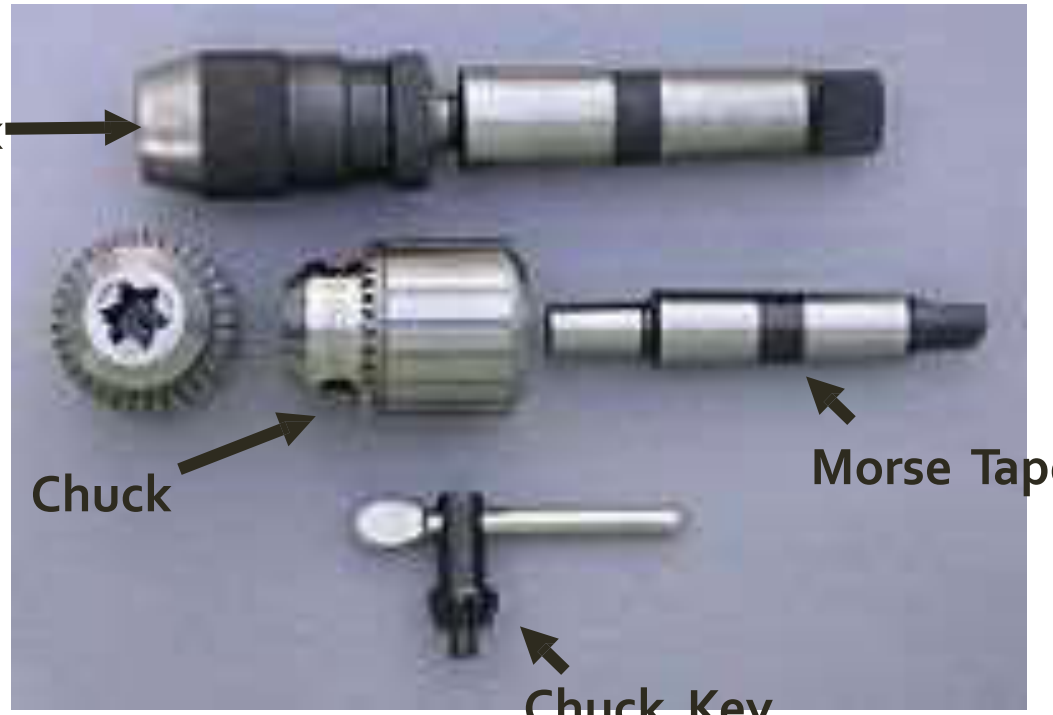
- Combination drills known as Subland drills combine a number of operations in a single tool; for example …
- drill and ream,
- drill two diameters,
- drill and chamfer,
- drill and spot face,
- drill and counter bore,
- Each cutting edge has a separate land and flute, fig. which enables cutting to take place and re-sharpening to be easily carried out.

Example of Subland Drills



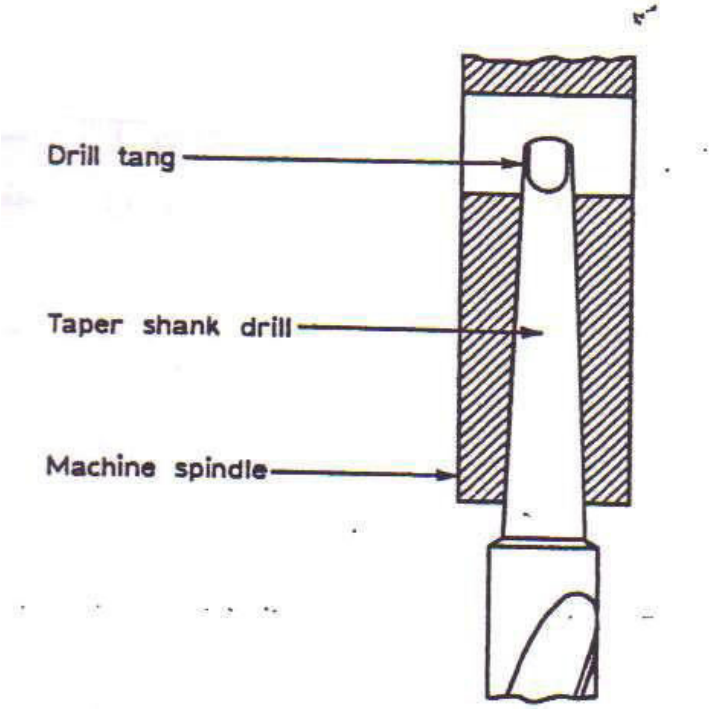
Tool Holding

- Drills and similar tools with parallel shanks are held in a drill chuck.
- By rotating the outer sleeve, the jaws can be opened and closed.
- To ensure maximum grip, the chuck should be tightened using the correct size of chuck key. This prevents the drill from spinning during use and chewing up the drill shank.



Tool Holding

- The chuck is fitted with a Morse-taper shank which fits into a corresponding Morse taper in the spindle.
- Drills are also available with Morse-taper shanks which fit directly into the spindle without the need for a chuck.



Holding taper shank drills

Tool Holding

- Where a cutting tool or chuck has a Morse taper smaller than that of the spindle, the difference is made up by using a **sleeve**.

Morse taper sleeve

Work Holding Devices

- When drilling a hole on a drilling it is important that the workpiece be secured rigidly to the machine table or base.
- Not properly secured work piece may be dangerous except in the case of small drills and very large work pieces.
- The workpiece can be secured in many ways depending upon the size of the job and the accuracy desired.
- A workpiece may be stopped from turning by fixing an obstruction on its way or it may be clamped to the machine table by using bolts or straps.

Drilling Machine Vice

- The **Machine Vice** has slots in the side of the base of the vice which enable the user to screw the **Machine Vice** to the Drilling Machine table.

Direct Clamping

Clamping set

V- Block and Clamps

Used when drilling round bars

Hand Vice

Used when drilling metal sheets

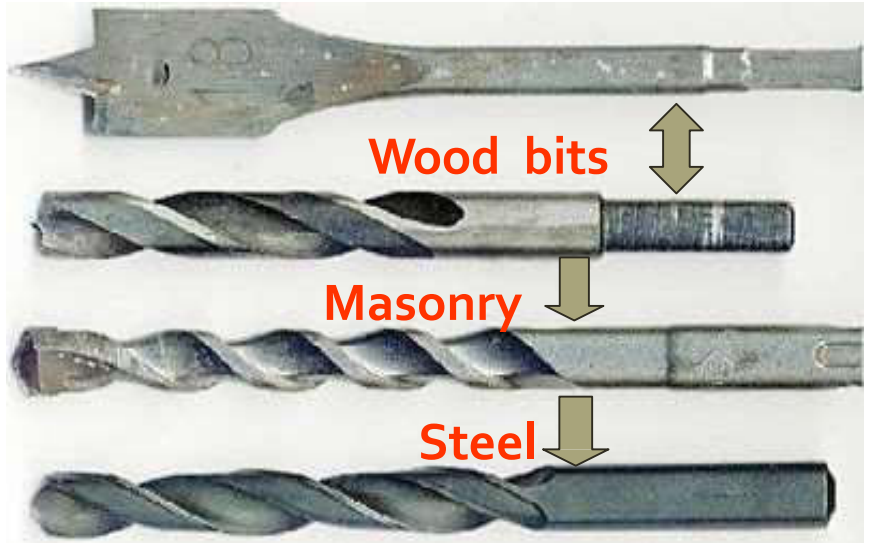
Drilling Machine Operations

- **On drilling machine bellows operation can be done:**

1. Drilling
2. Reaming
3. Boring
4. Counter boring
5. Counter sinking
6. Spot facing
7. Tapping
8. Trepanning

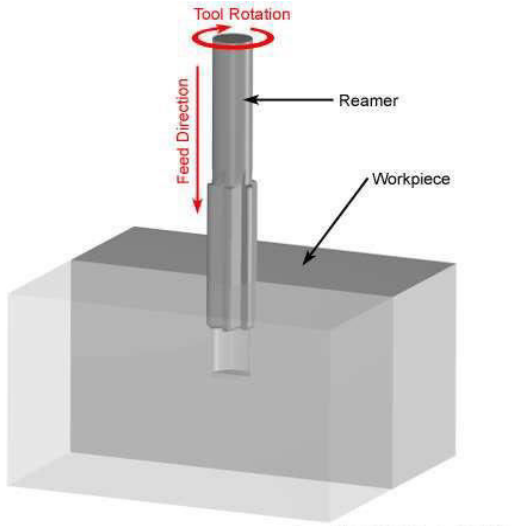
Drilling

- Drilling is the operation of producing circular holes in solid metal by rotating the drill and feeding it through the job. This is the main operation done on the this machine.
- Before starting the drilling it is necessary to mark the position of the hole on the work piece.
- Drilling process is dose not produce accurate hole. The center may not be accurate, the size of the hole is slightly larger than required.



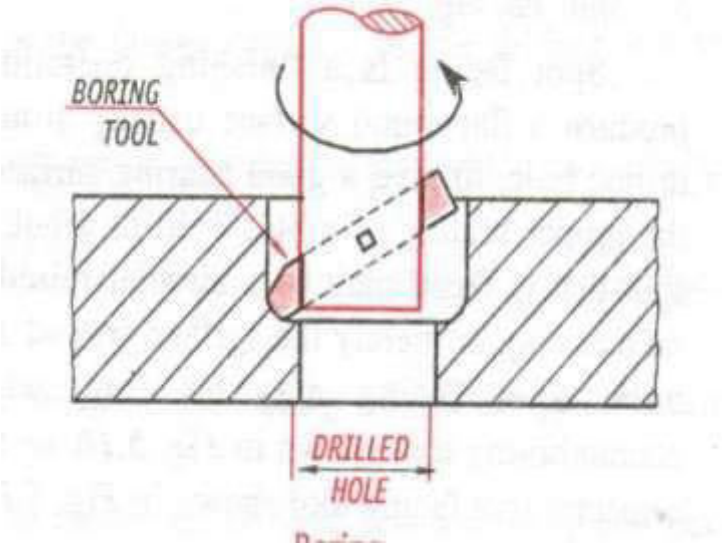
Reaming

- Reaming is an operation of sizing and shaping a hole using a tool called reamer.
- A reamer as shown on figure is multitoothed tool designed for remove relatively small amount of material from a previously drilled hole.
- Reaming is done to achieve accurate hole dimension.
- Initially a hole is drilled slightly smaller in size.



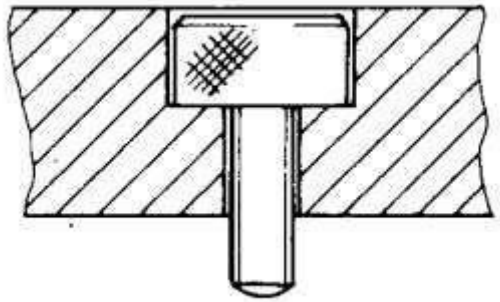
Boring

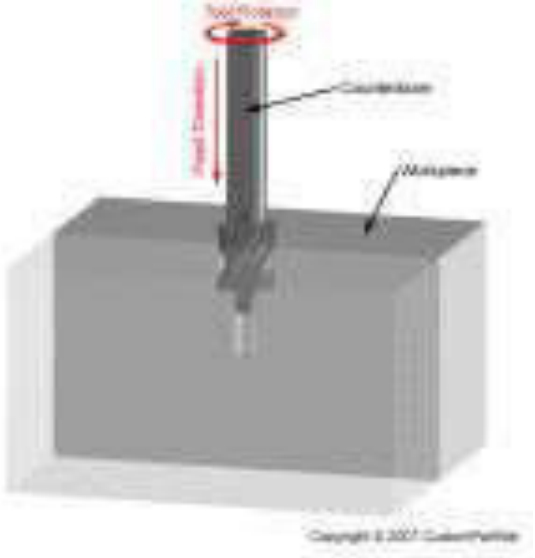
- Boring is a process of aligning, sizing and finishing a cylindrical hole.
- It uses single point cutting tool which rotates relative to the stationary work piece.
- The hole can be aligned and sized with good surface finish.
- Boring is often used to enlarge the drilled holes.



Counter Boring

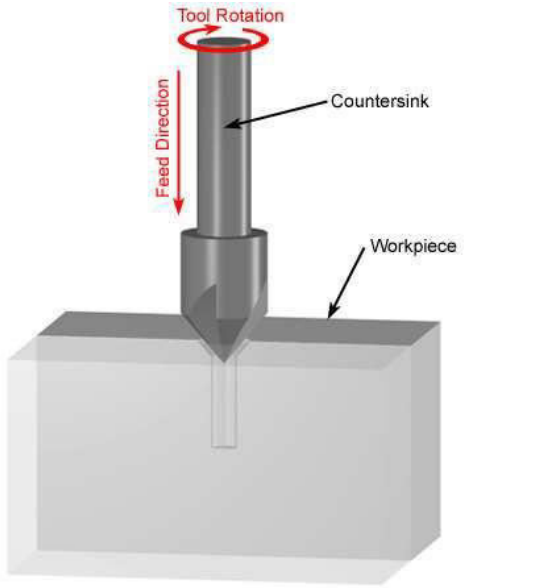
- Counter boring is the operation of enlarging one end of an existing hole concentric with the original hole with a square bottom as shown in figure.
- The counter tool known as counter bore has a pilot as shown in figure.
- The pilot enters in previously drilled hole and align the tool so that the counter bored hole is concentric with the existing hole.
- The tool has end cutting edges square with the axis to produce a flat bottom.
- Counter boring is used to recess a bolt head or a nut below the surface to permit a mitting part to operate with obstruction.

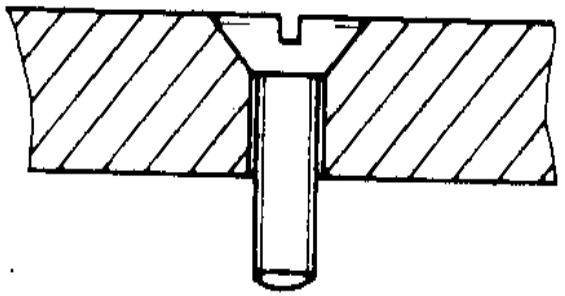




Counter Sinking

- A countersink tool enlarges the top portion of an existing hole to a cone-shaped opening.
- Countersinking is performed after drilling to provide space for the head of a fastener, such as a screw, to sit flush with the workpiece surface.
- Common included angles for a countersink include 60, 82, 90, 100, 118, and 120 degrees.

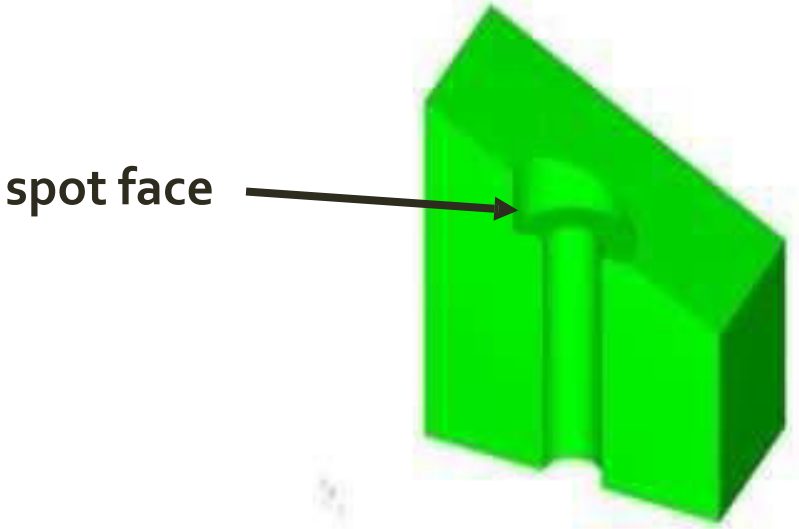




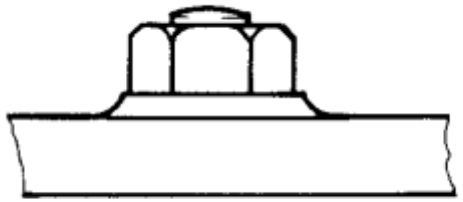
Counter Sinking Bits

Spot Facing

- Spot facing shown in figure is the process of producing a flat machined surface generally around a hole perpendicular to the hole axis.
- This flat surface allows the bottom of a screw or bolt to seat squarely with the material.
- Spot facing is commonly done on castings where irregular surfaces are found.
- Spot facing may be performed on a drill press with a counter bore of suitable size for the operation.

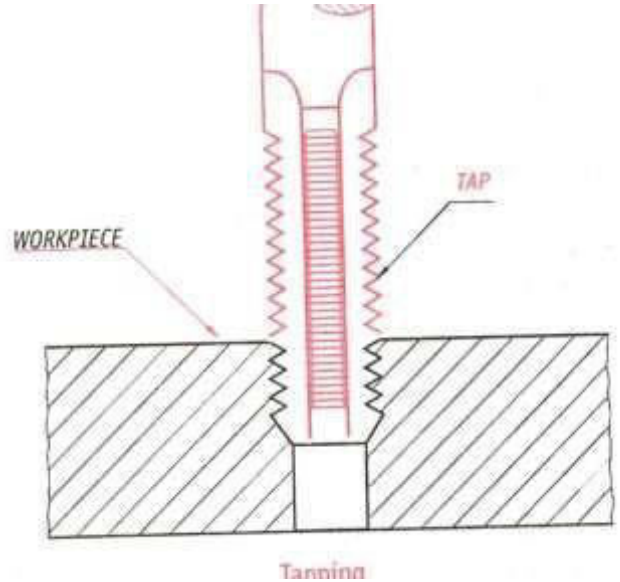


To seat a nut



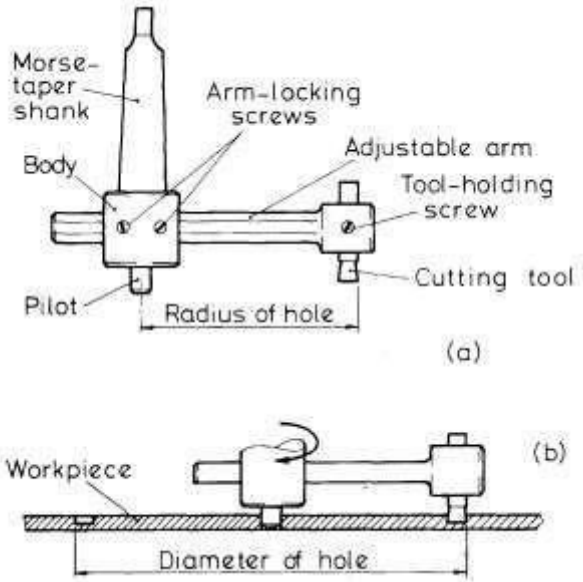
Tapping

- Tapping is a thread cutting for producing internal threads.
- Tapping uses multi- point cutting tool called taps may be done manually or on machine like drills.
- The tapping attachment used with the drill permits forward rotation of the tap when it is cutting and fast reverse rotation for withdrawal.



Trepanning

- Trepanning is the process for making large holes in sheet metal.
- A small diameter hole is drilled in center for drilling large diameter hole.
- The pilot of trepanning tool is fitted into this hole and the length of the adjustable arm is set to the radius of the hole to be cut.
- Holes up to a diameter of 350 mm can be cut by this arrangement.



CHAPTER-4

BORING MACHINES

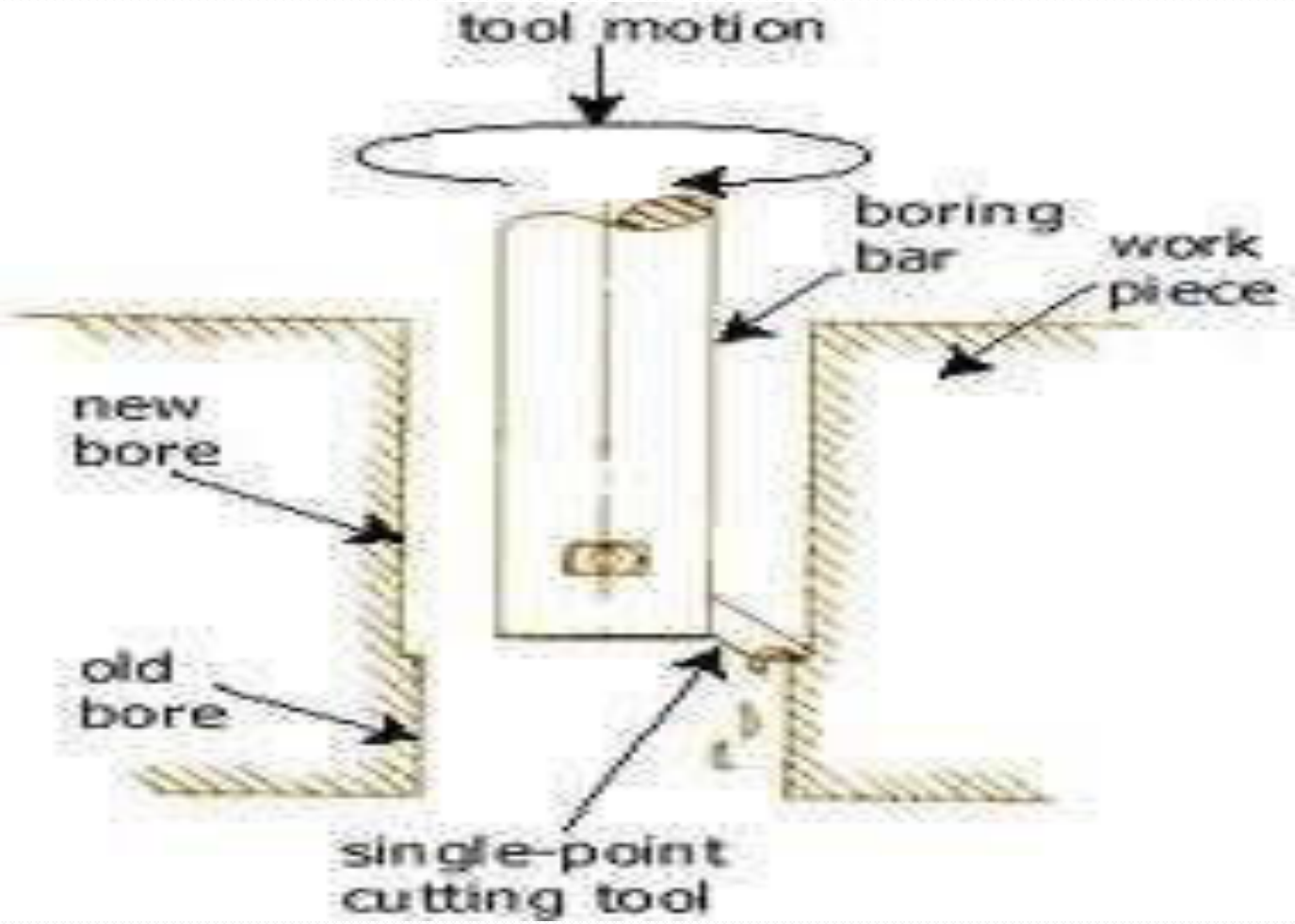
Boring Machine

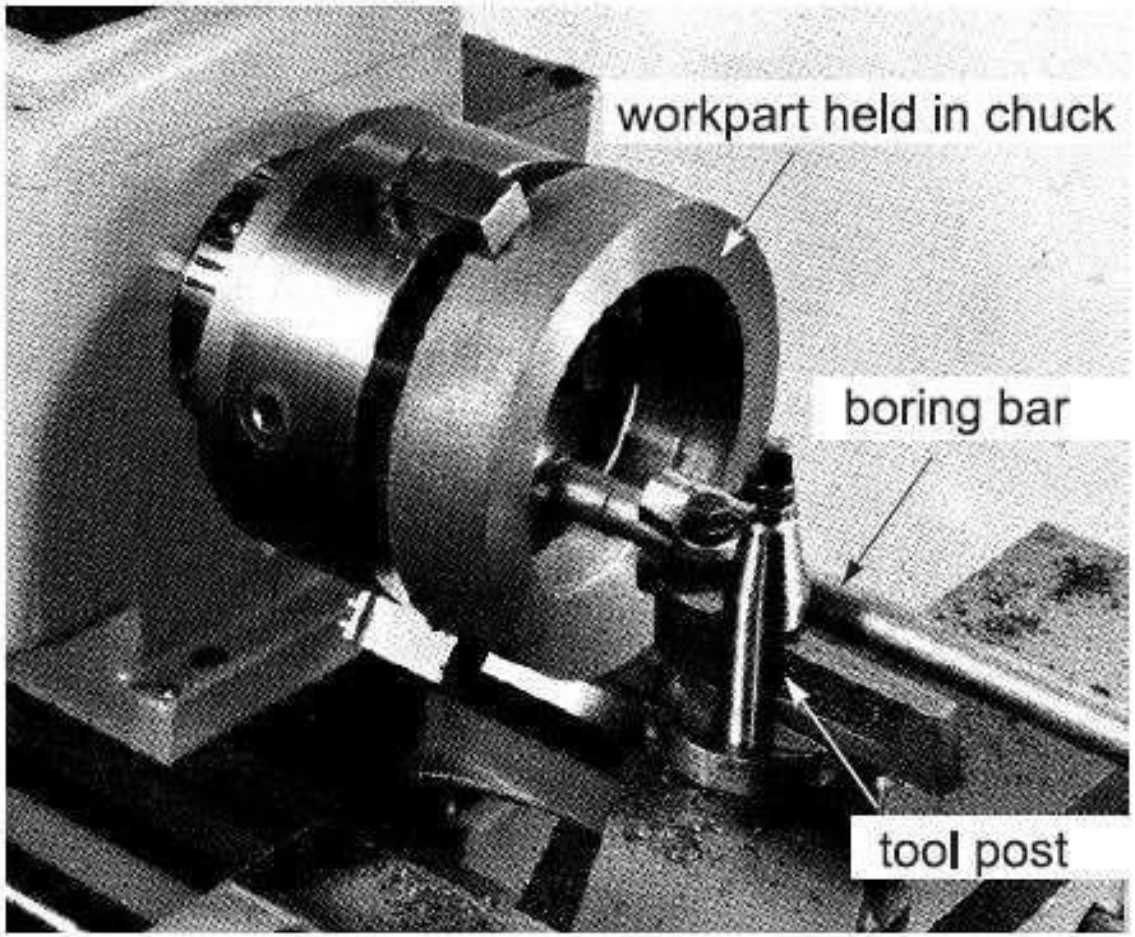
- Boring machine is used to bore holes in
- large & heavy parts such as engine frame
- ,steam engine cylinders ,machine housing etc. which are practicaly impossible to hold and rotate in an engine lathe or drilling machine .
- By using simple attachments boring
- machine can be used for screw cutting
- ,turning ,planetary grinding , gear cutting .

Boring

- Boring is a process of producing circular internal profiles on a hole made by drilling or another process. It uses single point cutting tool called a boring bar. In boring, the boring bar can be rotated, or the workpart can be rotated. Machine tools which rotate the boring bar against a stationary workpiece are called boring machines (also boring mills).
- Boring can be accomplished on a turning machine with a stationary boring bar positioned in the tool post and rotating workpiece held in the lathe chuck as illustrated in the figure. In this section, we will consider only boring on boring machine.

Boring


tool motion
boring bar
work piece
new bore
old bore
single-point cutting tool



Boring operation on a lathe.

