Presentation for
MANUFACTURING TECHNOLOGY
MECHANICAL ENGINEERING
B.TECH : V SEM

by

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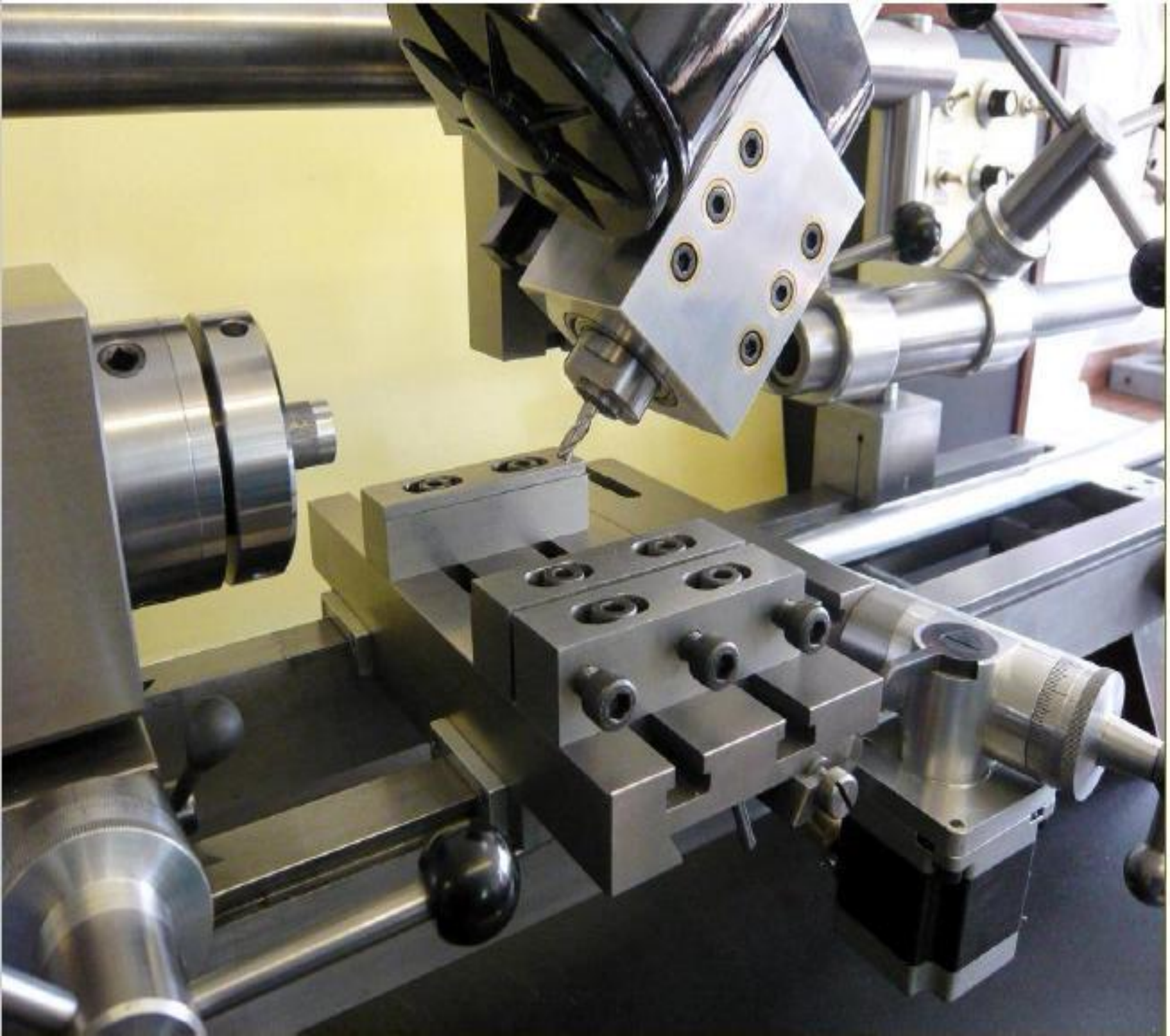
MANUFACTURING TECHNOLOGY -(AMEB16)



MECHANICAL
ENGINEERING
DEPARTMENT

UNIT	DETAILS
MODULE-I	**BASIC MECHANISM OF METAL CUTTING** Elementary treatment of metal cutting theory, element of cutting process, Geometry of single point tool and angles chip formation Types of chips, built up edge and its effects, chip breakers: Mechanics of orthogonal cutting, Merchant's force diagram, Cutting forces, cutting speeds, feed, depth of cut, tool life, coolants, machinability, tool materials.

UNIT	DETAILS
MODULE-II	**MACHINE TOOL-I** Engine lathe, Principle, specification, types, work and tool holding devices, Automatic lathes, classification: Single spindle and multi-spindle automatic lathes and its tool layouts; Shaping, slotting and planning machines, Principles of working, specification, operations performed, Kinematic scheme.