6.2 TYPES OF BORING MACHINES

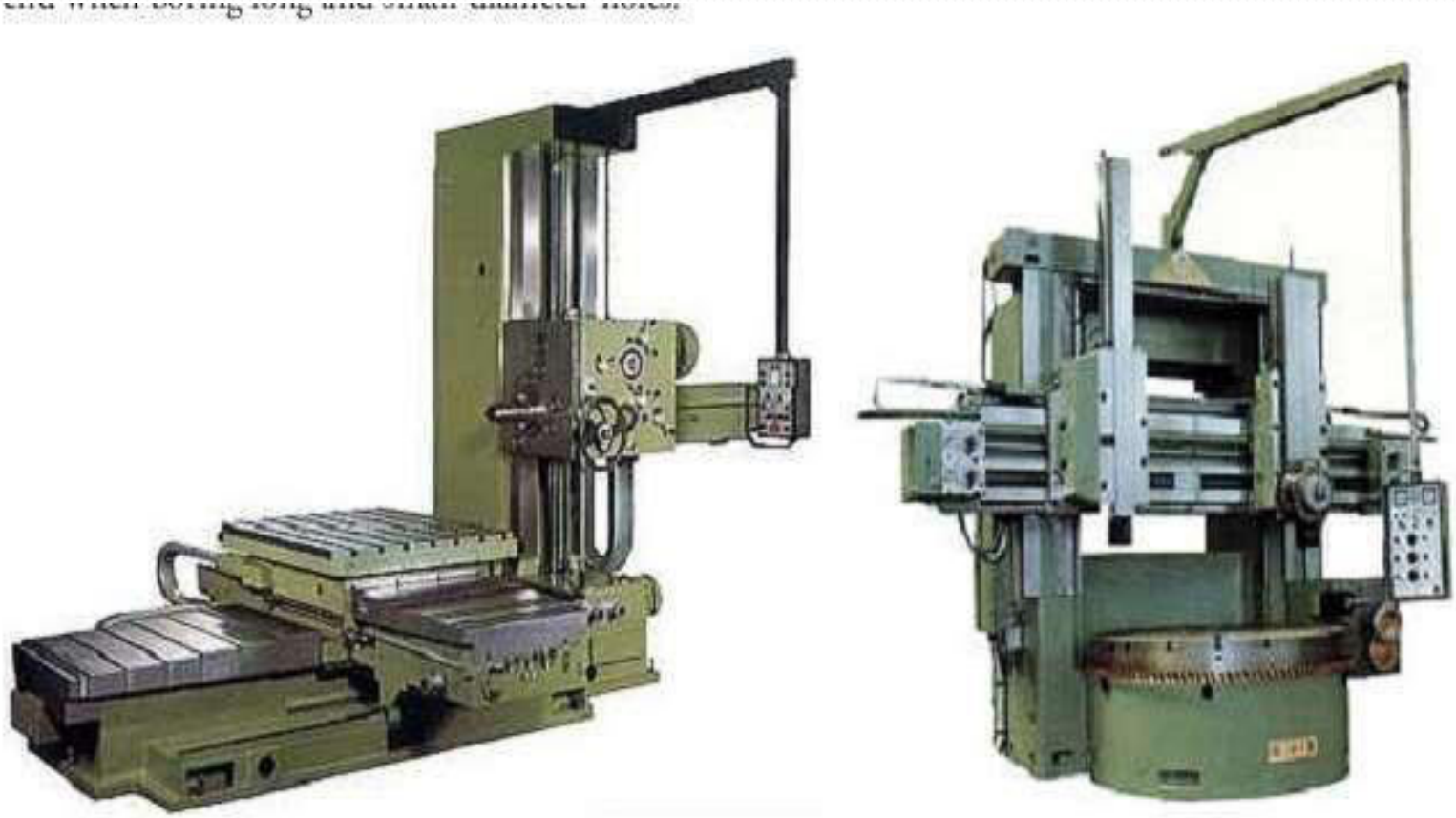
The boring machines may be classified under the four headings

1. Horizontal boring machine.
    - (a) Table type.
    - (b) Floor type.
    - (c) Planer type.
    - (d) Multiple head type.
2. Vertical boring machine.
    - (a) Vertical turret lathe.
    - (b) Standard vertical boring machine.
3. Precision boring machine.
4. Jig boring machine.
    - (a) Vertical milling machine type.
    - (b) Planer type.

Boring Machine

Boring machines can be horizontal or vertical according to the orientation of the axis of rotation of the machine spindle

Boring Machine



Horizontal boring machine (*Left*) and vertical boring mill (*Right*).

Horizontal Boring Machine

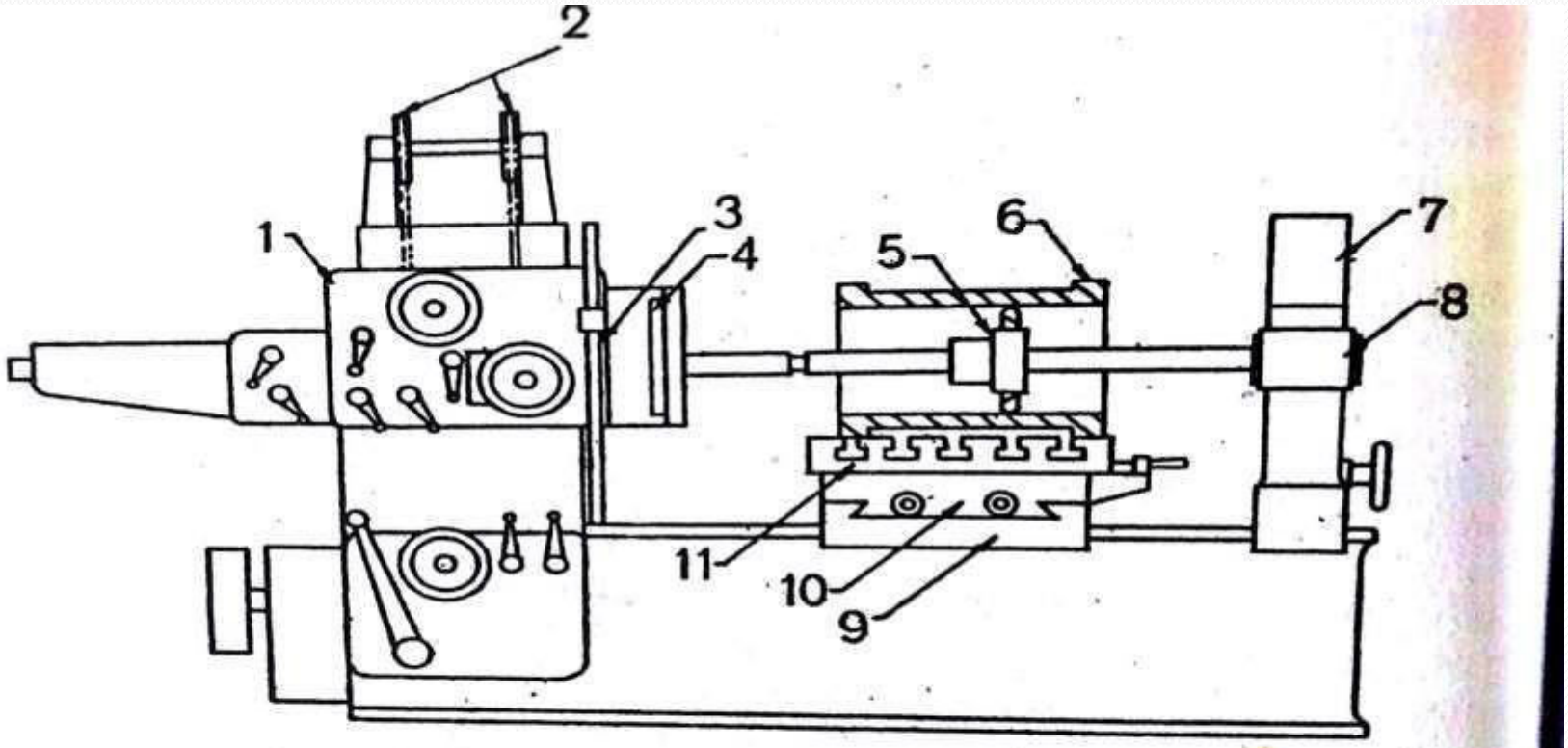
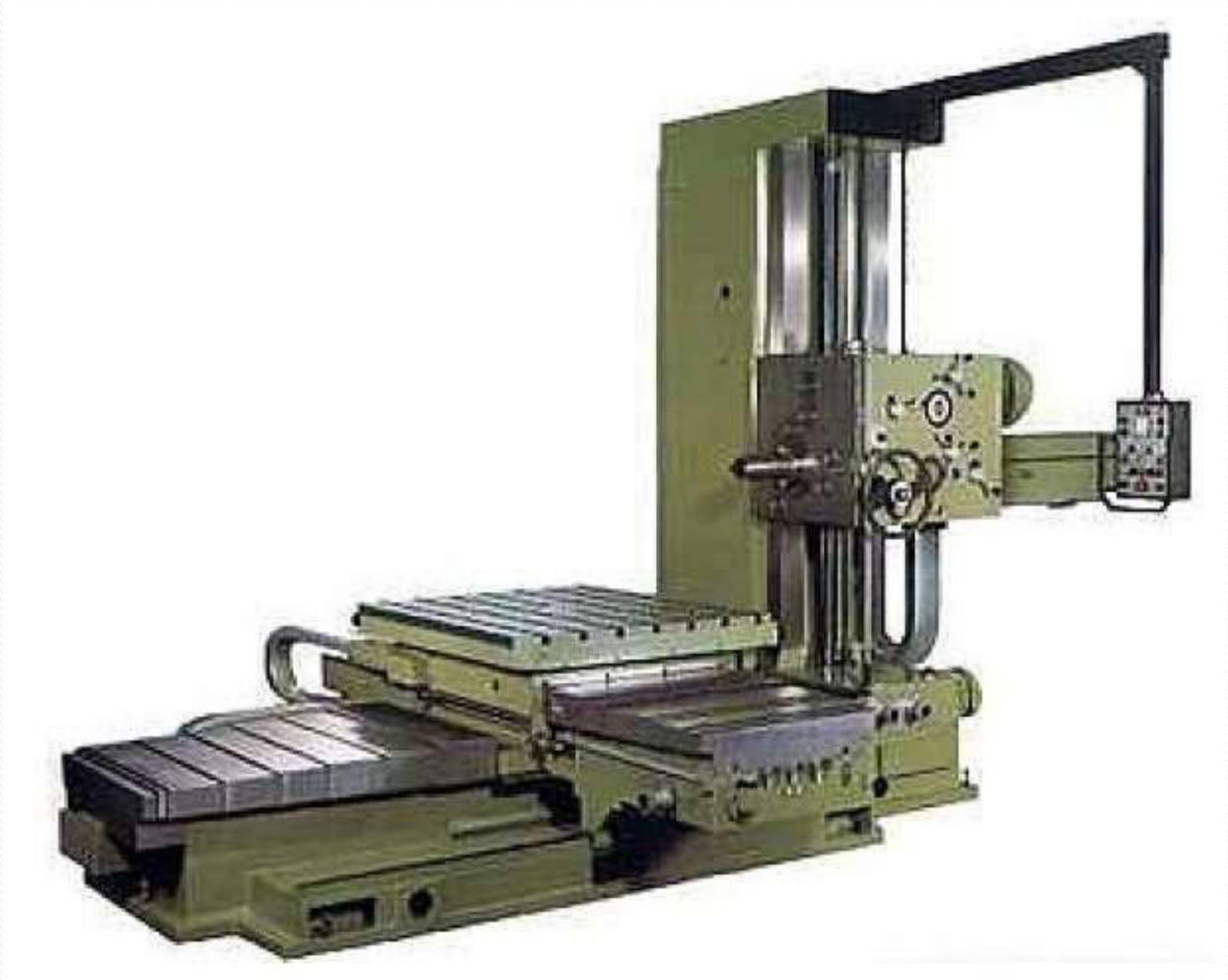


Figure 6.1 Horizontal boring machine

1. Headstock, 2. Pulley for counter balancing weight of headstock, 3. Headstock elevating screw, 4. Boring head, 5. Boring cutter on boring bar, 6. Work, 7. End supporting column, 8. Bearing block, 9. Saddle, 10 Cross-slide, 11. Table.



Parts OF Horizontal Boring Machine

- BED
- Headstock supporting coloum
- End supporting coluum
- Headstock
- Saddle
- Boring Bar

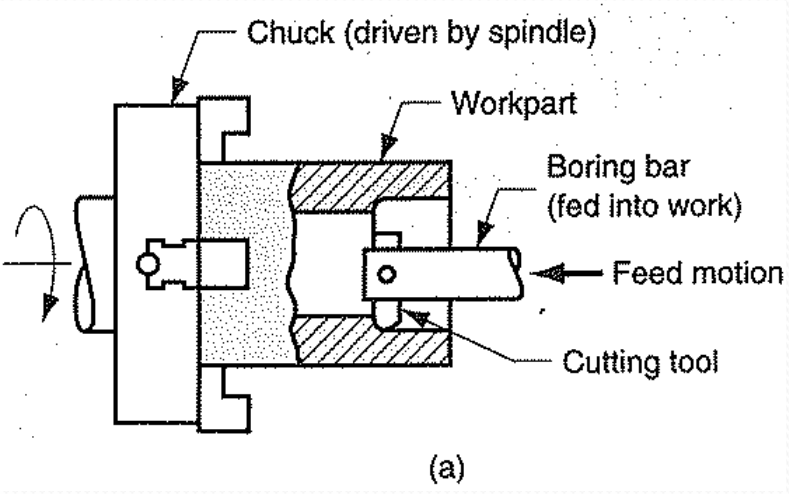
Horizontal Boring Machine

- Work stationary on table (workpies may be heavy , bulky or unsymmetrical ,irregular)
- Tools revolves in horizontal axis
- Boring ,reaming ,turning ,threading ,facing ,milling ,grooving operations can be done with suitable tools.

Horizontal Boring Machine

- In horizontal boring operation, boring bar is mounted in a tool slide, which position is adjusted relative to the spindle face plate to machine different diameters. The boring bar must be supported on the other end when boring long and small-diameter holes

Horizontal Boring Mill



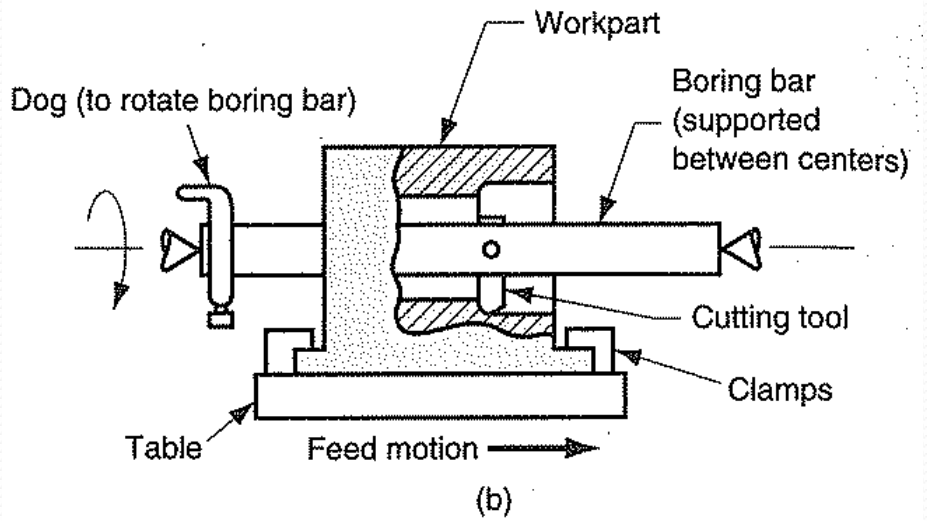
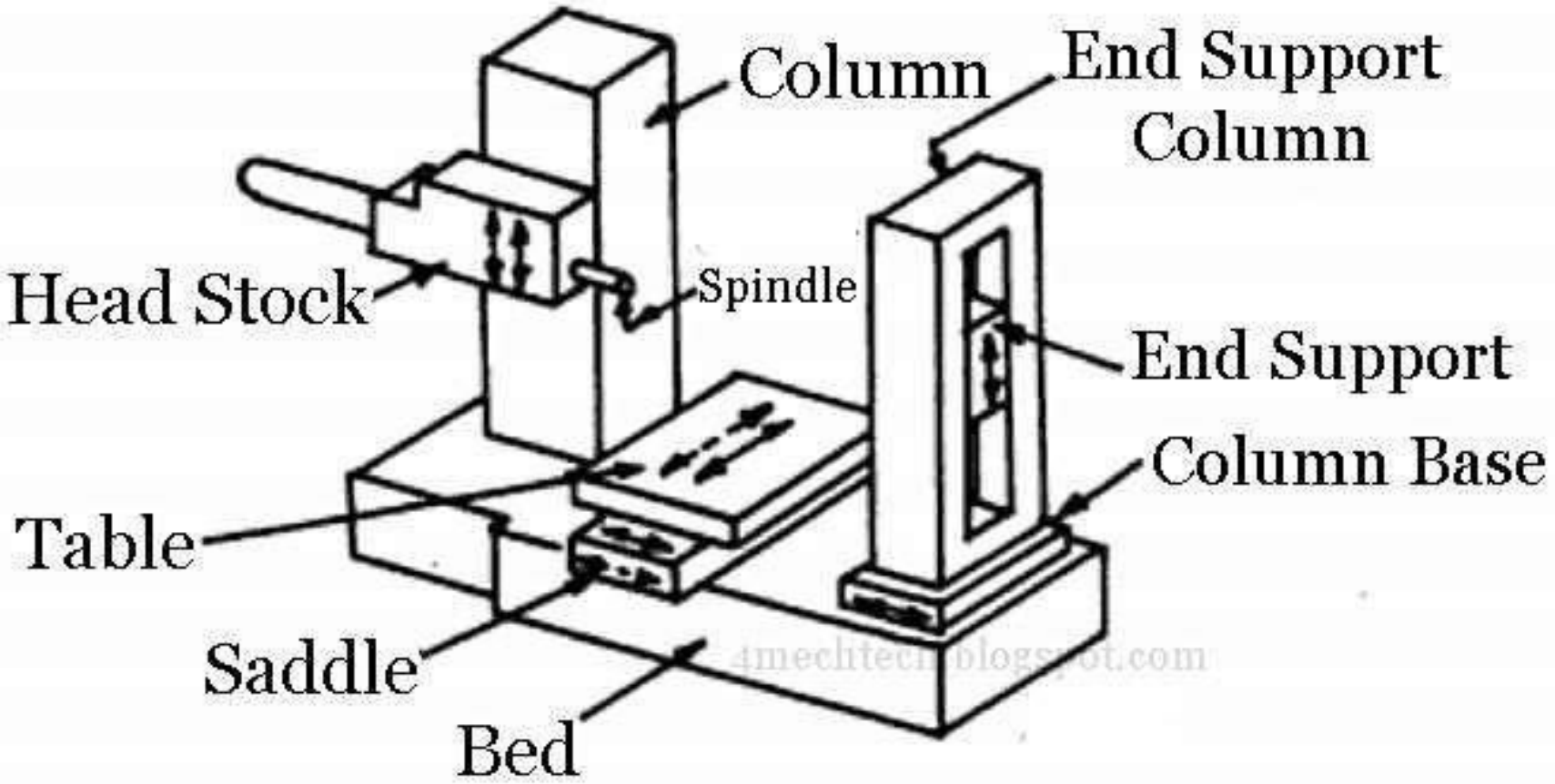


Fig. Horizontal boring m/c

(a) boring bar is fed into a rotating workpart, and (b) work is fed past a rotating boring

- Used when Length of part is larger than its diameter; and the weight is low

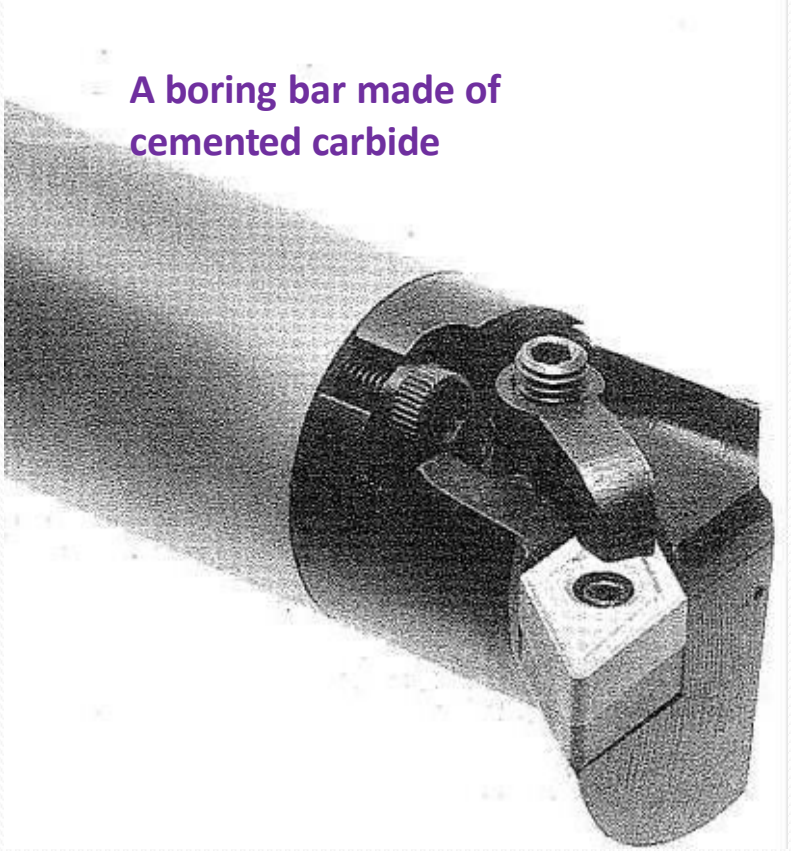
Horizontal Boring Mill



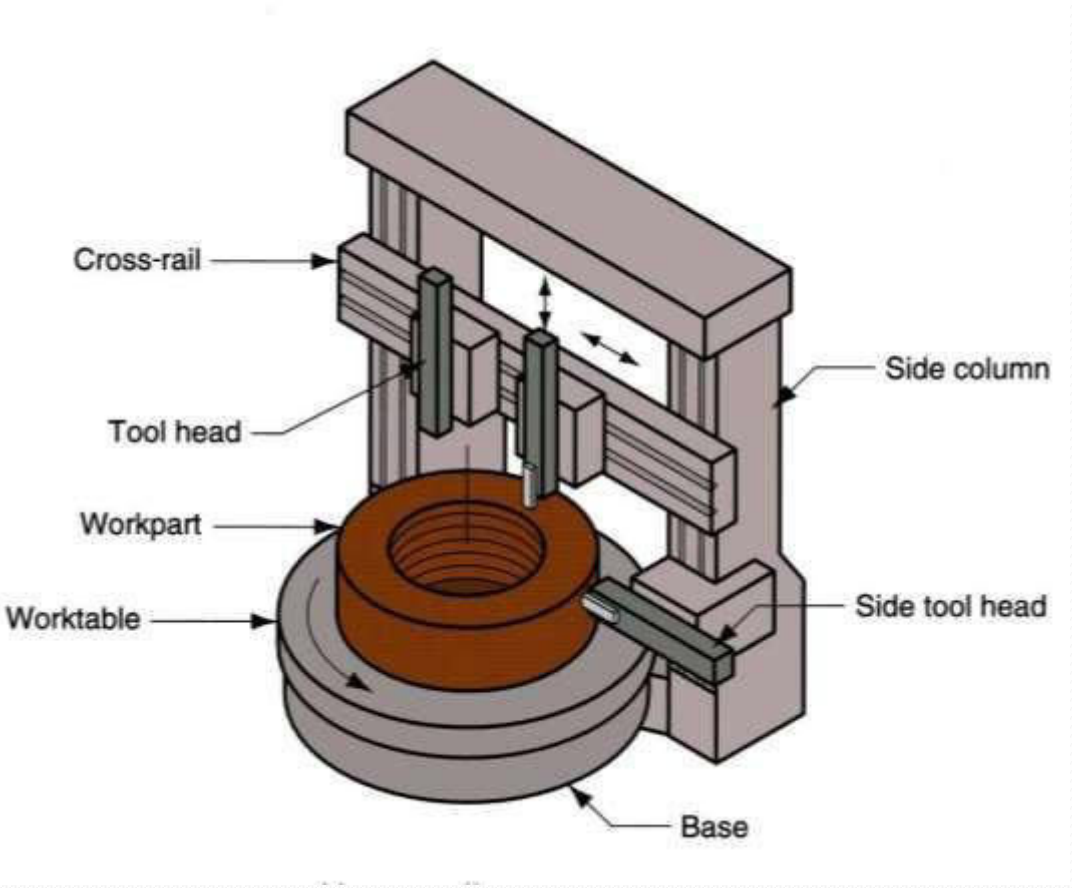
VERTICAL BORING MACHINE

A vertical boring mill is used for large, heavy workparts with diameters up to 12 m. The typical boring mill can position and feed several cutting tools simultaneously. The workpart may be mounted on a rotating worktable.

Vertical Boring Mill



A boring bar made of cemented carbide



A vertical lathe or boring m/c

- Used when Length of part is smaller than its Diameter; and the part is heavy

Vertical Boring Mill

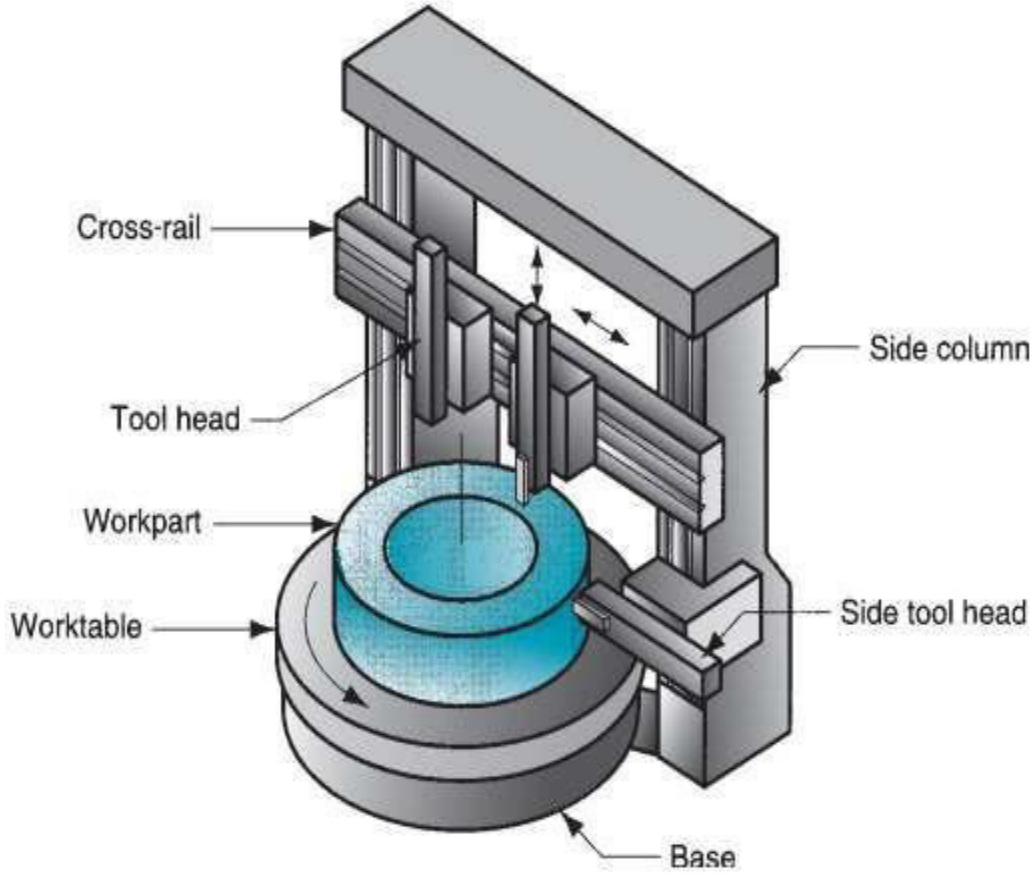
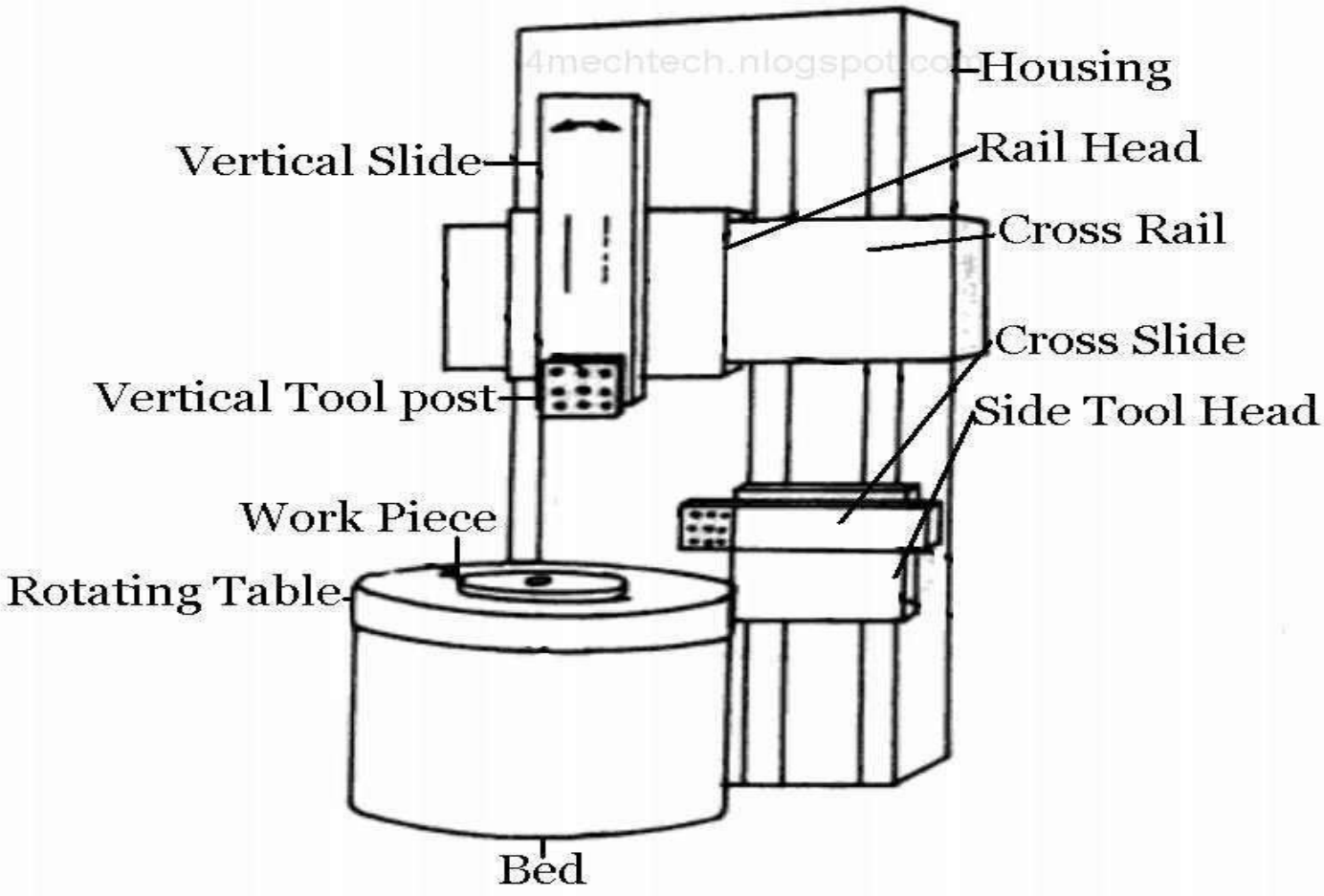


FIGURE 22.12
A vertical boring mill.

Vertical Boring Mill



VERTICAL BORING MACHINE

Typical applications -

- **Line boring of large machine tool casings and engine blocks.**
- **Machining internal bearing diameters in large castings.**
- **Finish machining of cylindrical surfaces on very large work pieces**

Parts OF Vertical Boring Machine

- BED
- Table
- Housing
- Crossrail
- Tool-head assembly

Cutting tool for boring (boring bar)

The typical boring bar is shown in the figure. When boring with a rotating tool, size is controlled by changing the radial position of the tool slide, which hold the boring bar, with respect to the spindle axis of rotation. For finishing machining, the boring bar is additionally mounted in an adjustable boring head for more precise control of the bar radial position.

BORING HEAD OR CUTTER HEAD

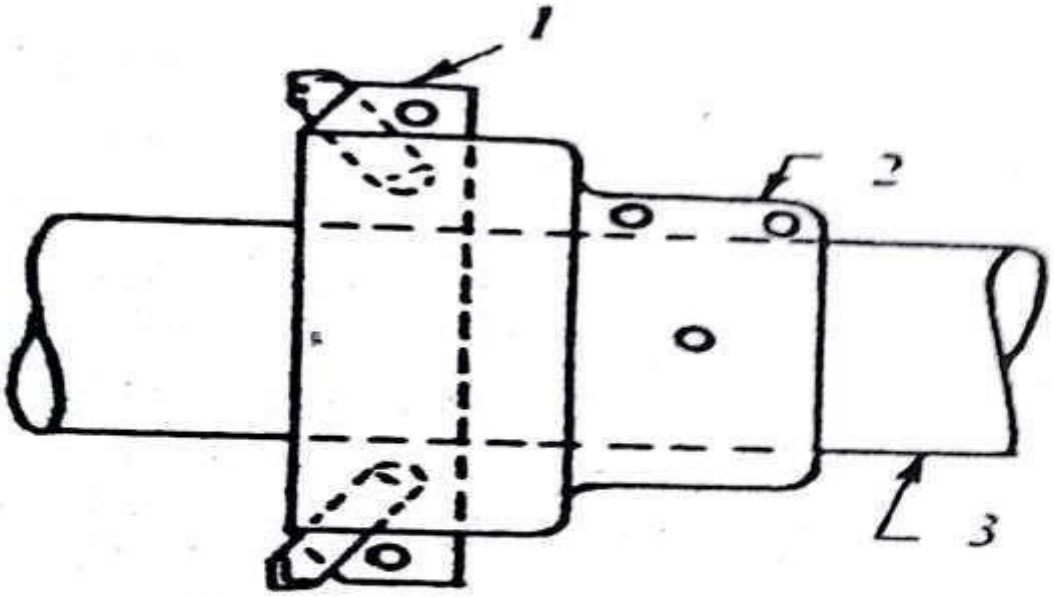


Figure 6.13 Boring head

1. Cutter, 2. Boring head, 3. Boring bar.

Boring Bar

Boring bar with indexable carbide insert (*Left*), and adjustable boring head with accessories (*Right*).

BORING HEAD OR CUTTER HEAD

- Boring heads are used for mounting cutters while machining large diameter holes where a standard boring bar is unsuitable due to smaller diameter or overhanging of cutter.
- Two or more cutters held on boring head
- boring head supports tool & reduce machine time due to larger numbers of cutting edges.

CHAPTER-5

Shaping, Planing and Slotting Machines

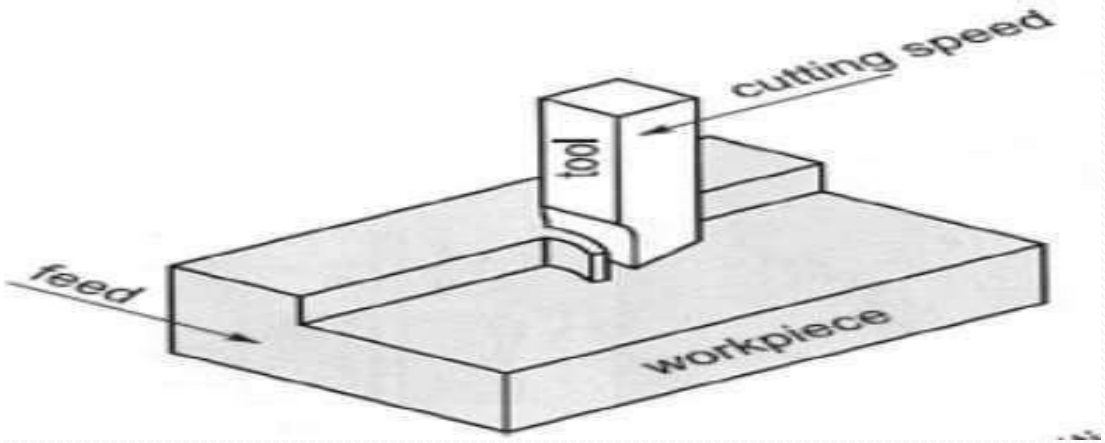
Shaper Machine

- Working Principle:

  The job is rigidly fixed on the machine table. The single point cutting tool held properly in the tool post is mounted on a reciprocating ram. The reciprocating motion of the ram is obtained by a quick return motion mechanism. As the ram reciprocates, the tool cuts the material during its forward stroke. During return, there is no cutting action and this stroke is called the idle stroke. The forward and return strokes constitute one operating cycle of the shaper.

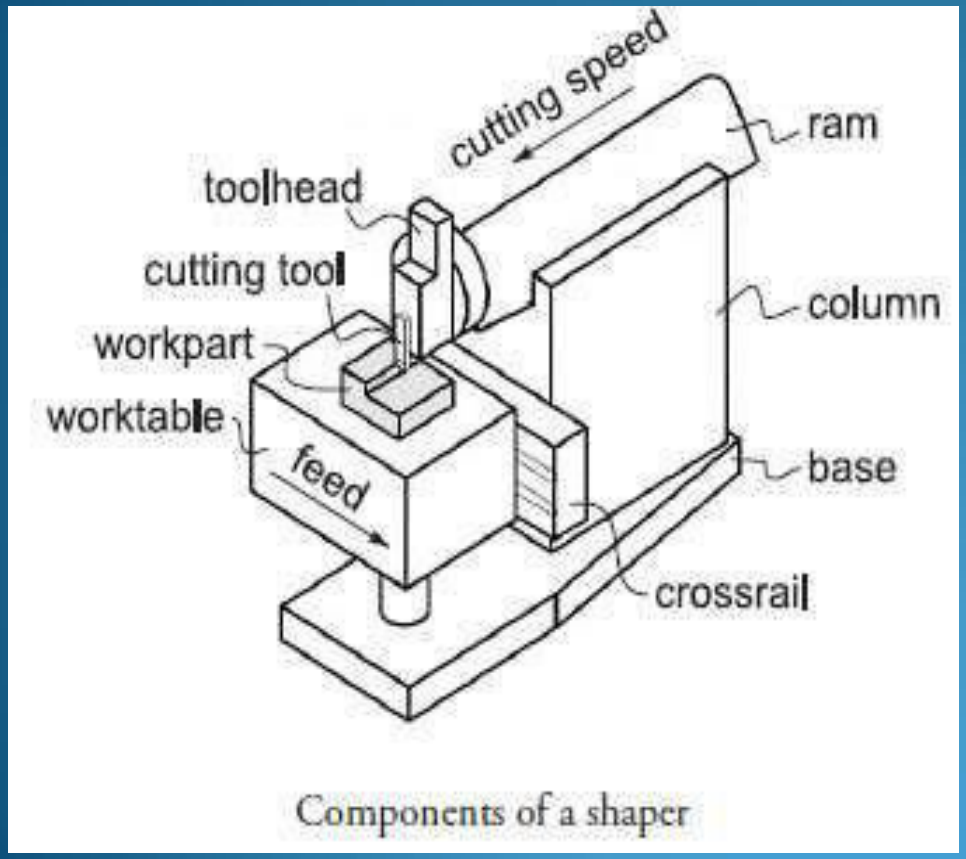
- Kinematic Scheme:

In shaping, the primary motion is performed by the tool, and feed by the work piece.

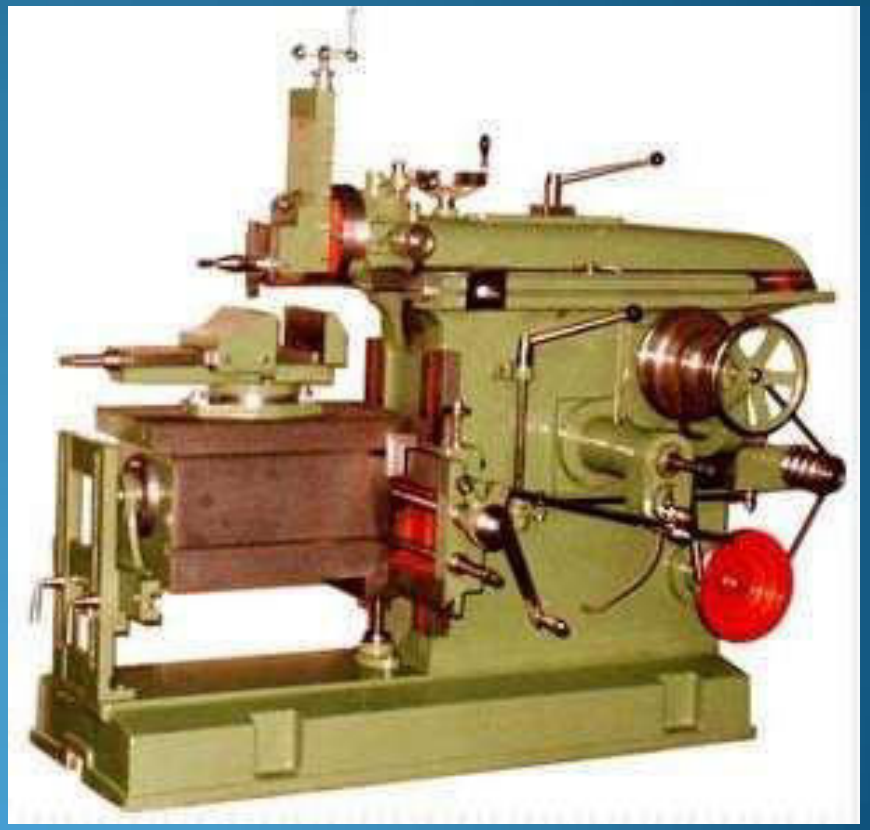


- Principal Parts and Specification:

The major components of a shaper are the *ram*, which has the *tool post* with cutting tool mounted on its face, and a *worktable*, which holds the part and accomplishes the feed motion.



Components of a shaper



- ## Classification of Shapers:

Shapers are classified according to various aspects.

1)Based on type of mechanism employed for the movement of the cutting tool i.e. tool carrying ram the shapers are classified into three types

a. Crank type
b. Gear type
c. Hydraulic type

2)According to position and movement of ram the shapers are classified in to three types

a. Horizontal type
b. Vertical type
c. Travelling head type

3) Shapers are classified in to two types based on design of the work table

a. Standard shaper
b. Universal shaper

4) Based on type of cutting stroke employed these are classified in to

a. Push type
b. Draw type

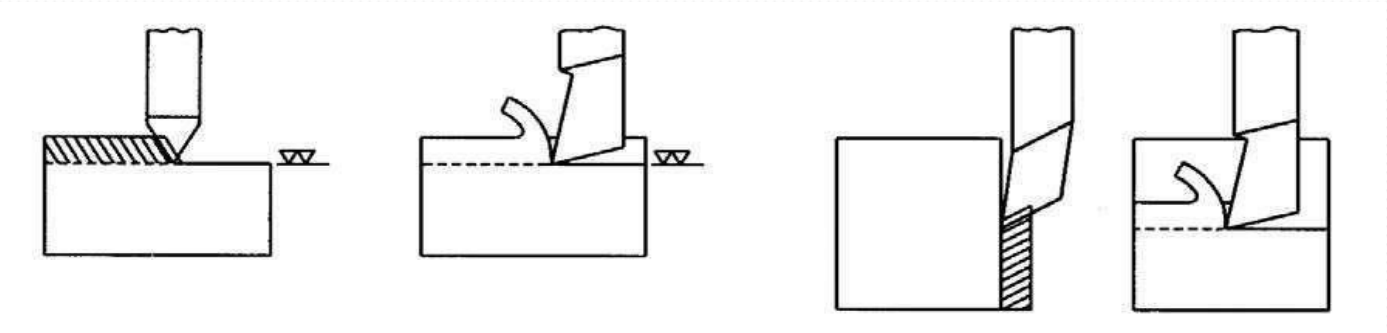
- **Operations Performed on Shaper:**

  Horizontal cutting

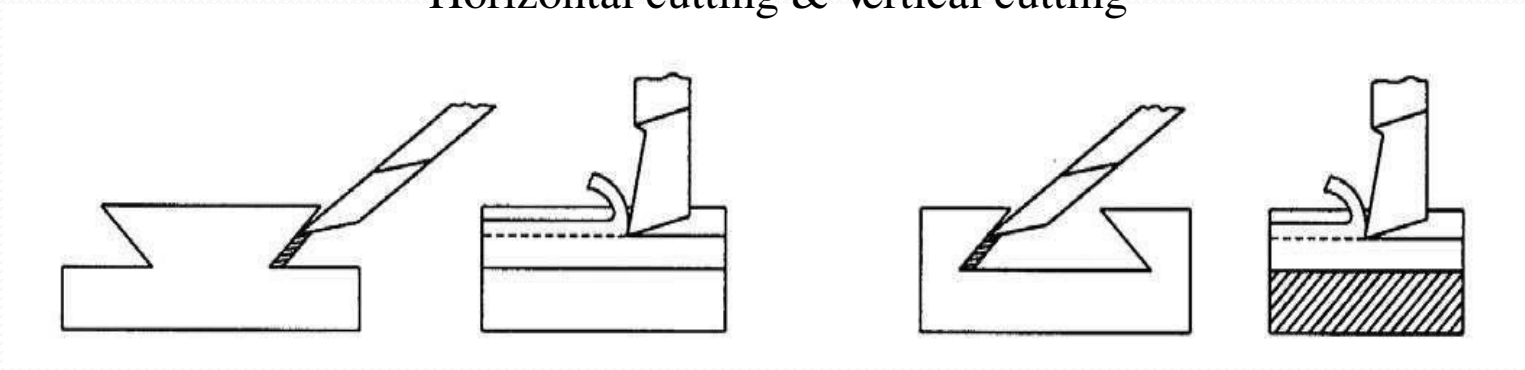
  Vertical cutting

  Inclined cutting

  Irregular cutting



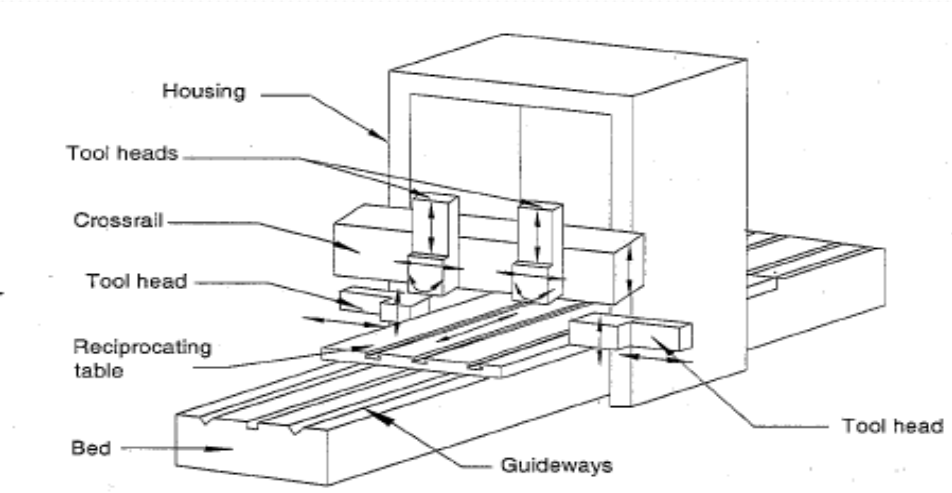
Horizontal cutting & Vertical cutting

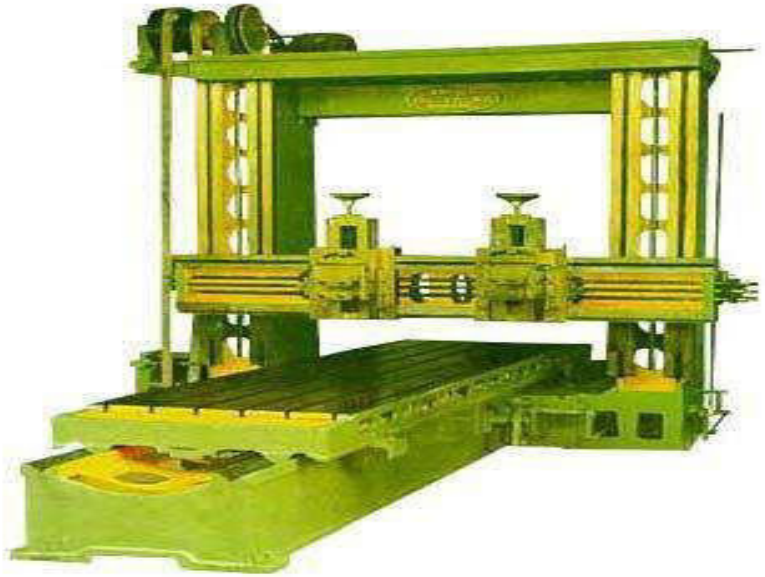


Inclined cutting & Irregular cutting

Planing Machine

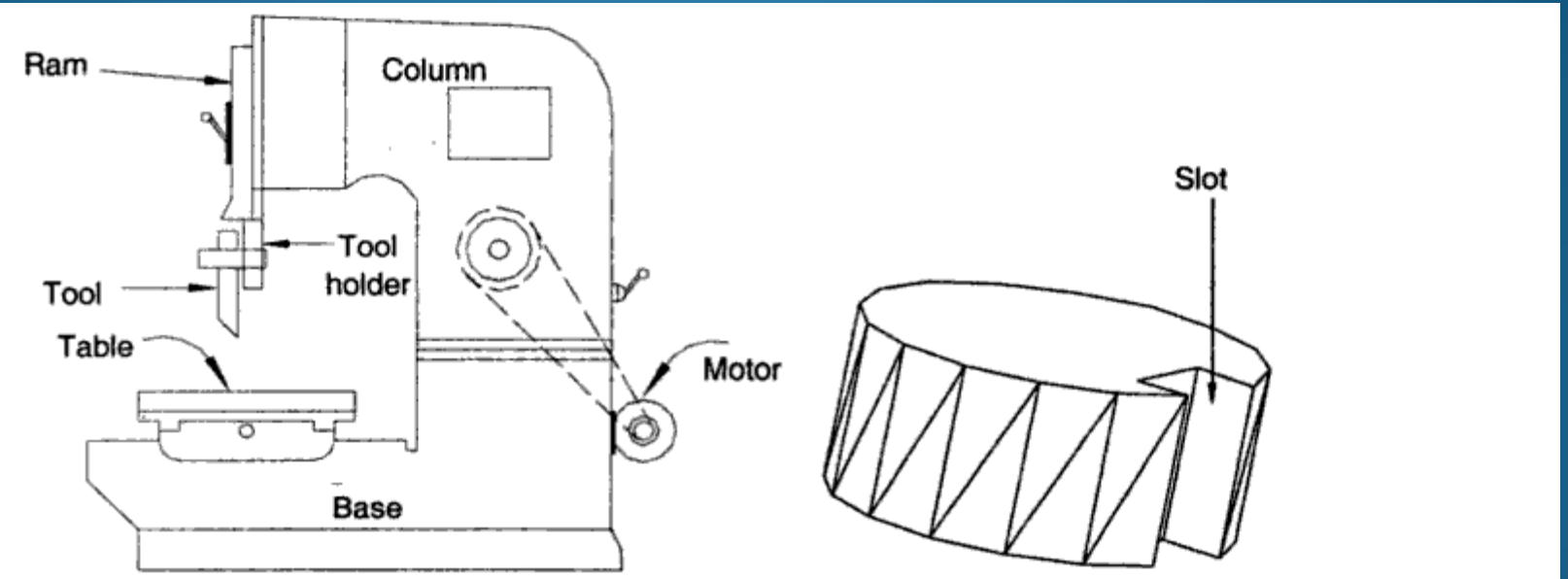
- Planning machines are used for generating large flat surfaces. These flat surfaces may be horizontal, vertical or inclined. Planning machines also perform all the functions that a shaping machine does. The planning machines handle larger and heavy jobs.
- In planning machines the job is mounted on a table which moves forward and backward. The tool is held firmly on the cross rails in the middle of the machine.





Slotting Machine

- Slotting machines can simply be considered as vertical shaping machine. Unlike shaping and planning machines, slotting machines are generally used to machine internal surfaces (flat, formed grooves and cylindrical).



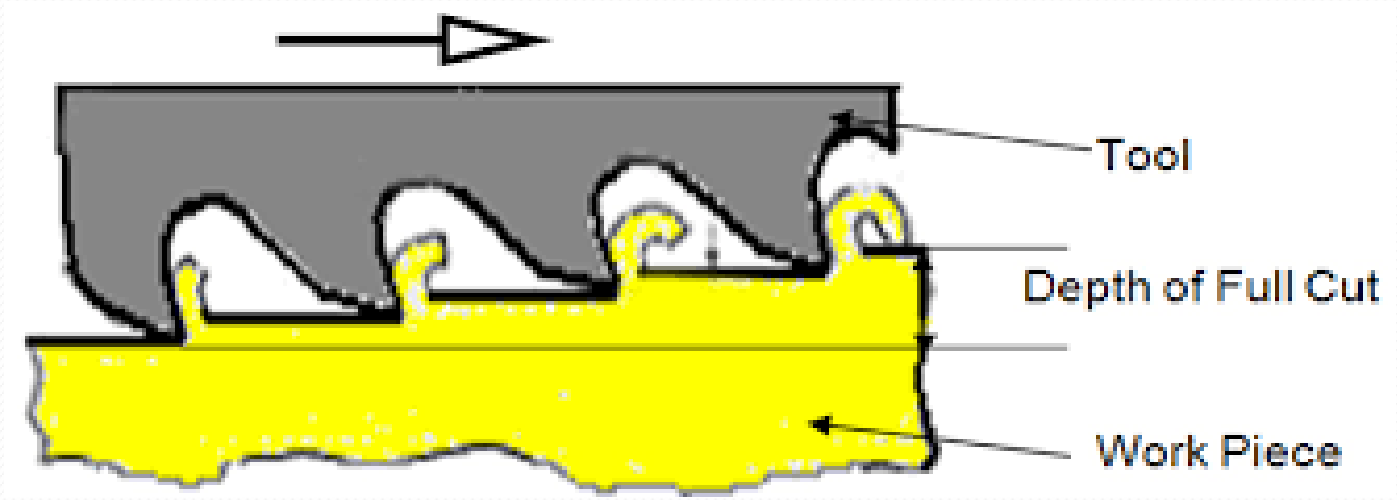
Slotting machine and a slot produced by slotting machine.

CHAPTER-6

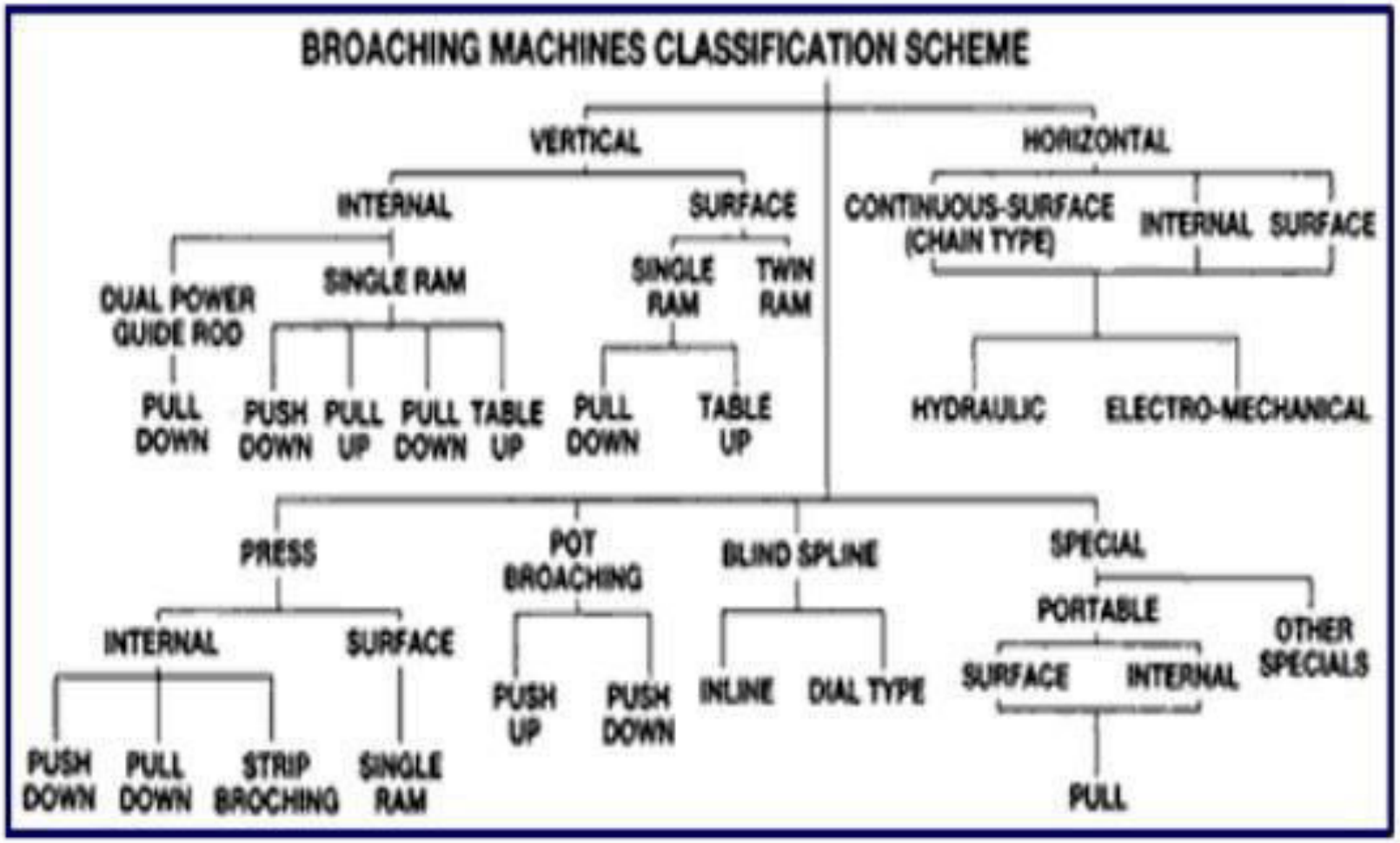
BROACHING

BROACHING

- Broaching is a maching process that uses a toothed tool,called a broach ,to remove material.
- Broaching is a similar technique to shaping with a long multiple-tooth cutter.



Classification of Broaching Macine



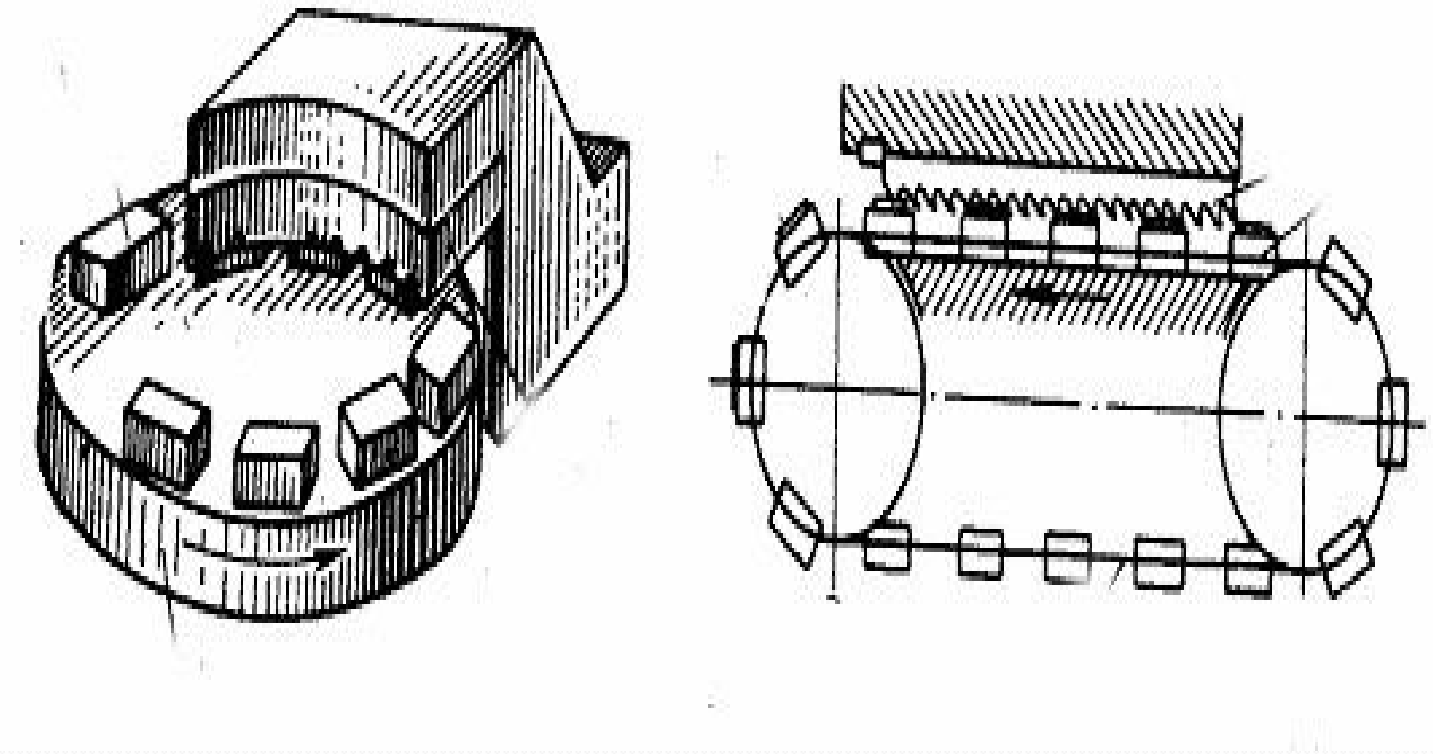
HORIZONTAL BROACHING

These machines are designed for pull broaching, surface broaching, continuous broaching, and rotary broaching

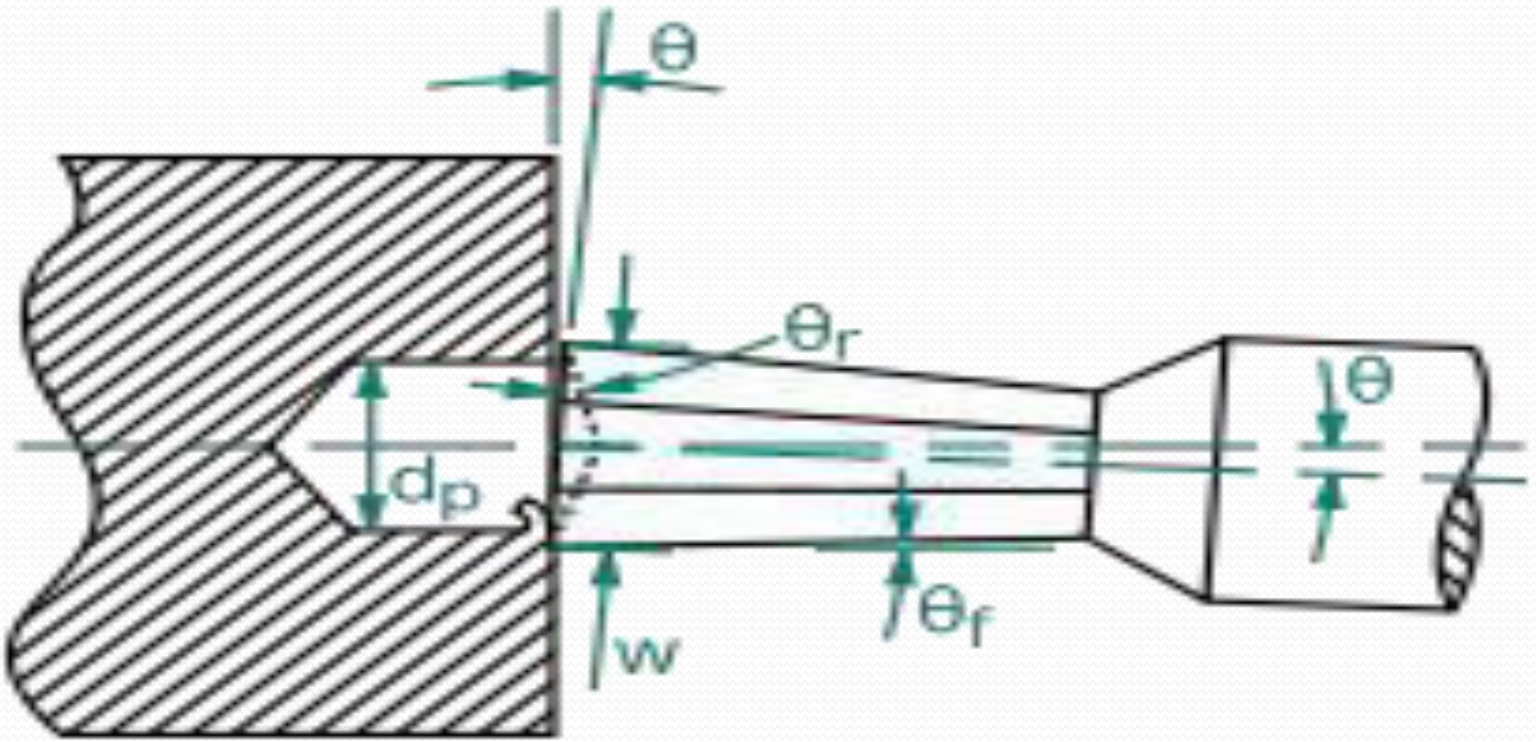
VERTICAL BROACHING

These machines can be designed for push broaching, pull-down broaching, pull-up broaching, or surface broaching.

CONTINUOUS BROACHING



ROTARY BROACHING



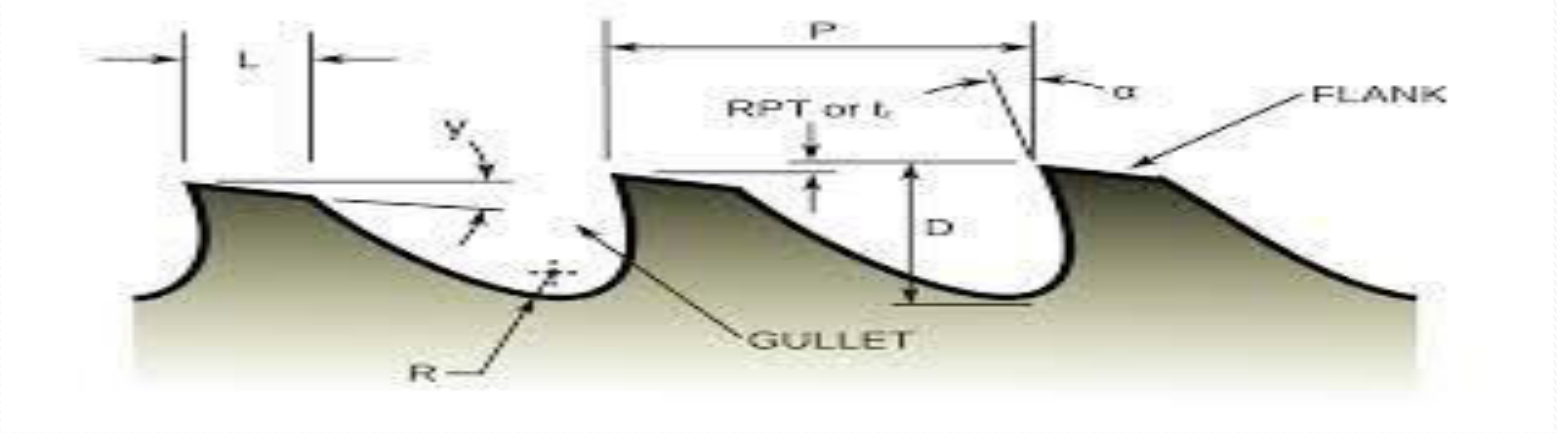
Where

Θ=off- axis angle,

Θ_r =rake,

Θ_f = front releif, W=width across corners, d_p = pilot diameter

BROACHING TOOL



Broaching tool geometry

WHERE

P=pitch, γ=clearance angle, α=rake angle.

RPT=rise per tooth,L=land.

R=radius of the gullet.

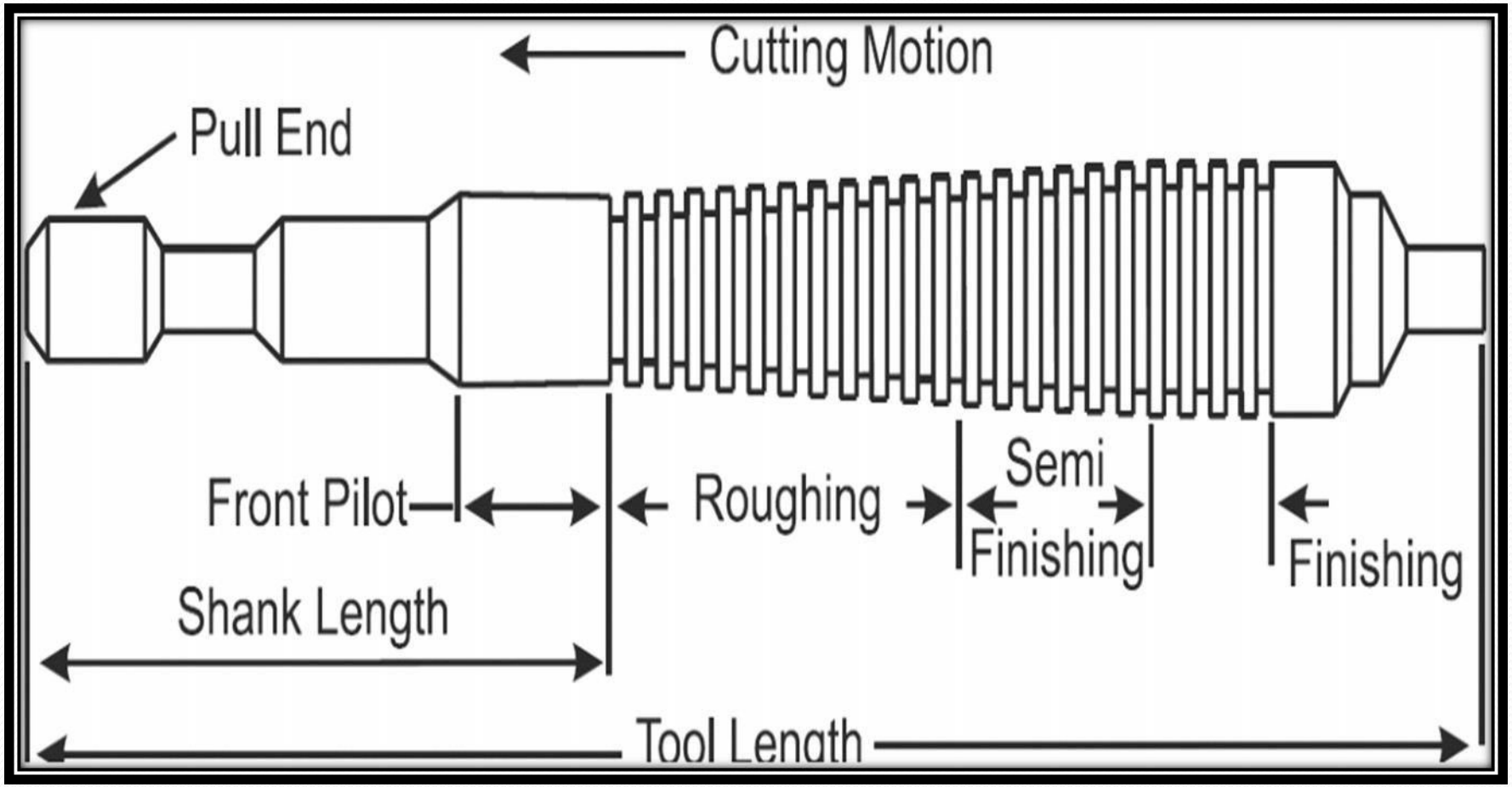
D=depth of the tooth.

Broaching Tools

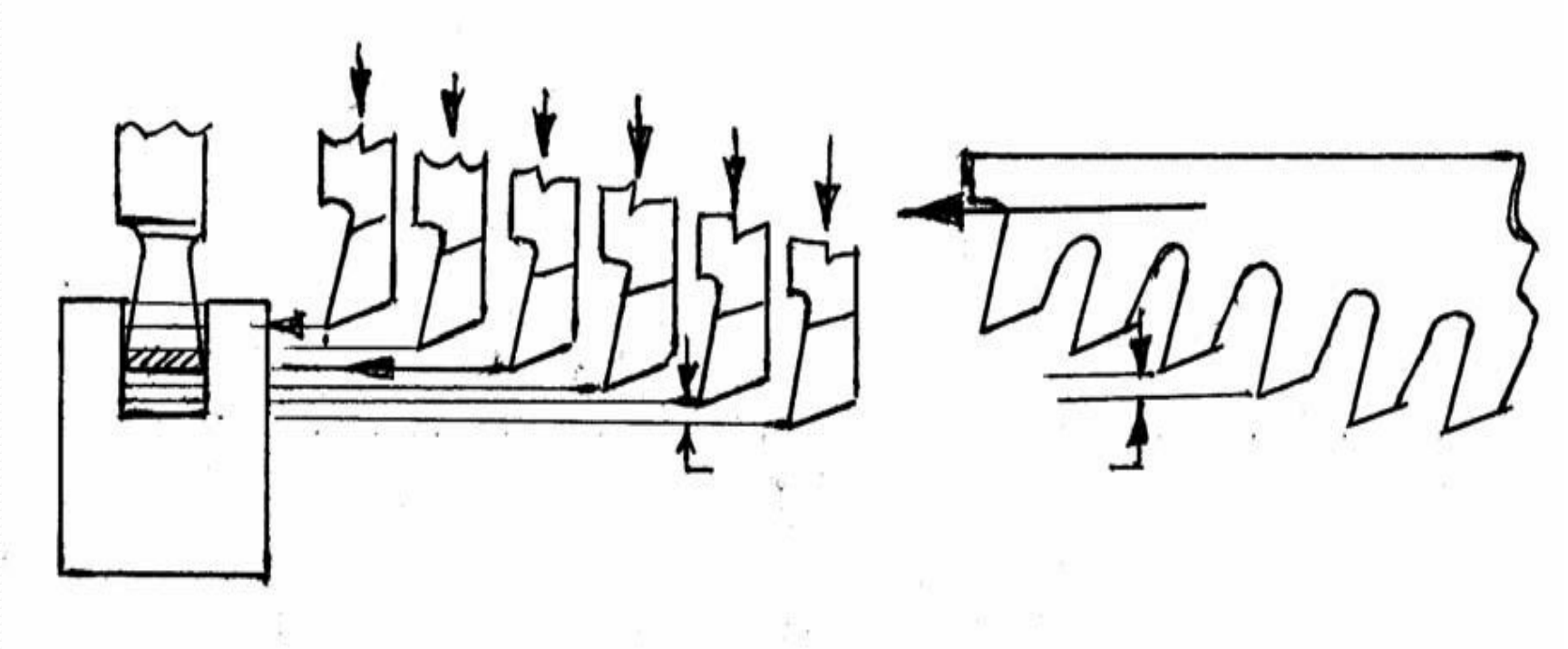
Design and construction considerations

- – Material to be broached
- – Size and shape of cut
- – Quality of surface finish
- – Part tolerance
- – Productions rates
- – Type of machine
- –Workholding method
- – Strength of the workpiece

DESIGN

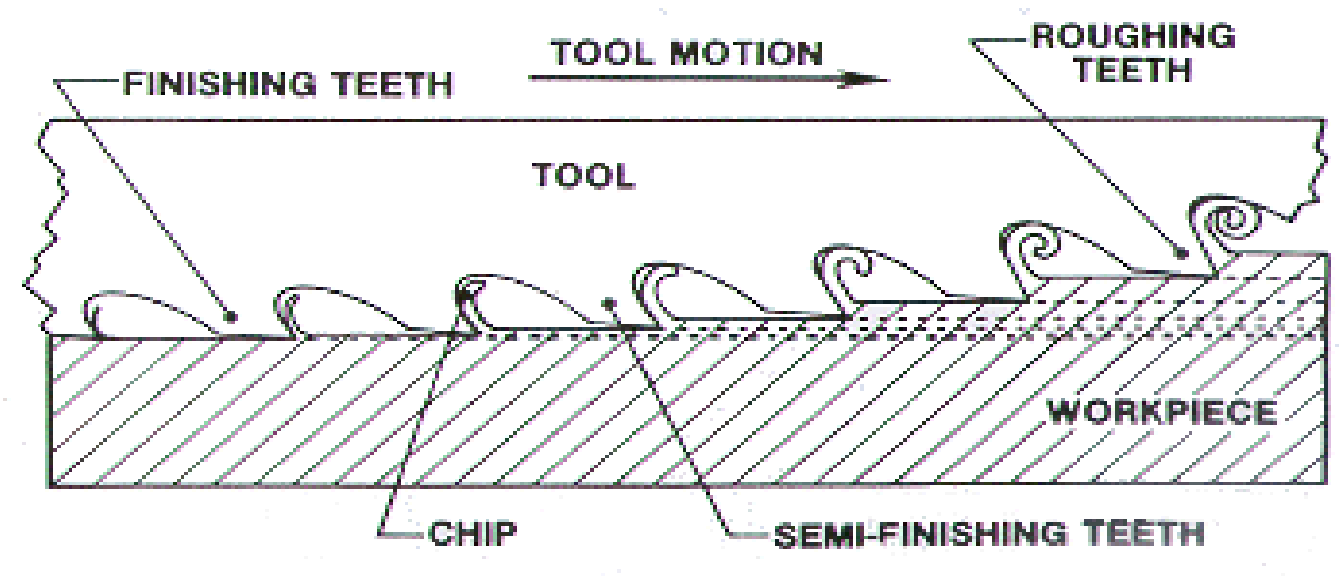

Cutting Motion
Pull End
Front Pilot
Roughing
Semi
Finishing
Finishing
Shank Length
Tool Length

BASIC PRINCIPLE OF BROACHING

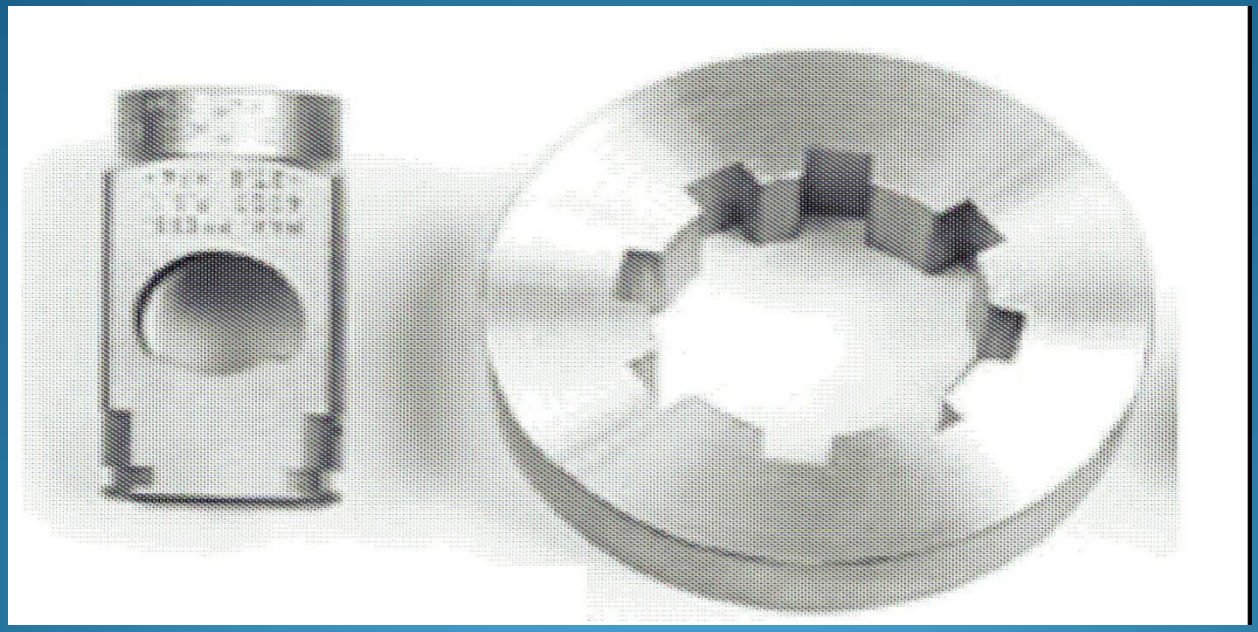


WORKING

- Uses a single pass for finished shapes or sized.
- Uses a multipoint cutting tool (broach) .
- The rise per tooth determines the amount of material removed and the size of chips.



Broaching products



Complex hole shapes cut by broaching

CHAPTER-7

JIGS AND FIXTURES

Definitions

Jig: A device that holds the work and locates the path of the tool.

Fixture: A device fixed to the worktable of a machine and locates the work in an exact position relative to the cutting tool.

JIG

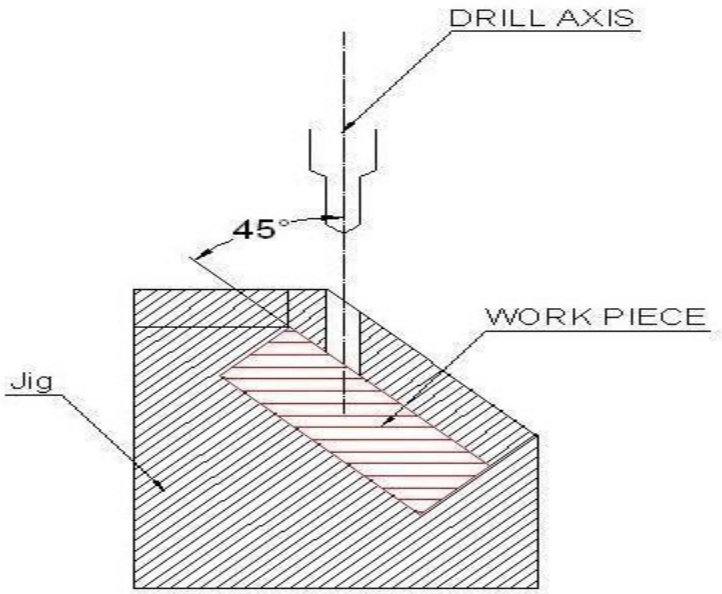


Fig.1.1- Simple Drill Jig

FIXTURE

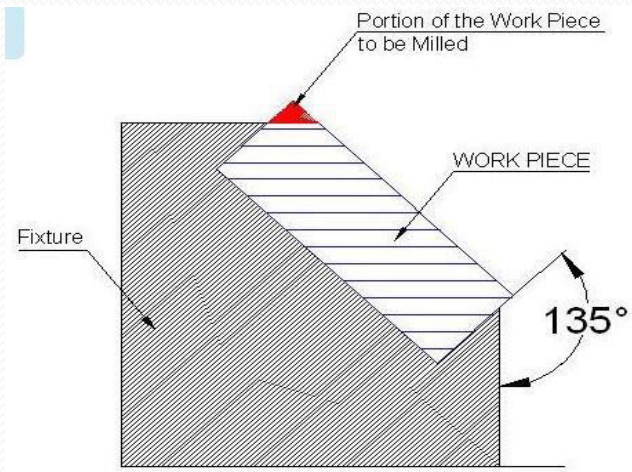
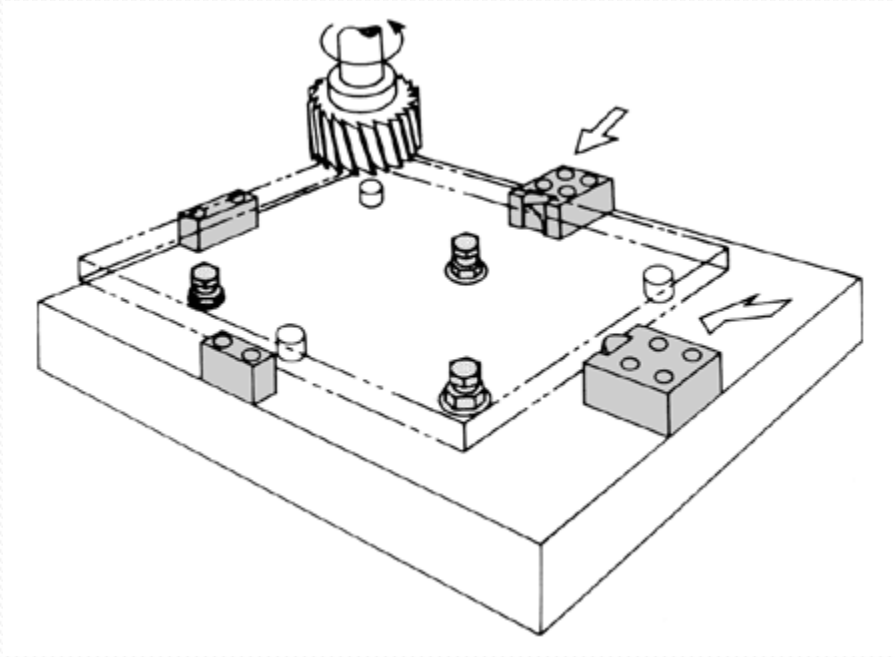
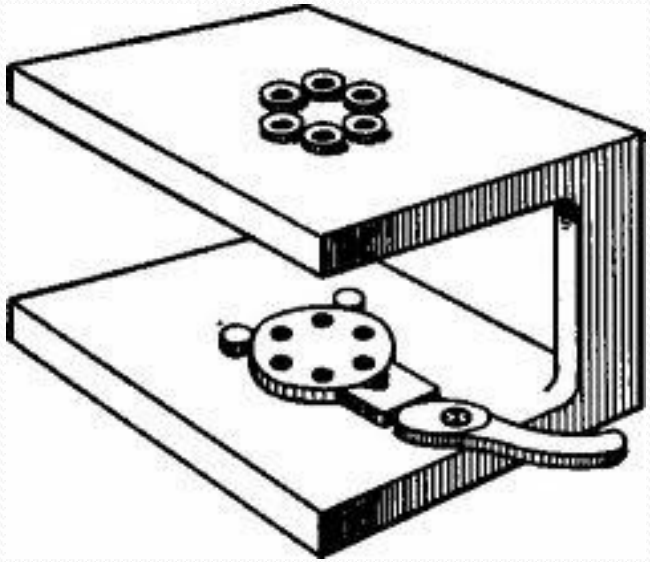


Fig.1.1- Milling Fixture

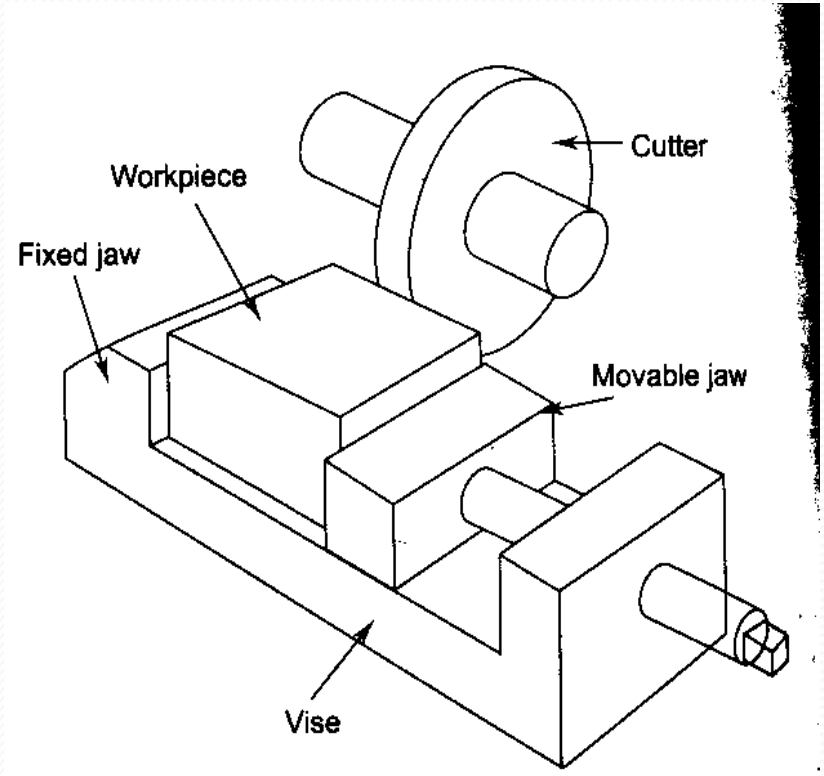


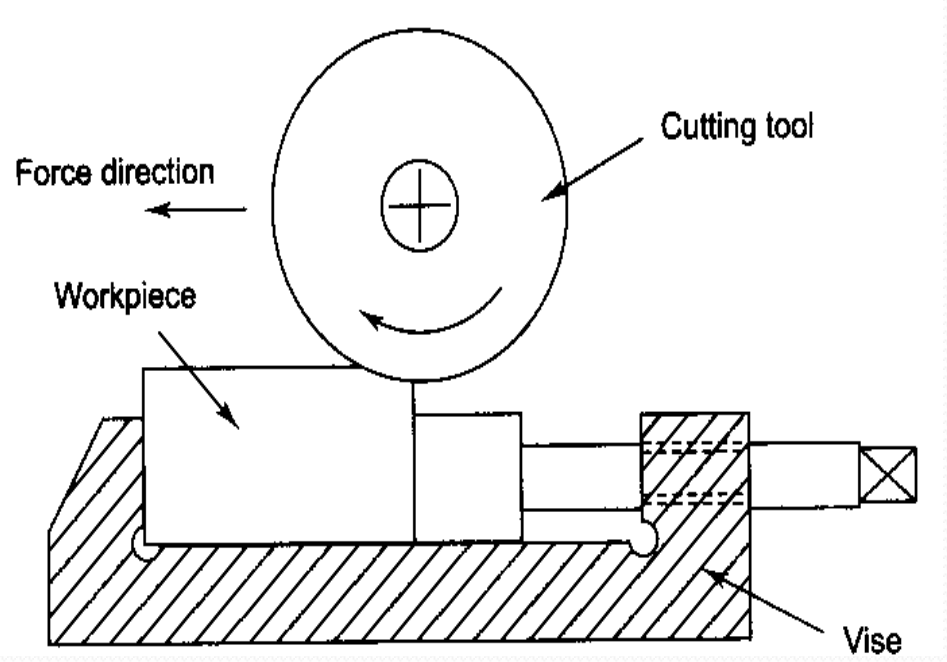


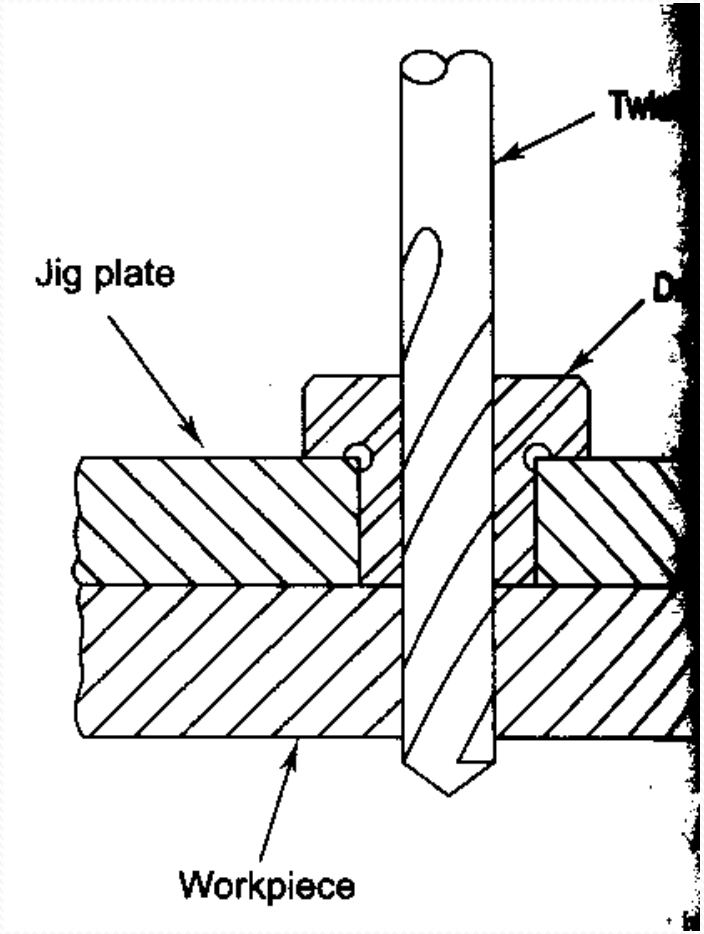
- Jigs & Fixtures are special purpose tools which are used to facilitate production in mass scale
- They eliminate the necessity of a special set up for each individual part
- Jigs & Fixtures provide a means for manufacturing interchangeable parts
- They establish a relation between tool and work with pre-determined tolerance.
- Once a Jig or fixture is properly set-up any number of same parts may be readily produced without additional set-up.

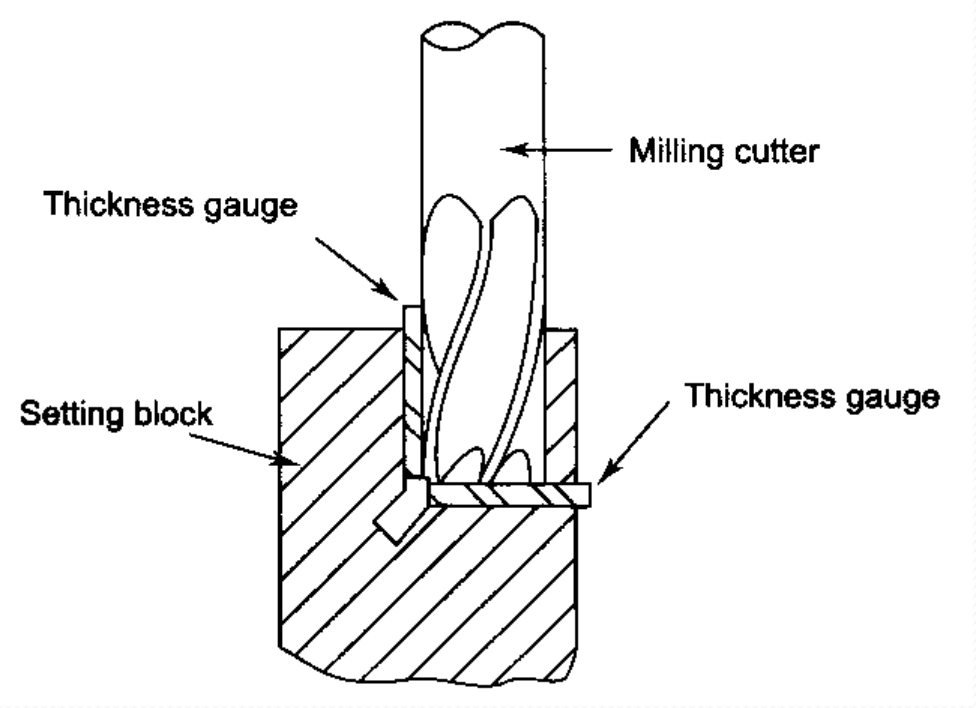
Uses of J & F in Manufacturing Industries

1) To reduce production cost
2) To increase production rate
3) To ensure high accuracy in part manufacture
4) To enable heavy and complicated complex shaped parts to be machined by being held rigidly to a machine
5) To provide interchangeability
6) Reduce quality control expenses
7) Less skilled labour & save labour costs
8) Improve work safety


Cutter
Workpiece
Fixed jaw
Movable jaw
Vise


Cutting tool
Force direction
Workpiece
Vise

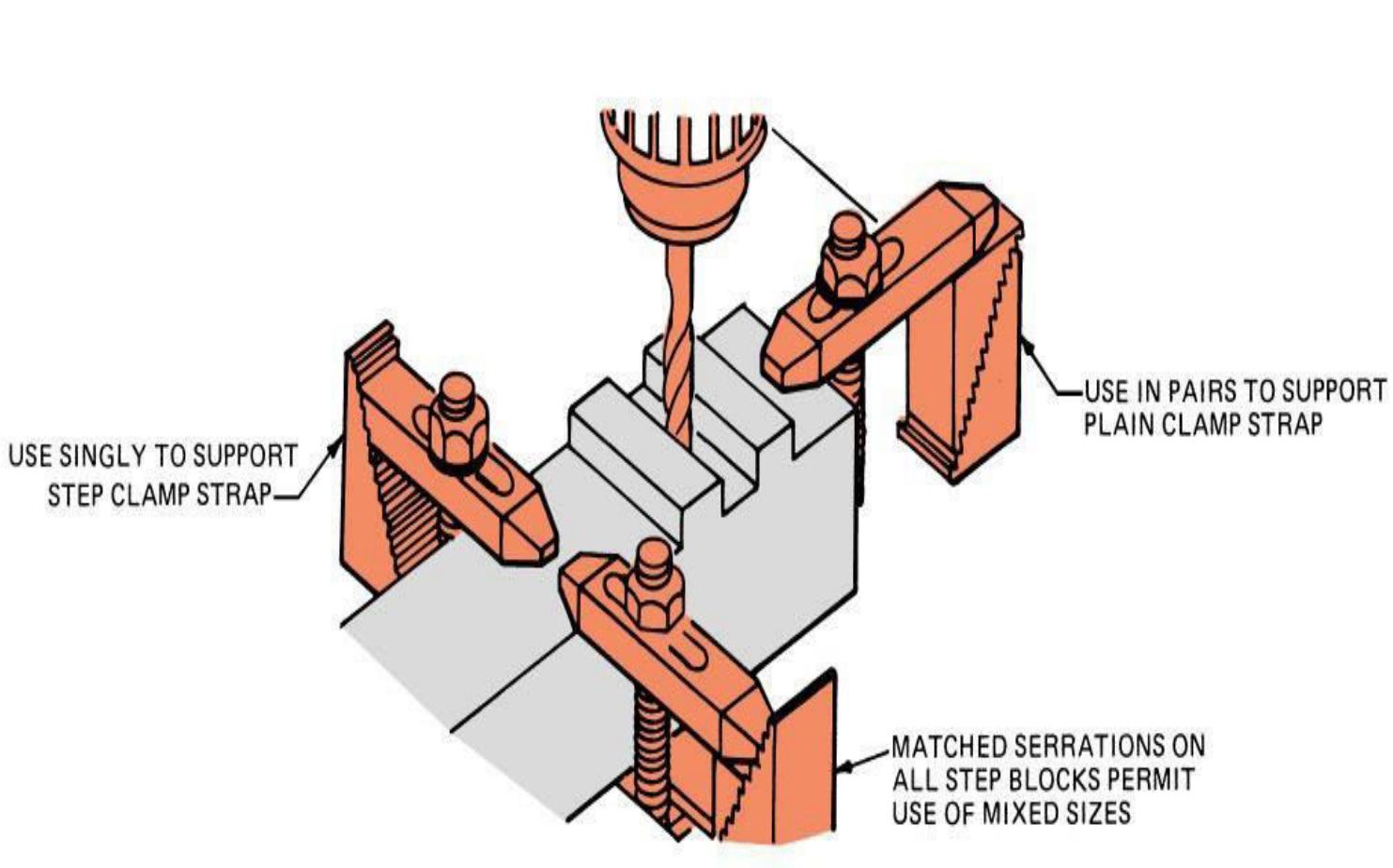

Jig plate
Workpiece


Milling cutter
Thickness gauge
Setting block
Thickness gauge

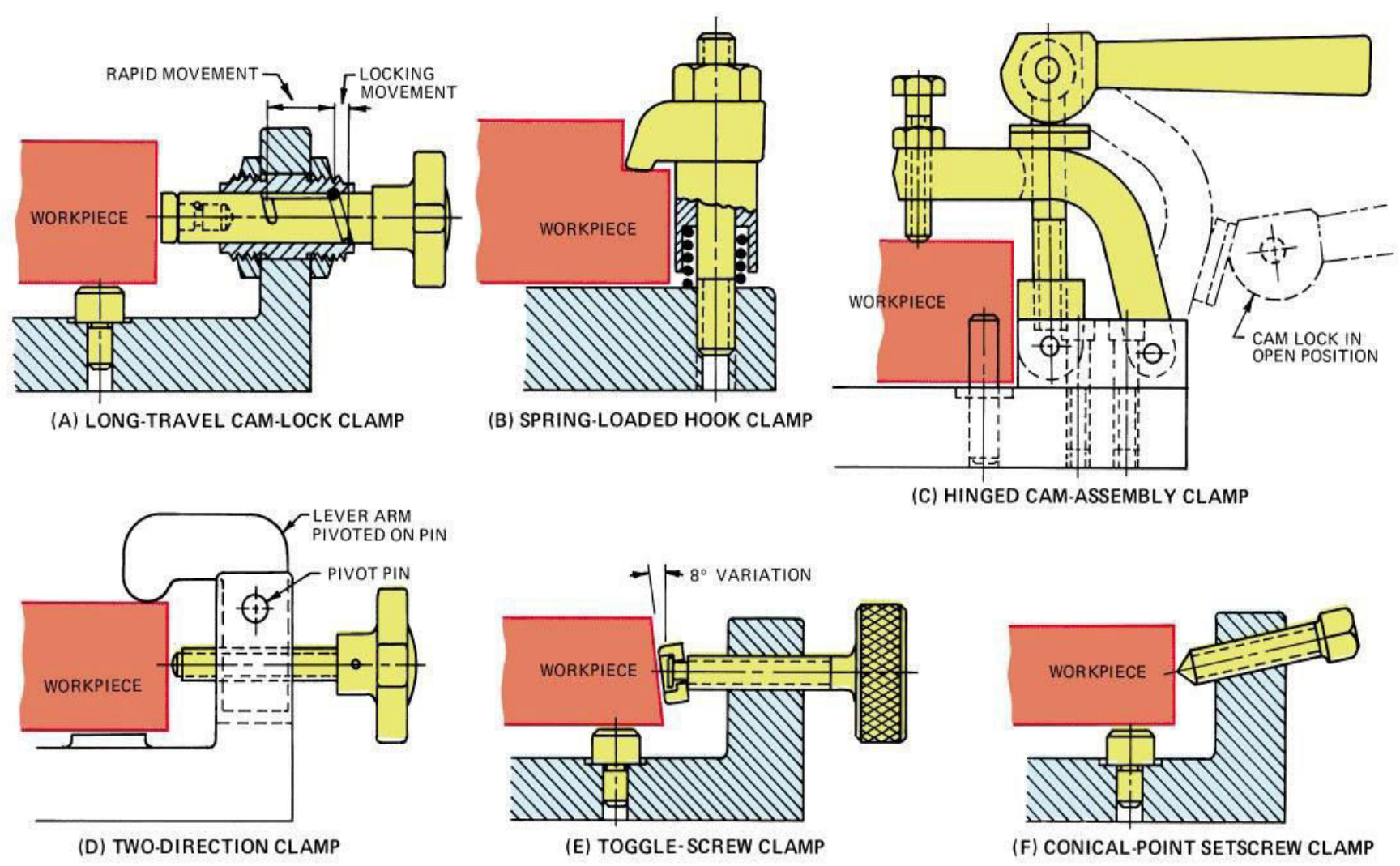
Locating & Clamping

- The overall accuracy depends on consistent location
- Location refers to the establishment of relationship between the w/p and Jig or Fixture.
- Clamping is to hold the work in position inside the Jig/Fixture body so that there is no work movement during maching

Clamping devices



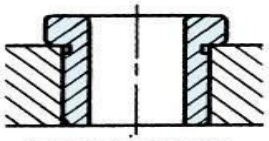
Clamping devices



JIG

JIG BUSHES

(A) HEADLESS



(B) HEAD TYPE

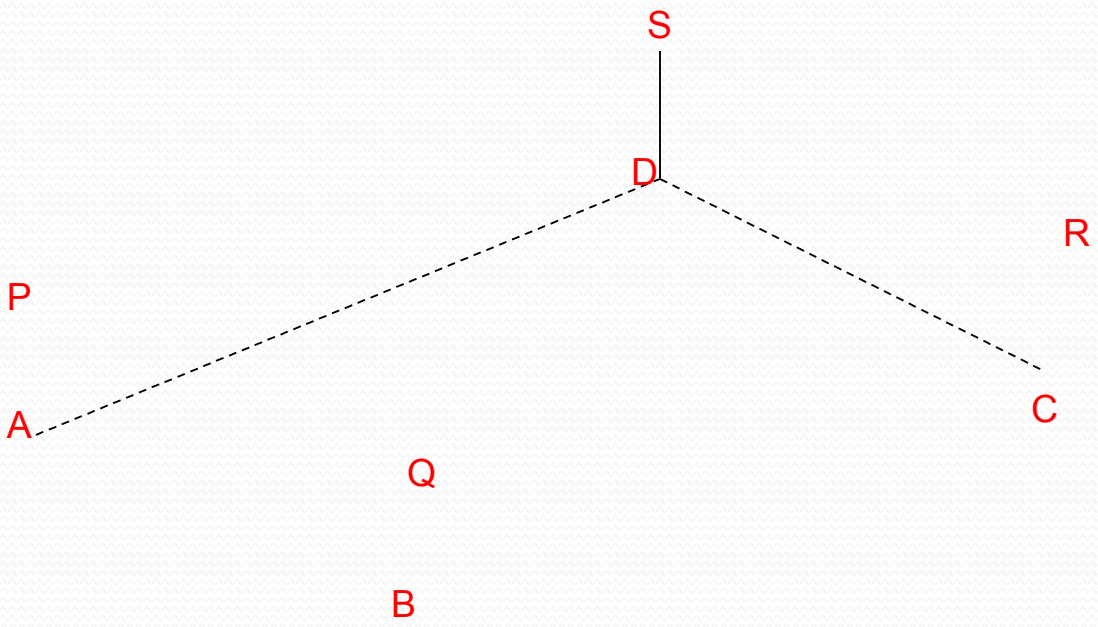
FEELER GAUGES

DIFFERENCES

	JIG	FIXTURE
Definition	Locates and Holds the work and guides the cutting tool in true position of the work	Only Holds & Positions the work, but doesn't guide the work
Elements	Work Locating elements, Tool Guiding elements & Work Clamping elements	Work Locating elements, Tool setting elements & Work Clamping elements
Construction	Light	Heavy
Applications	Drilling, reaming , Tapping, Counterboring, Countersinking	Milling, Turning, Grinding, Broaching etc.,
Special features	Drill bushes used for tool guiding	Feeler gauges, setting blocks to adjust position of tool in relation to work

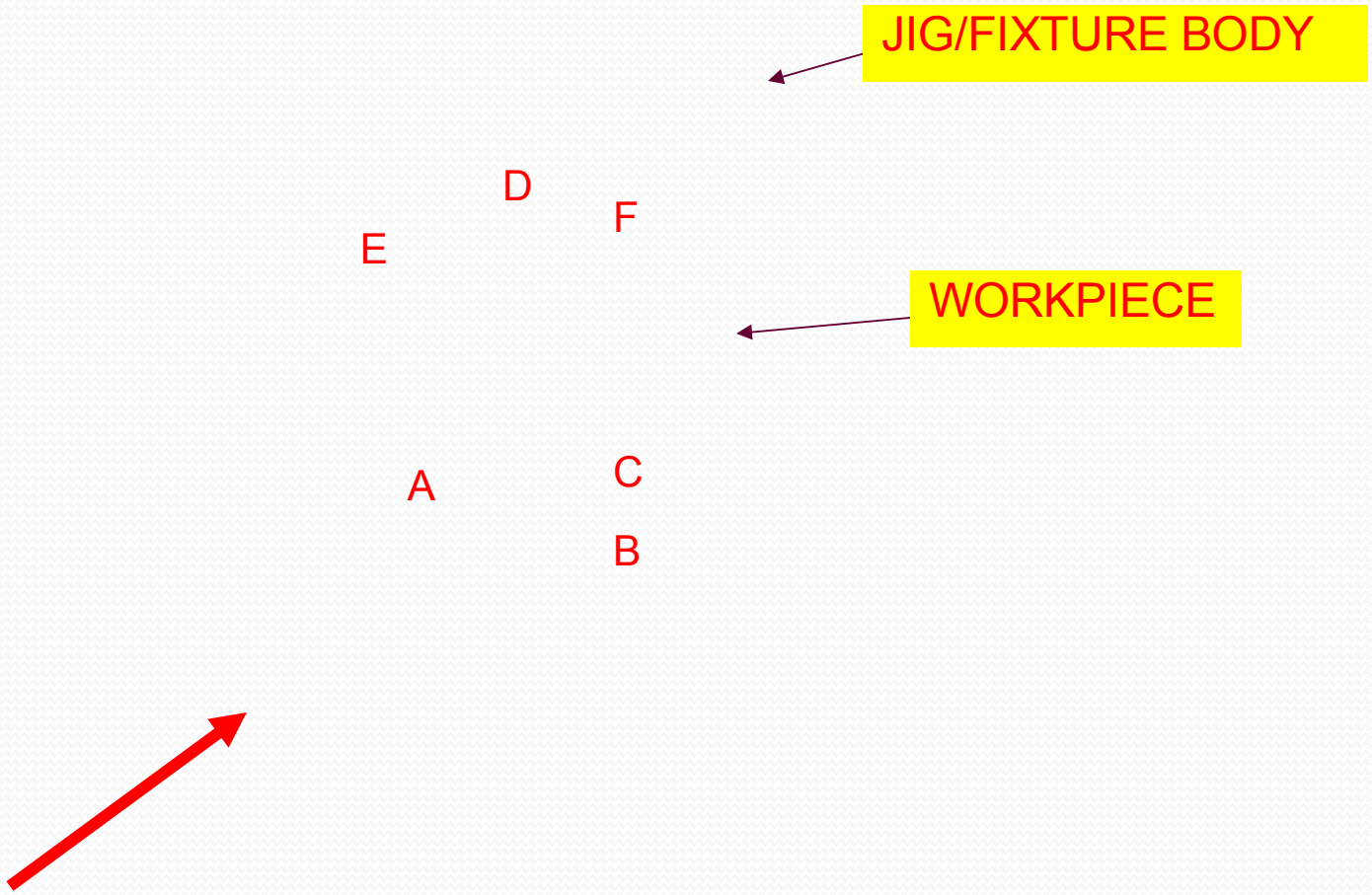
Principle of Location
(3-2-1 Location principle)

WORKPIECE IN SPACE

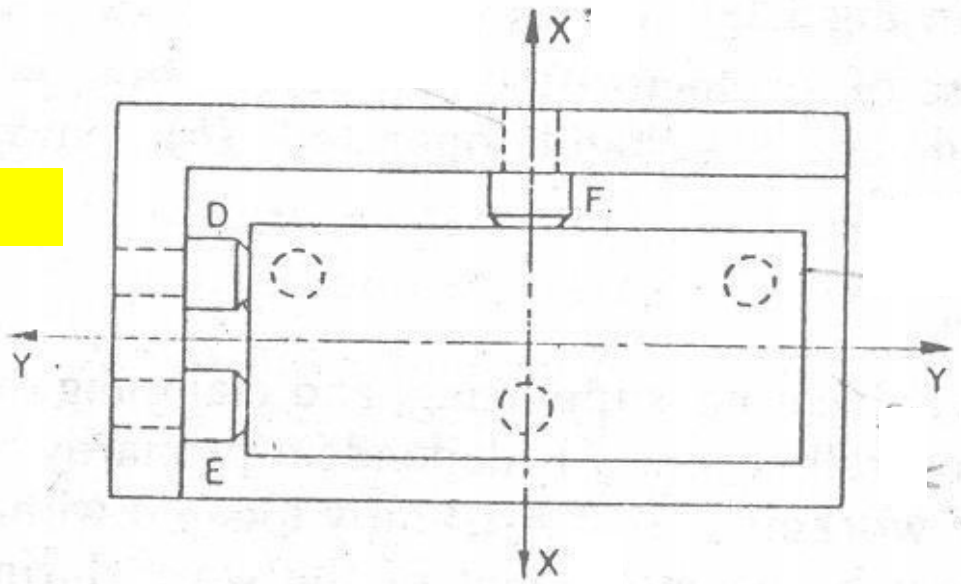


A,B,C,D,E,F – LOCATING PINS

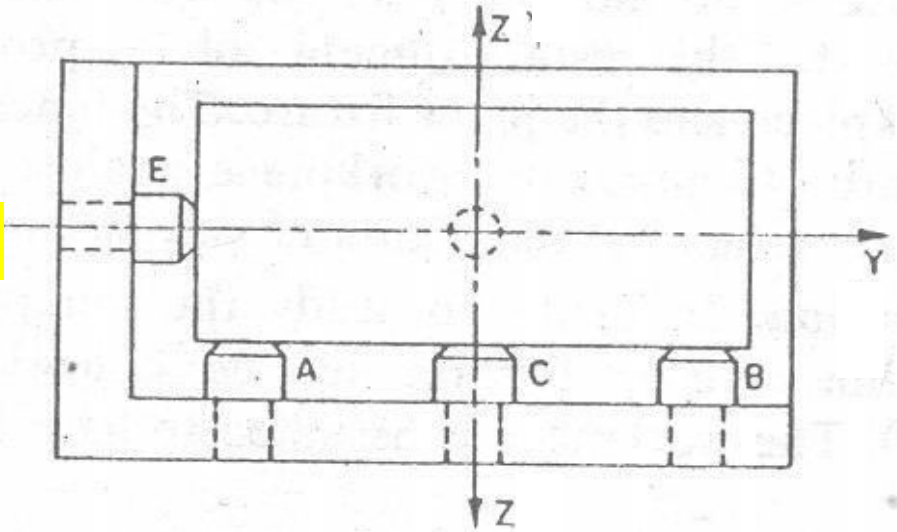
WORKPIECE LOCATED IN A JIG/FIXTURE BODY

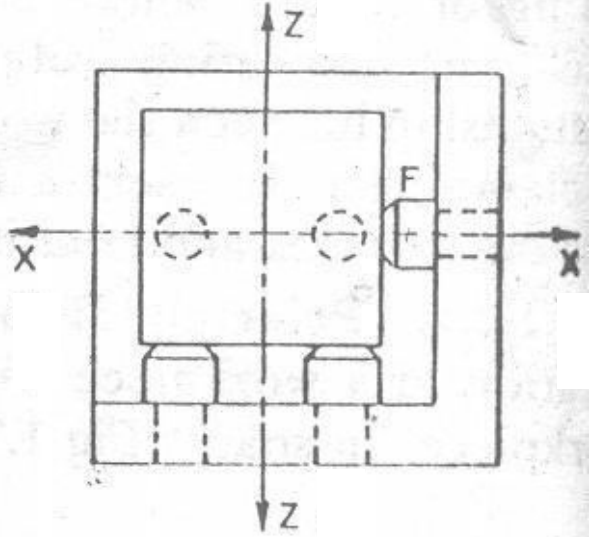


TV



FV





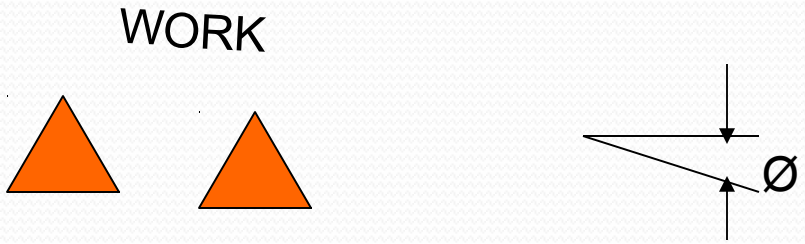
SV

Principles of Location

1) The principle of minimum locating points
2) The principle of mutually perpendicular planes
3) The principle of extreme position of pins
4) Relief should be provided where burr or swarf will get collected
5) Locating surface should be raised above the surrounding surfaces of J/F so that chips can be swept off readily.
6) Sharp corners in the locating surfaces must be avoided
7) Adjustable type locators to be used for rough surfaces

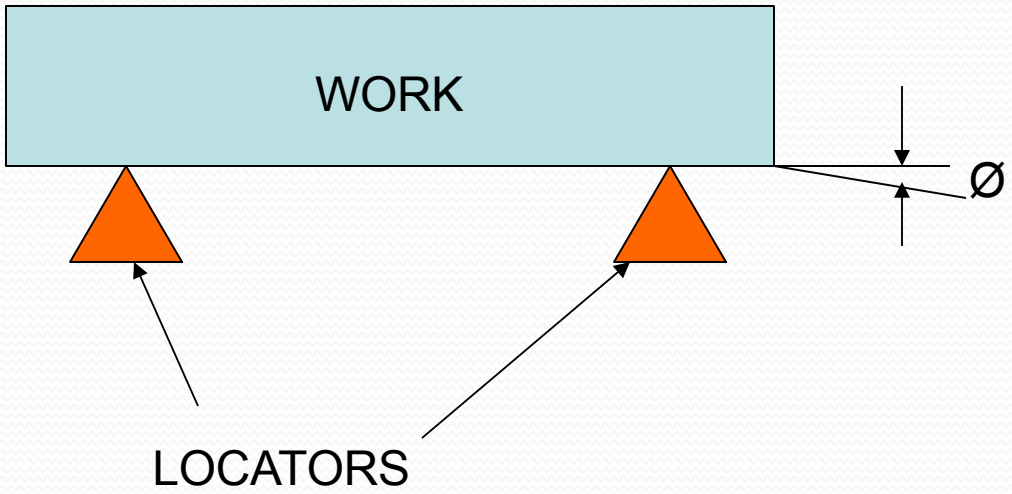
The principle of extreme position of pins

CASE-1



Locators at short distance

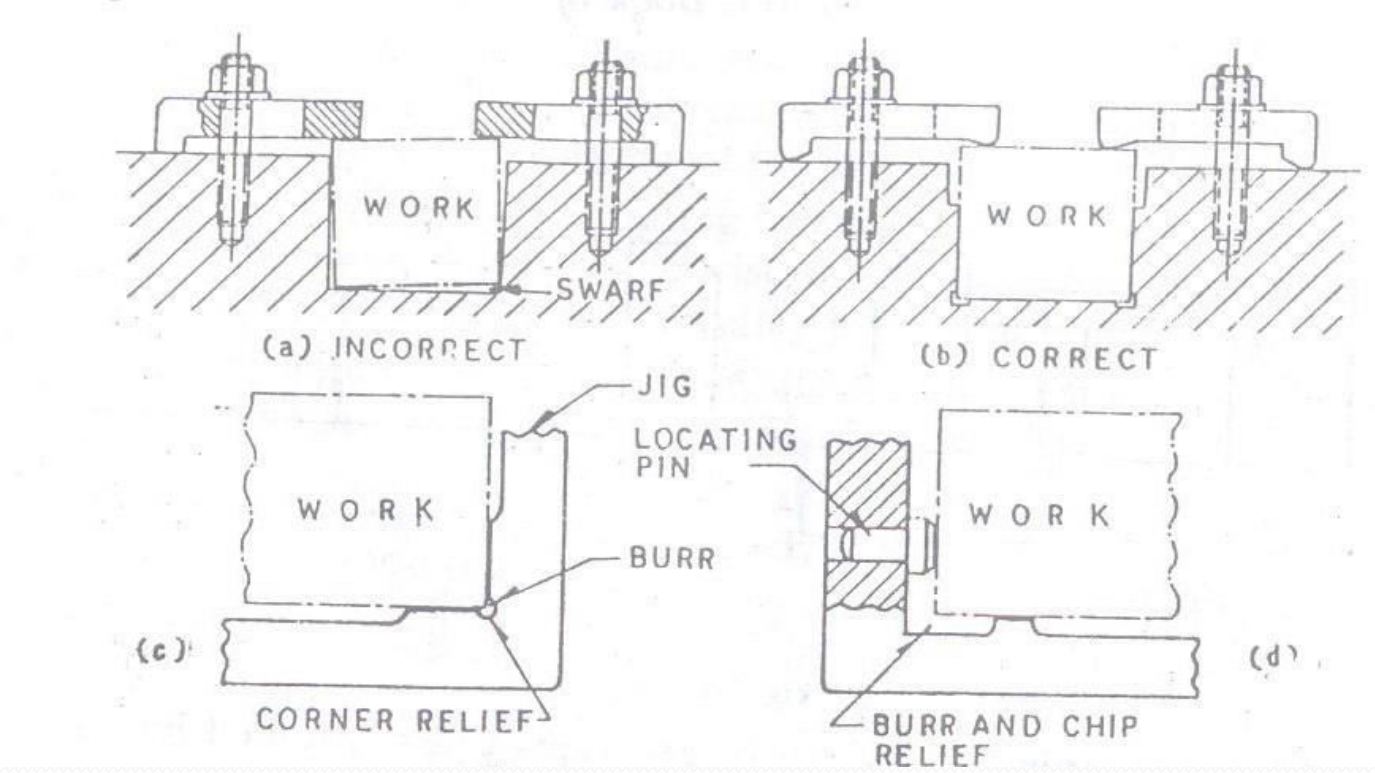
CASE-2



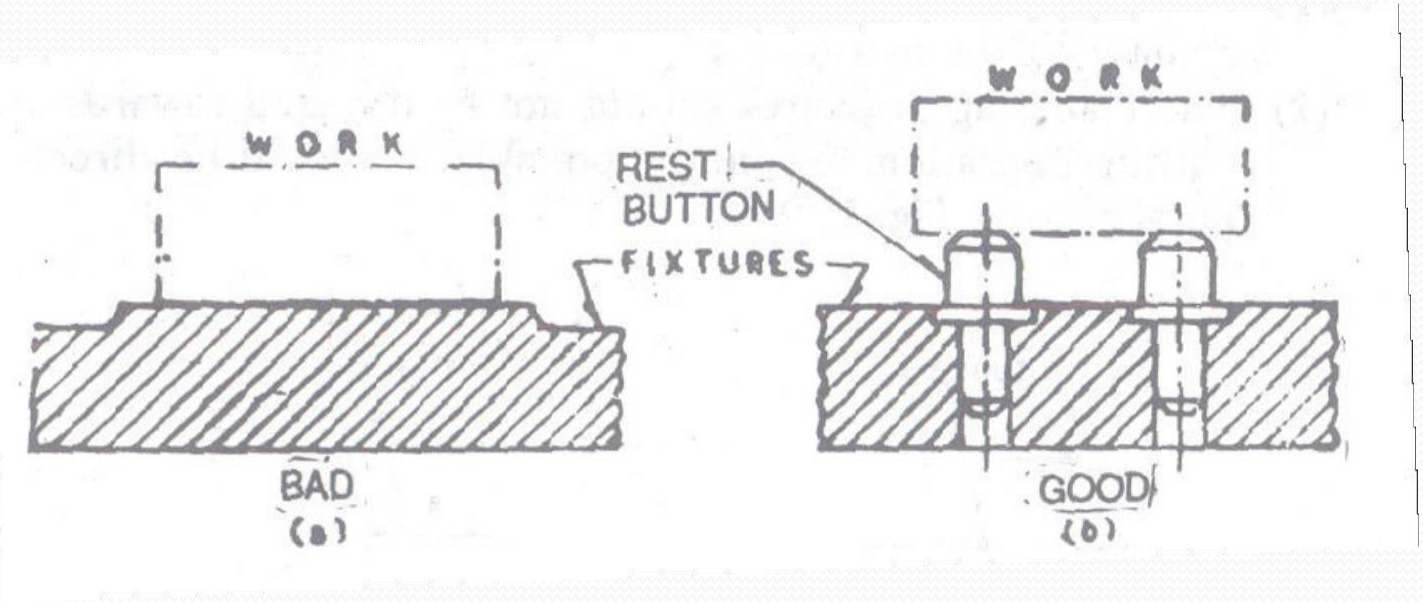
Locators widely displaced

Ø= Angle of Error

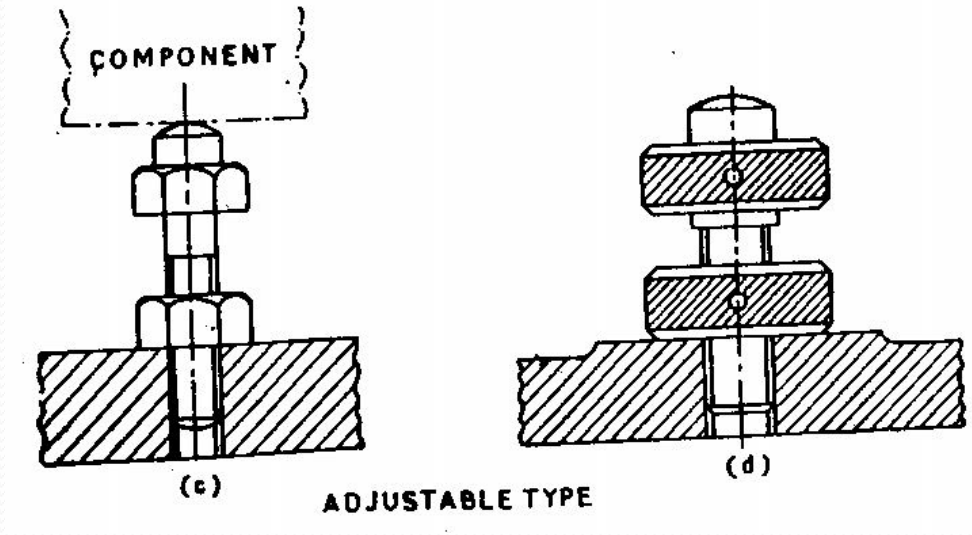
Provision of relief



Locators above surface



Adjustable type Locators



Locating Devices

- The pins of various design and made of hardened steel are the most common locating devices used to locate a work piece in a jig or fixture.

- The shank of the pin is press fitted or driven into the body of jig or fixture.

- The locating diameter of the pin is made larger than the shank to prevent it from being forced into the jig or fixture body due to the weight of the work piece or cutting forces.

- Depending upon the mutual relation between the work piece and the pin.

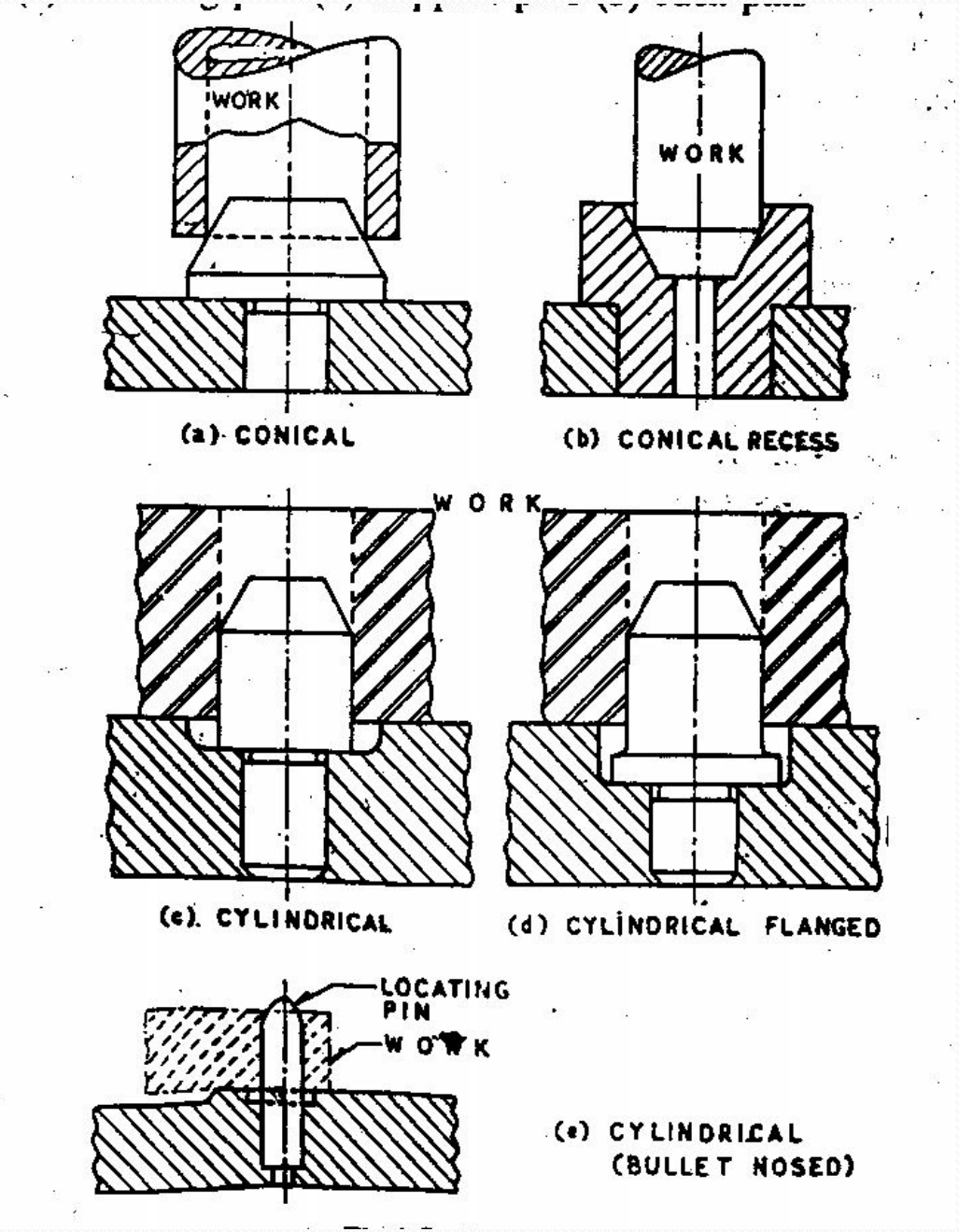
The pin may be classify as follows:
(1) Locating Pins (2) Support Pins (3) Jack Pins

✓ Locating Pins

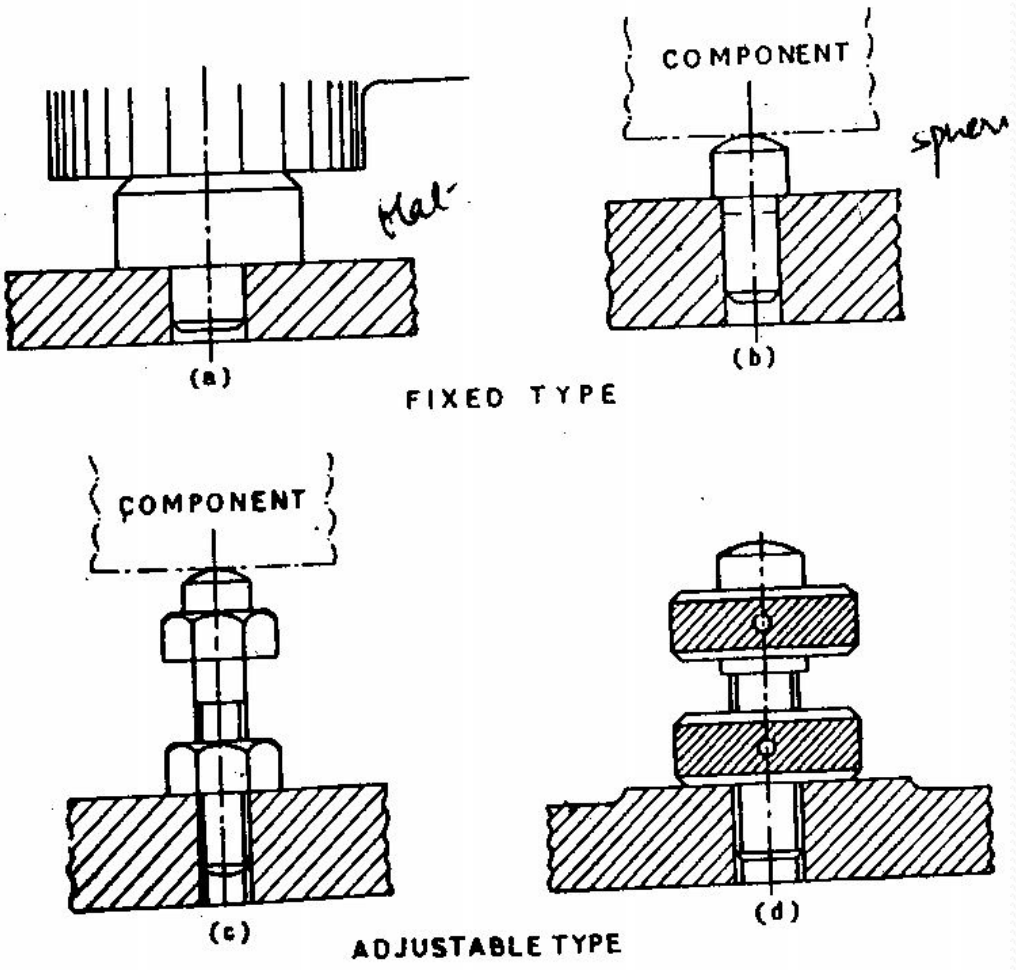
When reamed or finally finished holes are available in work piece, these can be used for locating purpose. these are two types of locating pins:

- Conical locating pins
- Cylindrical locating pins

(1) LOCATING PINS

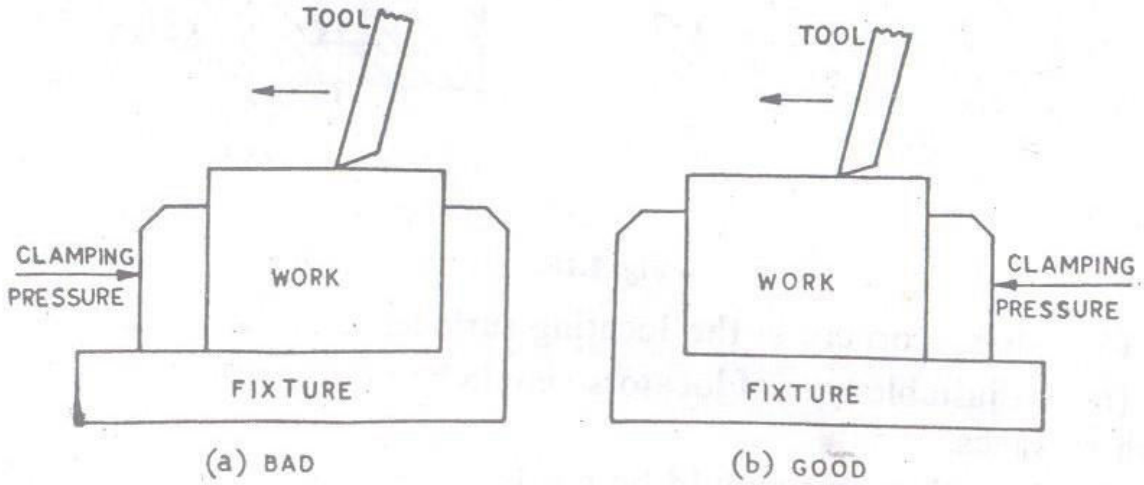


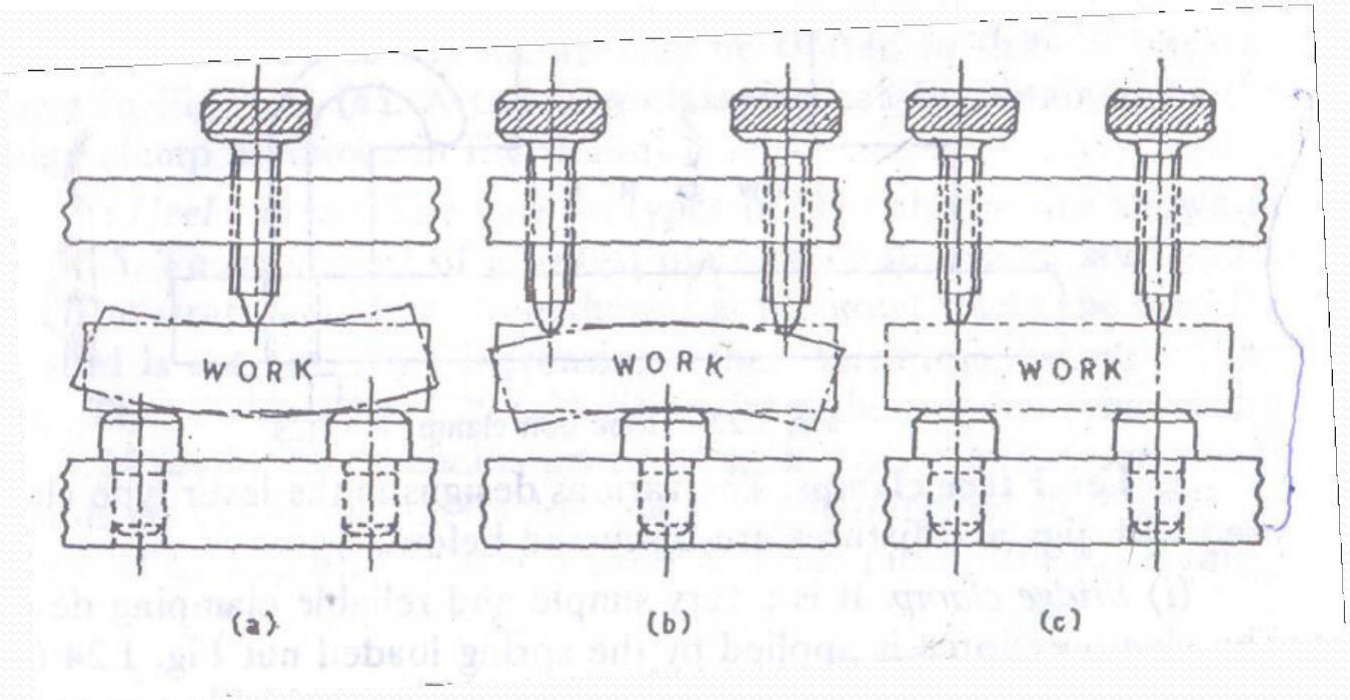
(2) SUPPORT PINS

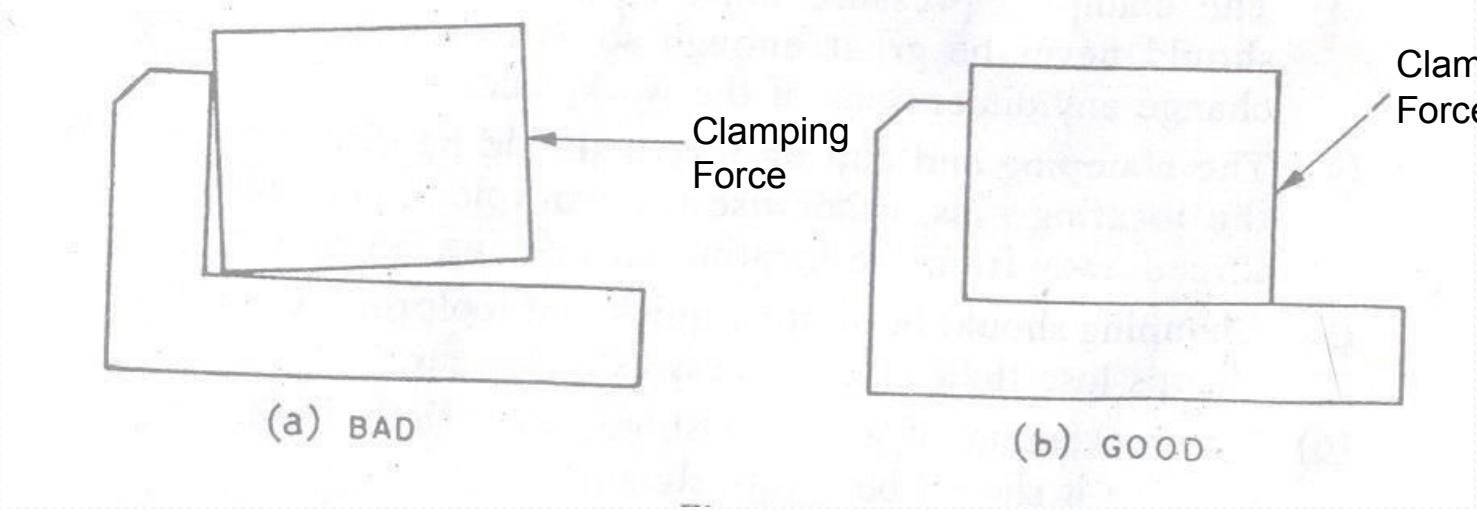


PRINCIPLE OF CLAMPING

1) The clamping pressure applied against the workpiece must counteract the tool forces
2) The clamping pressure should not be directed towards the cutting operation. Wherever possible it should be directed parallel to it.
3) The clamping pressure must not damage/deform the work surface.
4) Clamps should be arranged directly above the points supporting the work, otherwise distortion of work may occur.
5) Clamping pressure should be directed towards the points of support, else the work will tend to rise from support
6) Clamping should be simple, effective and foolproof.
7) Fibre pads should be riveted to clamp faces to avoid damage to fragile workpieces


TOOL
CLAMPING
PRESSURE
WORK
FIXTURE
(a) BAD
TOOL
WORK
CLAMPING
PRESSURE
FIXTURE
(b) GOOD


WORK
WORK
WORK
(a)
(b)
(c)


Clamping
Force
(a) BAD
Clamping
Force
(b) GOOD

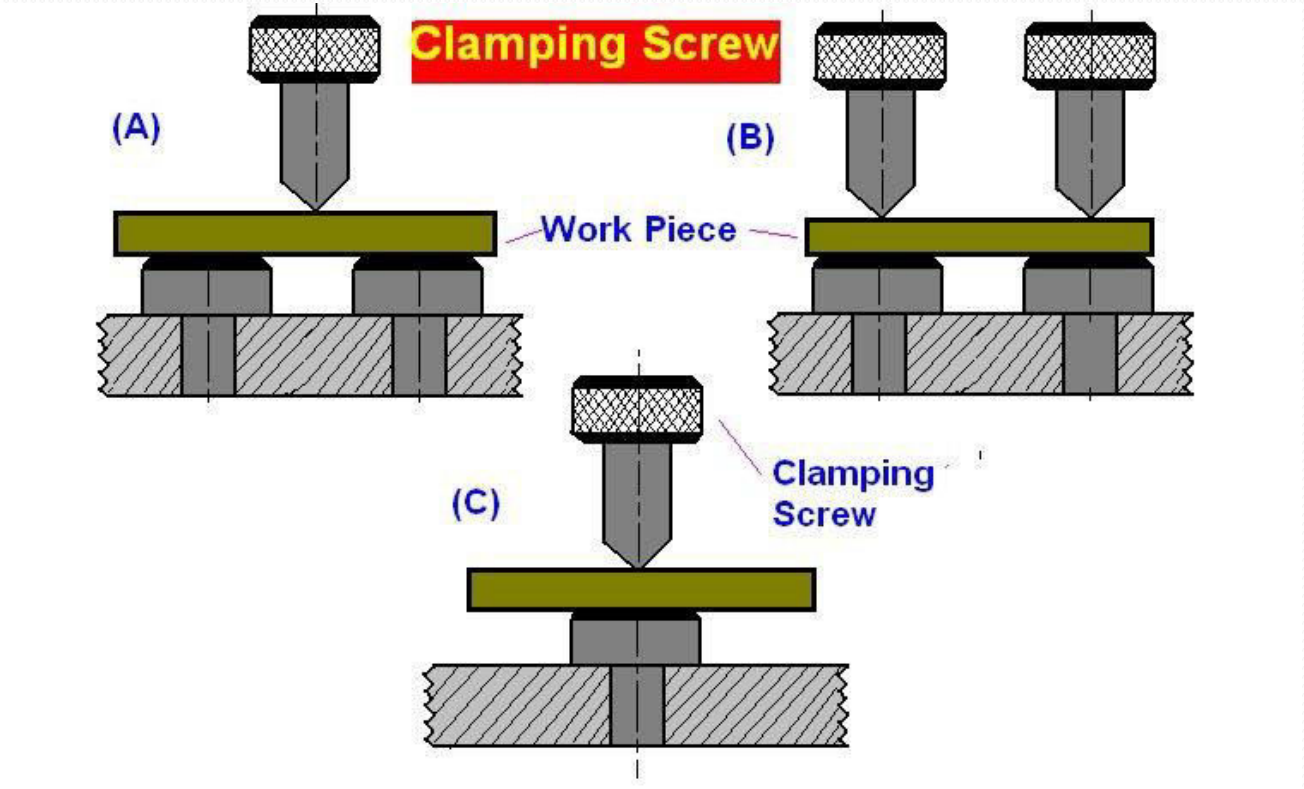
CLAMPING DEVICES

- If the work piece can not be restrained by the locating devices or elements, it become necessary to clamp the work piece in jig or fixture body. The most common example of clamping devices is bench vice. The purpose of the clamping is to exert a pressure to press a work piece against the locating surfaces and hold it there in a position to the cutting forces. In bench vice the movable jaw of the vice exert force on the work piece , their by holding it in correct position of location in the fixed jaw of the vice.

- The commonly used clamping devices are follows:

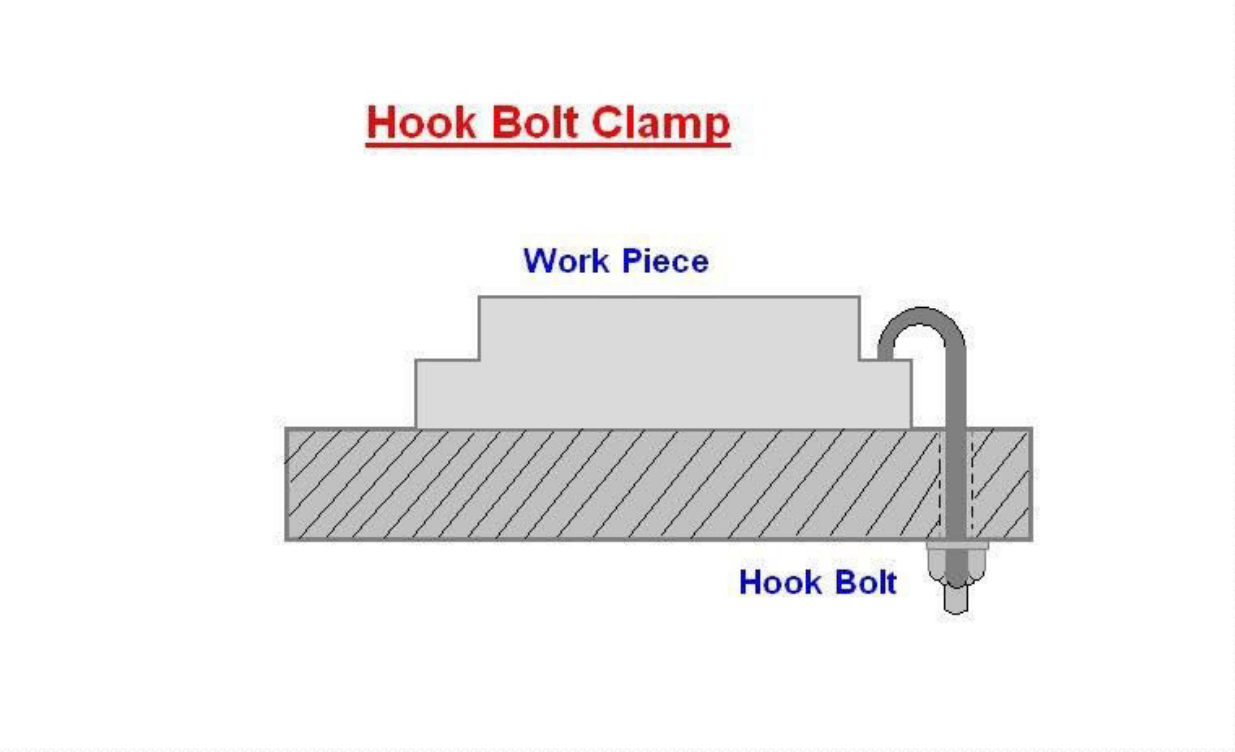
(A): Clamping Screws:

Clamping screws are used for light clamping. Clamping screws are shown in fig.



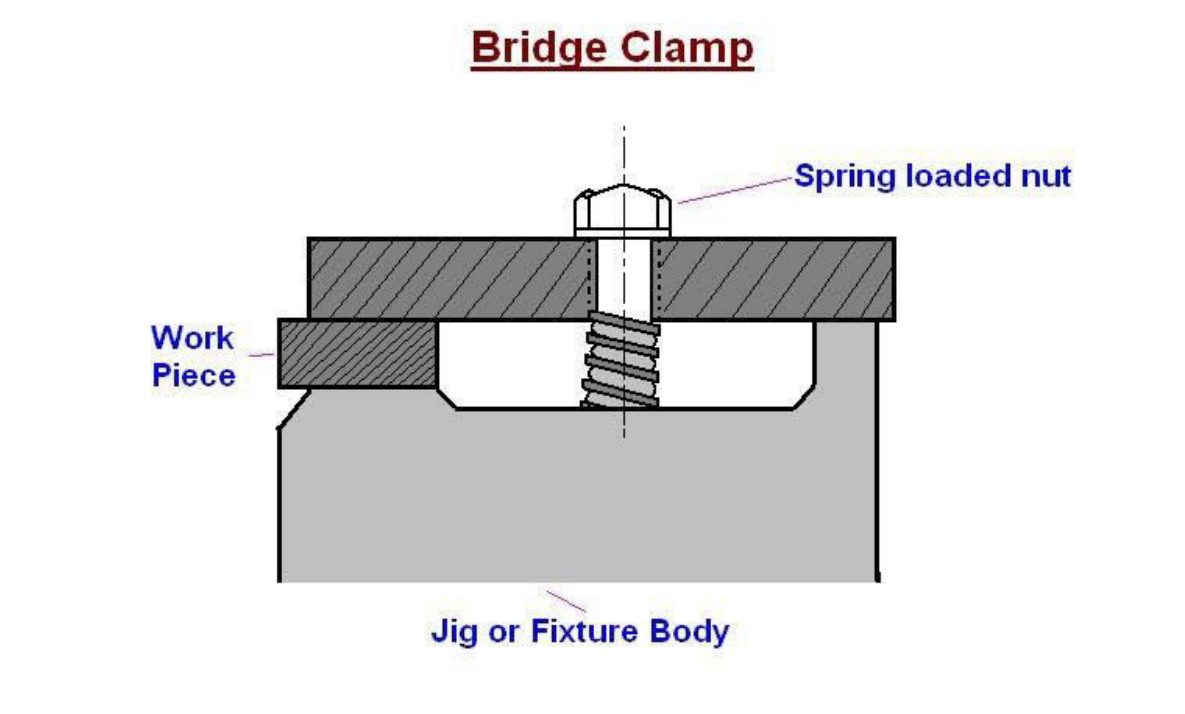
(B): Hook Bolt Clamp:

This is very simple clamping device and is only suitable for light work and where usual tip of the clamp is inconvenient. The typical hook bolt clamp is shown



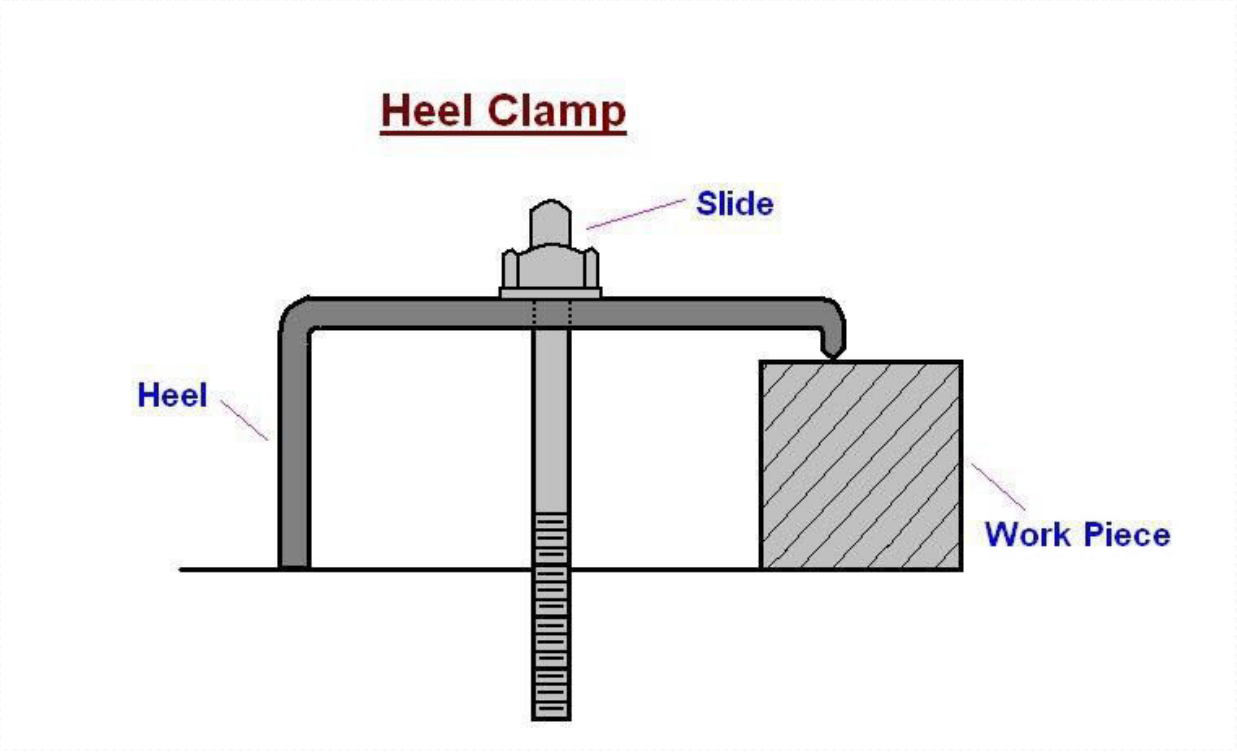
(C): Bridge Clamp:

It is very simple and reliable clamping device. The clamping force is applied by spring loaded nut.



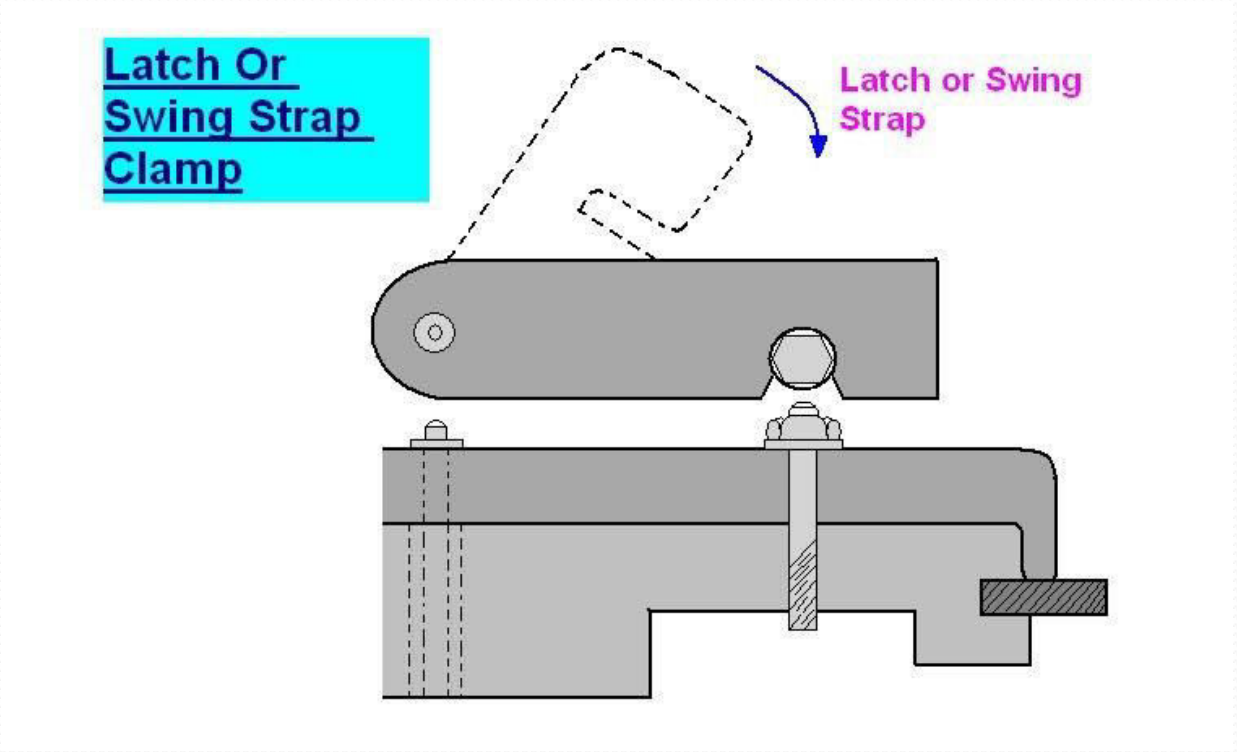
(D): Heel Clamp:

These consists of a rested plate, center stud and heel. This trap should be strengthen at the point where the hole for the stud is cut out, by increasing the thickness around the hole. The design differ from simple bridge clamp in that a heel is provided at the outer end of the clamp to guide its sliding motion for loading and unloading the work piece.



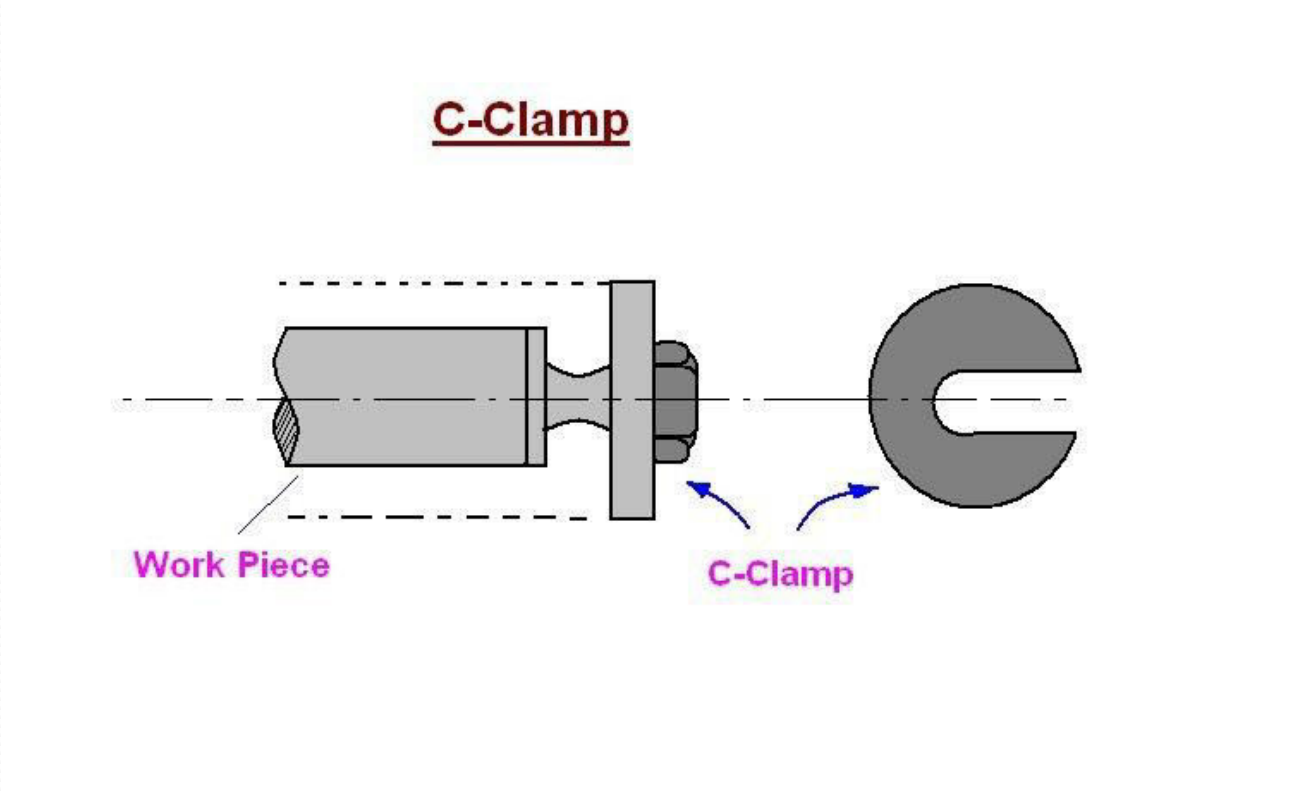
(E): Swinging Strap(Latch Clamp):

This is a special type of clamp which provides a means of entry for loading and unloading the work piece. For this the strap(latch or lid) can be swing out from the work piece. The typical swing strap or latch clamp is shown in figure.



F): C-Clamp:

To unload the work piece, the locking nut is unscrewed by giving it about one turn and this releases the c- clamp. When the clamp is removed or swing away the work piece can freely pass over the nut. Reverse procedure is adopted for loading the work piece.



Design principles Common to Jigs and Fixtures

There are some principles which are useful to design jigs and fixtures.

1: Rigidity:

Jigs and fixtures should be sufficiently stiff to secure the preset accuracy of machining.

2: Fool proofing:

It can be defined as " the incorporation of design feature in the jig or fixture that will make it impossible to lead the work into jig and fixture in an improper position" There are many fool proofing devices , such as fooling pegs, blocks or pins which clears correctly position parts but prevent incorrectly loaded parts from entering the jig and fixture body.

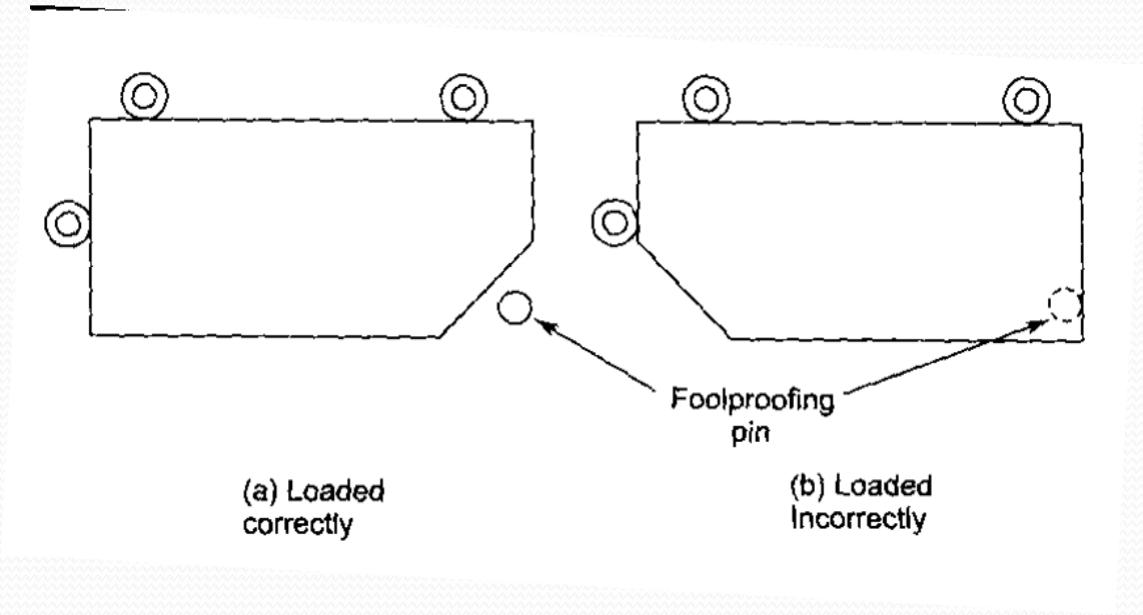
3: Clearance:

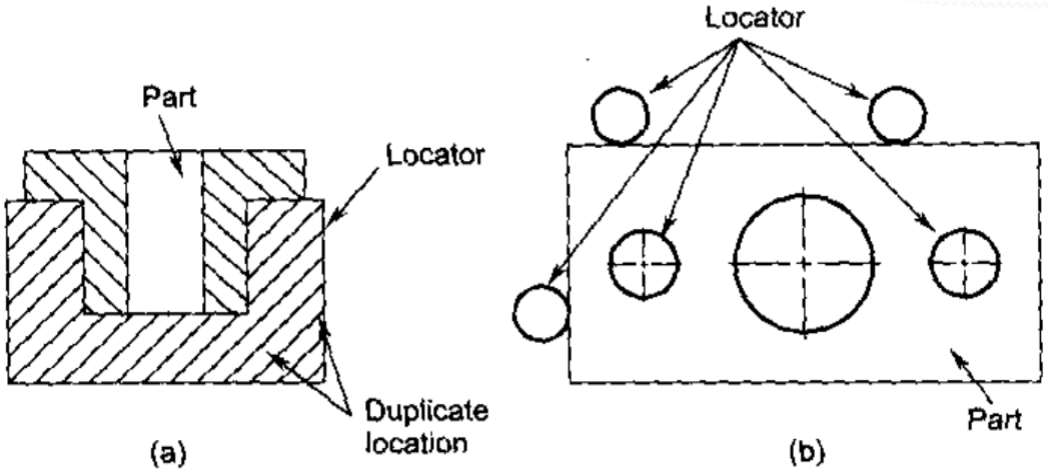
Clearance is provided in the jig or fixture body

(A)to allow for any variation in component sizes specially casting and forging.

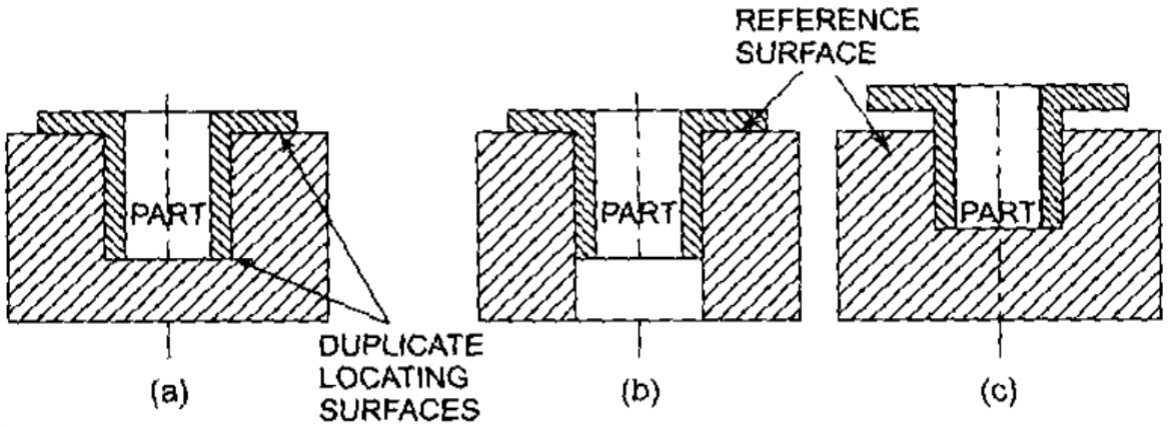
(B)To allow for hand movements so that the work piece can easily placed in the jig or fixture and removal after machining .

FOOL PROOFING OF A FIXTURE





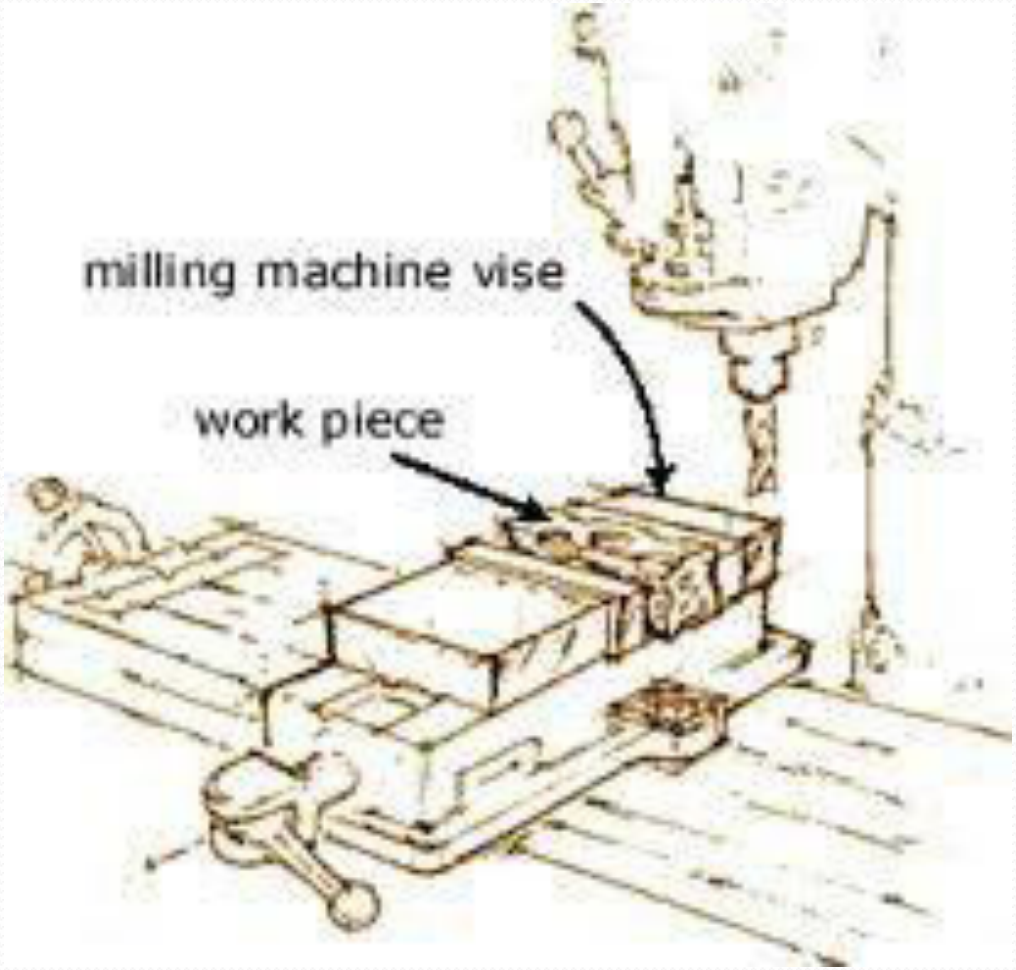
Redundant location



5: Ejectors:

The use of ejection devices to force the work piece out from the jig or fixture is important in two positions.

(A)the work piece is heavy
(B)machining pressure forces the work piece to the slides or based on the jig or fixture and the pressure and oil or coolant fill will cause the work to strick and difficult to remove on small jigs and fixtures , a pin located under the work will remove the part radially.


milling machine vise
work piece

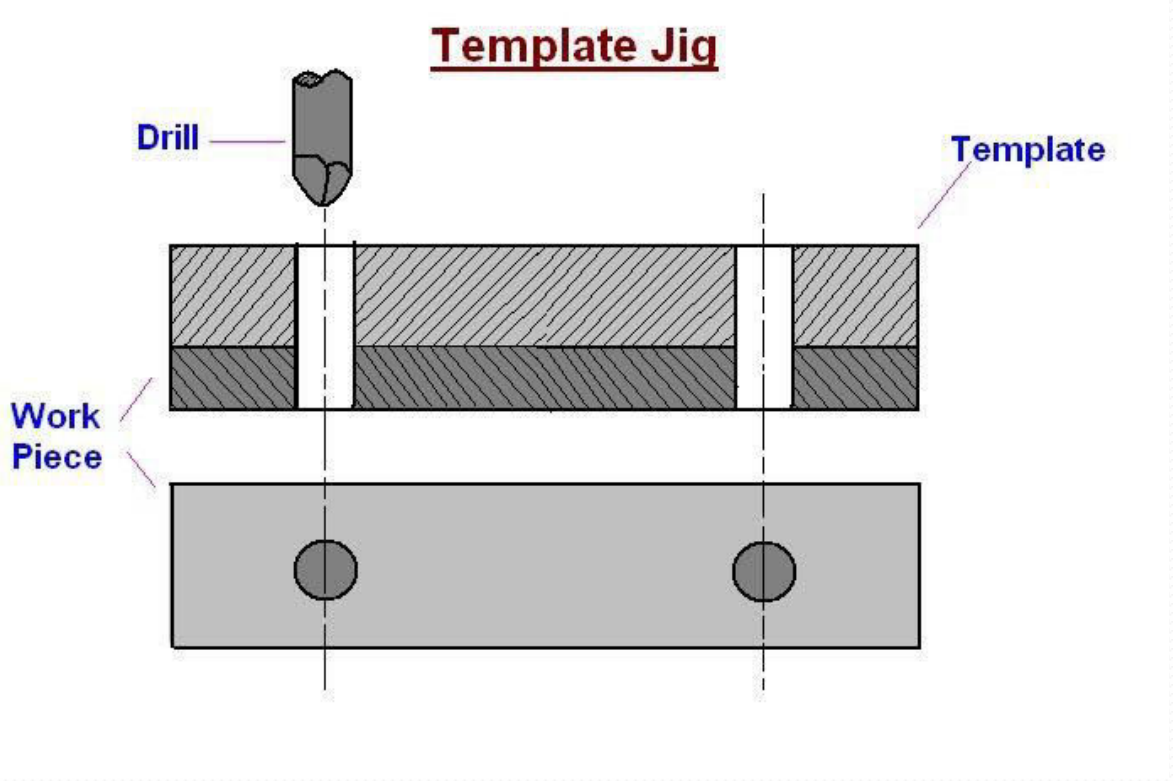
Types Of Drilling Jigs

Drilling jigs may be classified as follows:

1. Template jig
2. plate type jig
3. Open type jig
4. Channel jig
5. Leaf Jig
6. Box type jig

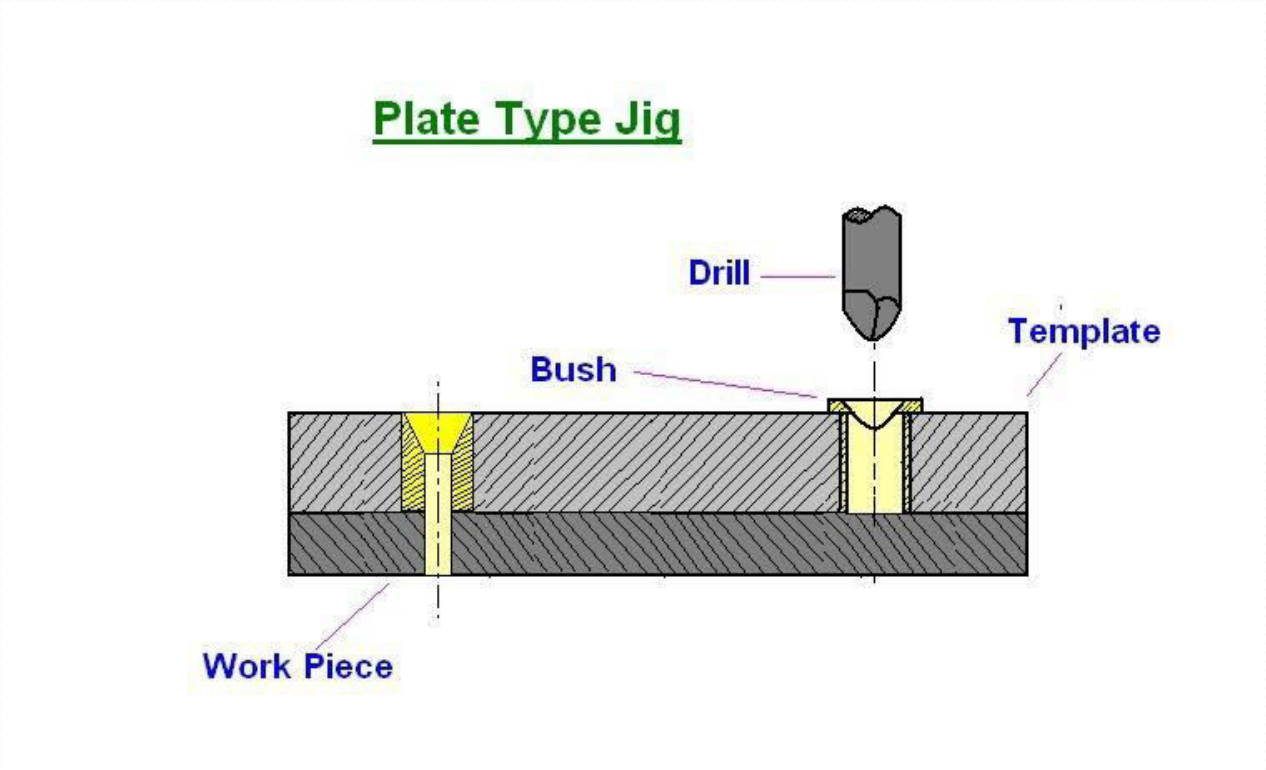
1: Template Jig:

This is the simplest type of jig; It is simply a plate made to the shape and size of the work piece; with the require number of holes made it. It is placed on the work piece and the hole will be made by the drill; which will be guided through the holes in the template plate should be hardened to avoid its frequent replacement This type of jig is suitable if only a few part are to be made.



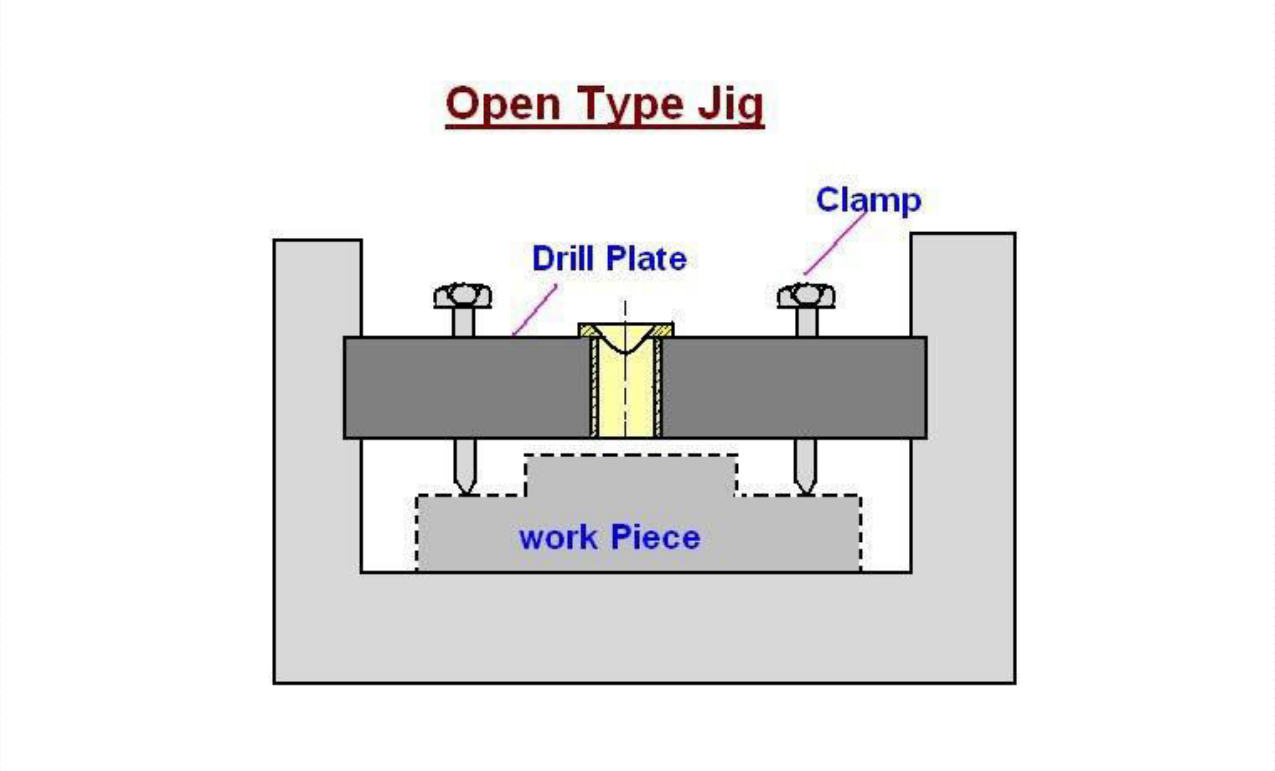
2: Plate Type Jig:

This is an improvement of the template type of jig. In place of simple holes, drill bushes are provided in the plate to guide the drill. The work piece can be clamped to the plate and holes can be drilled. The plate jig are employed to drill holes in large parts, maintaining accurate spacing with each other.



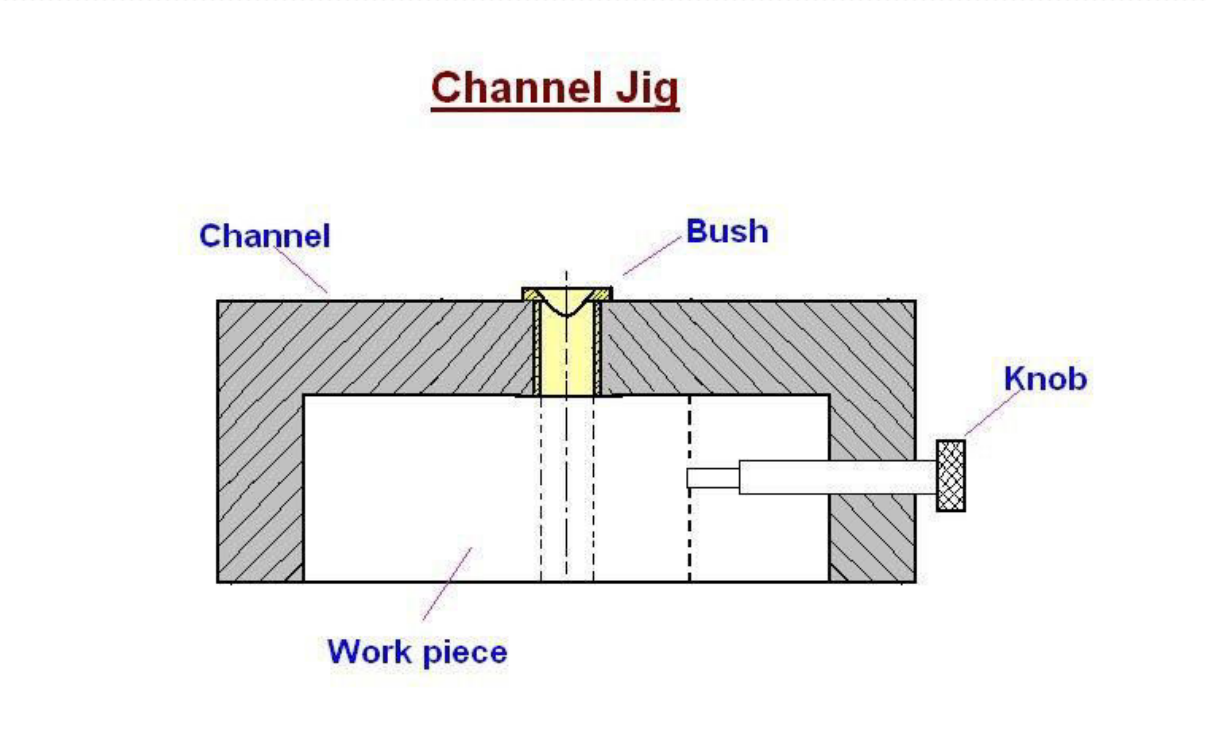
3:Open Type Jig:

In this jig the top of the jig is open; the work piece is placed on the top.



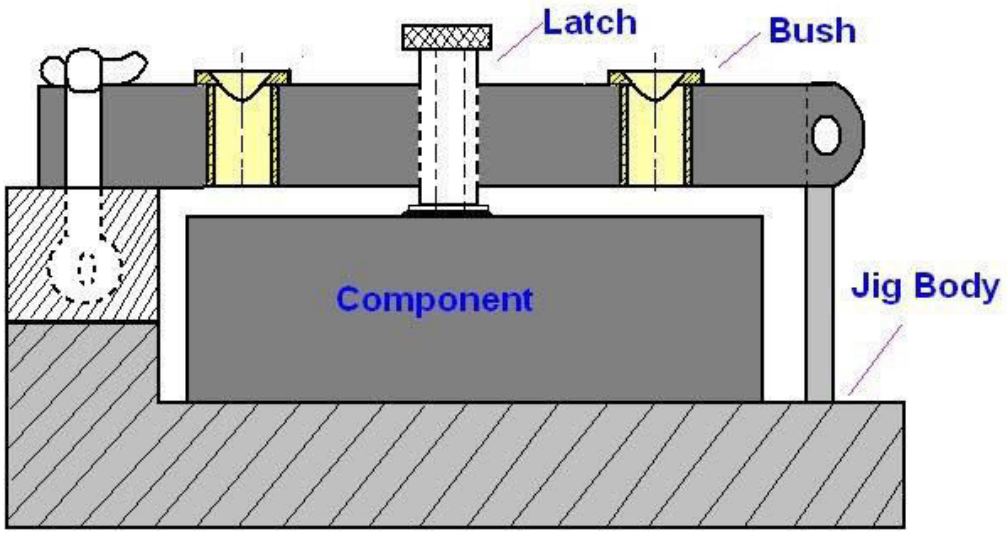
4 Channel jig;

The channel jig is a simple type of jig having channel like cross section. The component is fitted within the channel is located and clamped by locating the knob. The tool is guided through the drill bush.



5: Leaf Jig:

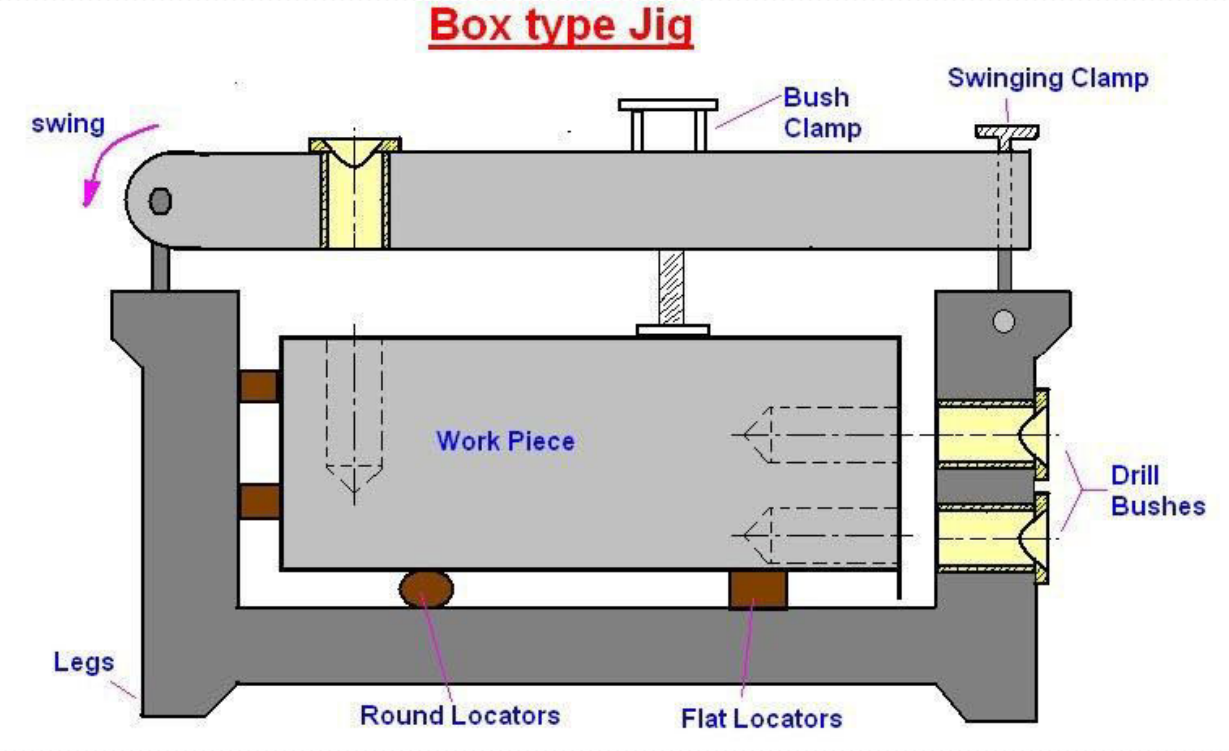
It is also a sort of open type jig , in which the top plate is arrange to swing about a fulcrum point , so that it is completely clears the jig for easy loading and unloading of the work piece. The drill bushes are fitted into the plates , which is also known as leaf , latch or lid.



Leaf Jig

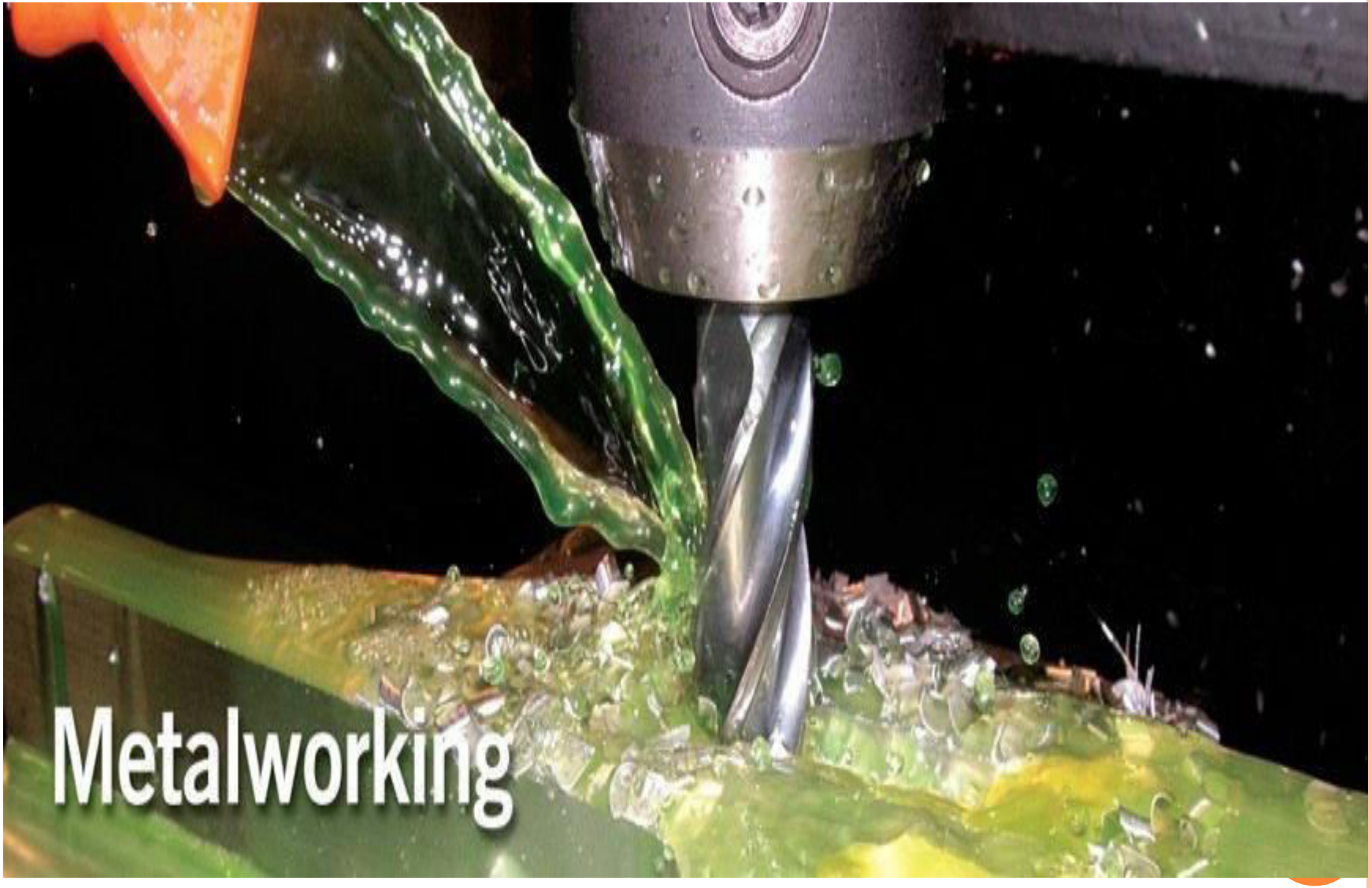
6: Box Type Jig:

When the holes are to drill more than one plane of the work piece , the jig has to be provided with equalant number of bush plates. For positioning jig on the machine table feet have to be provided opposite each drilling bush plate. One side of the jig will be provided with a swinging leaf for loading and unloading the work piece, such a jig would take the form of a box. Such a jig should be as light as possible. Since it will have lifted again and again. Typical figure of box type jig is shown:



CHAPTER-8

CUTTING FLUIDS AND LUBRICANTS


Metalworking

THE PRIMARY FUNCTIONS OF CUTTING FLUIDS IN MACHINING ARE…

- Lubricating the cutting process at low cutting speed.
- Cooling the work piece at high cutting speed.
- and flushing away chips from the cutting zone.

SECONDARY FUNCTIONS INCLUDE…

- Corrosion protection of the machined surface
- enabling part handling by cooling the hot surface

4 CATEGORIES

1. Straight oils
2. Soluble oils
3. Semi-synthetic fluids
4. Synthetic fluids

STRAIGHT OILS

- are the oldest class of engineered metal removal fluids
- used in machining operations in an undiluted form.
- They are composed of a base mineral or petroleum oil and often contains polar lubricants such as fats,
- vegetable oils and esters as well as extreme pressure additives such as Chlorine, Sulphur and Phosphorus.
- Straight oils provide the best lubrication and the poorest cooling characteristics among cutting fluids.

SOLUBLE OIL

- form an emulsion when mixed with water.
- The concentrate consists of a base mineral oil and emulsifiers to help produce a stable emulsion.
- They are used in a diluted form (usual concentration = 3 to 10%)
- provide good lubrication and heat transfer performance.
- They are widely used in industry and are the least expensive among all cutting fluids.

SYNTHETIC FLUIDS

- contain no petroleum or mineral oil base
- are formulated from alkaline inorganic and organic compounds
- They are generally used in a diluted form (usual concentration = 3 to 10%).
- Synthetic fluids often provide the best cooling performance among all cutting fluids.

SEMI-SYNTHETIC FLUIDS

- are essentially combination of synthetic and soluble oil fluids
- and have characteristics common to both types.
- The cost and heat transfer performance of semi-synthetic fluids lie between those of synthetic and soluble oil fluids.

PROPERTIES OF CUTTING FLUID..

- It should posses good lubricating properties to reduce the frictional force
- It should be non-toxic.
- It should be chemically inactive.
- It should not very easily flammable.
- It should be stable in use and storage.
- High heat conductivity.

CUTTING FLUID APPLICATION

- The principal methods of cutting fluid application include…

FLOOD APPLICATION OF FLUID

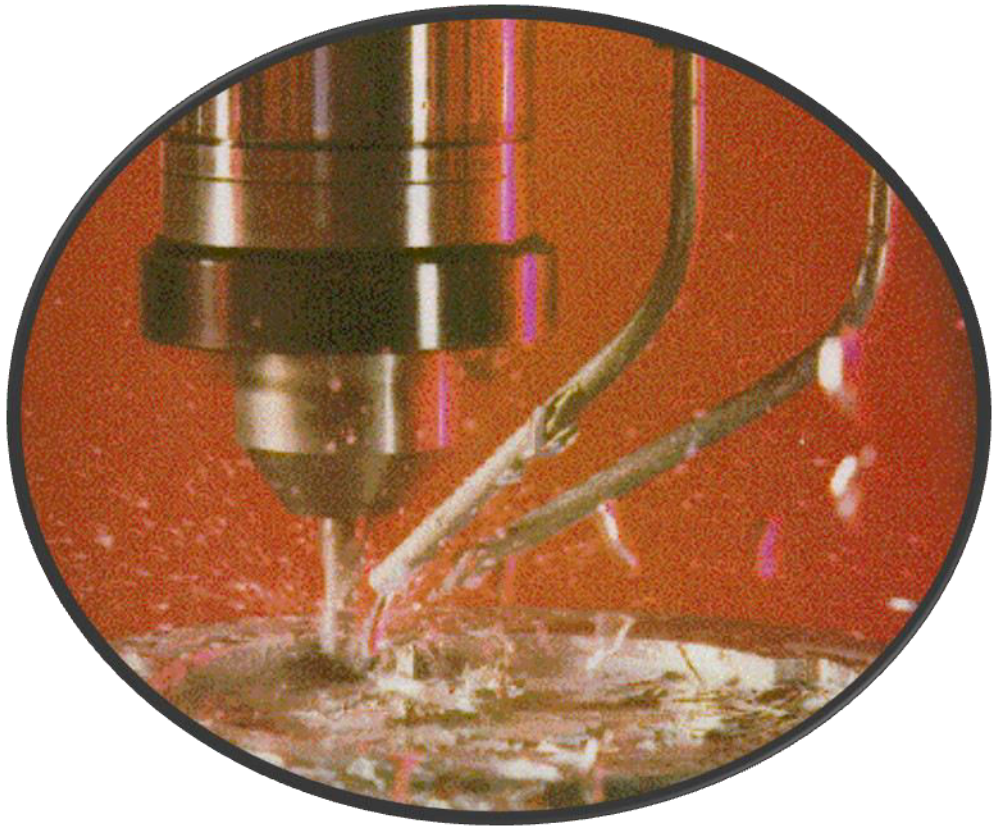
- *a flood of cutting fluid is applied on the workpiece*

JET APPLICATION OF FLUID

- *a jet of cutting fluid is applied on the workpiece*

MIST APPLICATION OF FLUID

- ***cutting fluid is atomised by a jet of air***



BENEFITS ACHIEVED WITH THE USE OF CUTTING FLUID

- improving tool life,
- Lower tool force ,
- improving surface finish,
- Finished surfaces are protected from corrosion

Lubricants

Lubricants are those substances, which are Used to reduce the force of Friction between two sliding surfaces.

Lubrication

Lubrication is the process, or technique employed to reduce wear on surfaces in close proximity, and moving relative to each another.

Composition of lubricants

- Typically contains 90% base oil(petroleum-mineral oils) and less than 10% additives
- Non liquid lubricants contains Grease, powder(dry graphite, Molibdenum disulphite), Teflon tape used in plumbing etc.
- Those non liquid lubricants provide lubrication at higher temp.(up to 350 °C)

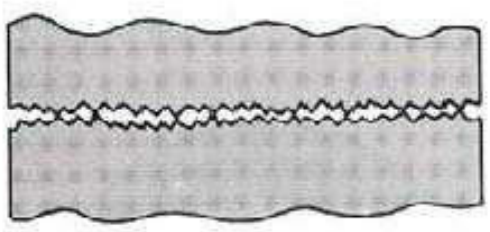
Additives

The properties of a lubricant can be improved by adding certain chemicals

- Anti oxidants
- Foam depressants
- Corrosion inhibitors
- Detergent Dispersers
- Oiliness improvers

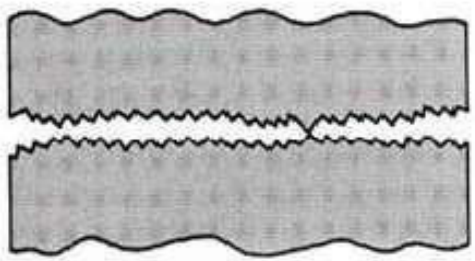
Different Lubricating conditions

- **Dry Lubrication-** No lubricant present between the surfaces



← **No oil film**

- **Boundary lubrication (Thin film)** -This condition is found on machine slide ways (Lathe cross slide, milling machine table).



← **Thin oil film**

Objectives of Lubrication

- To reduce frictional resistance.
- To reduce wear on the bearing surfaces.
- To protect the bearing surfaces from corrosion.
- To carry away heat from the bearing.
- To reduce noise from the moving components of the machine.

Lubricating Methods

- Oil can
- Oil gun
- Grease packing
- Wick type
- Bath type (Splash)
- Circulation (pressure)

Types of Lubricant

- Animal oils - From animal fats
- Vegetable oils - From plant seeds
- Mineral oils - Hydrocarbons obtained from minerals
- Synthetic oils - From various chemicals
- Grease - Semi-fluid lubricant
- Dry - Molybdenum disulphide, Graphite

Types of Lubricants

- Solid lubricants e.g Wax, Talc, Mica, Molibdenum disulphide
- Semi solid lubricants e.g. Grease and Vaseline
- Liquid Lubricants e.g. Mineral oils, Vegetable oils, Animal oils
- Synthetic lubricants e.g. Polyglycols, Silicones, Organic amines, Imines, Amides.

Properties of Lubricant

- **Viscosity** - Resistance of a liquid to flow.

- **Oiliness**- Ability of the lubricant to stay in placebetween the bearing surfaces.

- **Stability** –Retention of properties as long as possible (Oxidization, Biological degradation, Dilution)

Volatility

- It shows the evaporation behavior of lubricant at high temperature.
- A good lubricant should have low volatility

Emulsification

- It is the property of a lubricant due to which the lubricating oil mixed with water to form an emulsion.
- A good lubricant should have low emulsion number.

Properties of Lubricant

➢ Corrosion Stability

- It is properties of lubricant which represents its resistance toward the metals.
- A good lubricant should not take part in corrosion.

➢ Thermal Stability

- A good lubricant must be stable towards heat.
- It should not decompose during operation at high temperature.

Functions of Lubricants

- Keep moving parts apart
- Reduce friction
- Transfer heat
- Carry away contaminants & debris
- Transmit power
- Protect against wear
- Prevent corrosion

THANK YOU