UNIT	DETAILS
MODULE-III	**MACHINE TOOL-II** Milling machine, classifications, specifications, working principles of milling machines; Geometry of milling cutters, methods of indexing , kinematic scheme of milling machines; Drilling and boring machines, principles of working, specifications, types, operations performed, twist drill; Kinematics scheme of the drilling and boring machines.

UNIT	DETAILS
MODULE-IV	**GEOMETRICAL DIMENSIONING AND TOLERANCES** Systems of Limits and Fits: Introduction, normal size, tolerance limits, deviations, allowance, fits and their types Unilateral and bilateral tolerance system, hole and shaft basis systems, Interchangeability and selective assembly. Linear Measurement: Slip gauges, dial indicator, micrometers; Measurement of angles and tapers: Bevel protractor, angle slip gauges, spirit levels, sine bar.

UNIT	DETAILS
MODULE-V	**MEASURING INSTRUMENTS** Optical measuring instruments: Tool maker's microscope and its uses, collimators, optical projector, interferometer; Screw thread measurement: Element of measurement, errors in screw threads, measurement of effective diameter, angle of thread and thread pitch, profile thread gauges; Surface roughness measurement: Numerical assessment of surface finish: CLA, R.M.S Values, Rz values, Methods of measurement of surface finish: profilograph, talysurf - ISI symbol for indication of surface finish.

S. No	Description	Bloom's Taxonomy Level
Upon the successful completion of this course, students will be able to		
CO 1	**Recognize** the importance of geometry of cutting tools, coolants and tool materials for the analysis of material behavior during manufacturing processes	**Remember (L1)**
CO 2	**Illustrate** mechanism of orthogonal and oblique cutting along with developed cutting forces	**Understand (L2)**
CO 3	**Explain** the chip formation mechanism by measuring the cutting forces during the chip formation process	**Understand (L2)**
CO 4	**Apply** the operational principles of different lathe machines and various reciprocating machines for quality machining	**Apply (L3)**
CO 5	**Select** a machining operation, corresponding machine tool for a specific application in real time	**Remember (L1)**
CO 6	**Identify** most significant process parameters in machine tool for optimal machining	**Remember (L1)**

S. No	Description	Bloom's Taxonomy Level
CO 7	**Explain** the working principles of Milling, drilling and surface grinding machines for manufacturing the components of their requirement	**Understand (L2)**
CO 8	**Estimate** machining times for machining operations at specified levels of cutting parameters of machine tools	**Apply (L3)**
CO 9	**Apply** the principles of limits, fits and tolerance while designing and manufacturing the components of their requirement	**Apply (L3)**
CO 10	**Choose** a measuring instrument for accurate inspection of the dimensional and geometric features of a given component	**Apply (L3)**
CO 11	**Apply** various methods for the measurements of screw threads, surface roughness parameters and the working of optical measuring instruments	**Apply (L3)**
CO 12	**Analyze** the results of various measuring systems and instruments for motion and dimensional measurements	**Analyze (L4)**

UNIT - I

BASIC MECHANISM OF METAL CUTTING

UNIT- I SYLLABUS

- Elementary treatment of metal cutting theory, element of cutting process
- Geometry of single point tool and angles chip formation
- Types of chips, built up edge and its effects, chip breakers
- Mechanics of orthogonal cutting, Merchant's force diagram
- Cutting forces, cutting speeds, feed, depth of cut, tool life, coolants, machinability, tool materials.

UNIT- I

At the end of the course students are able to :		
Course Outcomes		**Knowledge Level (Bloom's Taxonomy)**
CO 1	**Recognize** the importance of geometry of cutting tools, coolants and tool materials for the analysis of material behavior during manufacturing processes	**Remember (L1)**
CO 2	**Illustrate** mechanism of orthogonal and oblique cutting along with developed cutting forces	**Understand (L2)**
CO 3	**Explain** the chip formation mechanism by measuring the cutting forces during the chip formation process	**Understand (L2)**

UNIT- I

Program Outcomes (POs)		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE / Quiz / AAT
PO 2	**Problem Analysis:** An ability to analyze complex engineering problems to arrive at a relevant conclusion using knowledge of mathematics, science and engineering.	1	CIE / Quiz / AAT

Introduction

- Manufacturing is important activity for economical growth and development

- For rapid development and a stronger economy, manufacturing should be competitive not only locally, but also internationally

- Manufacturing as a major source of wealth of a nation

- Manufacturing is a central function for realization of ideas

Introduction

- Manufacturing is derived from the Latin words manus (hand) and factus (make), meaning "made by hand“

- Manufacturing consists of the ways by which materials are converted into useful products

- This conversion involves the shape of the initial material, and the physical and mechanical properties of the material

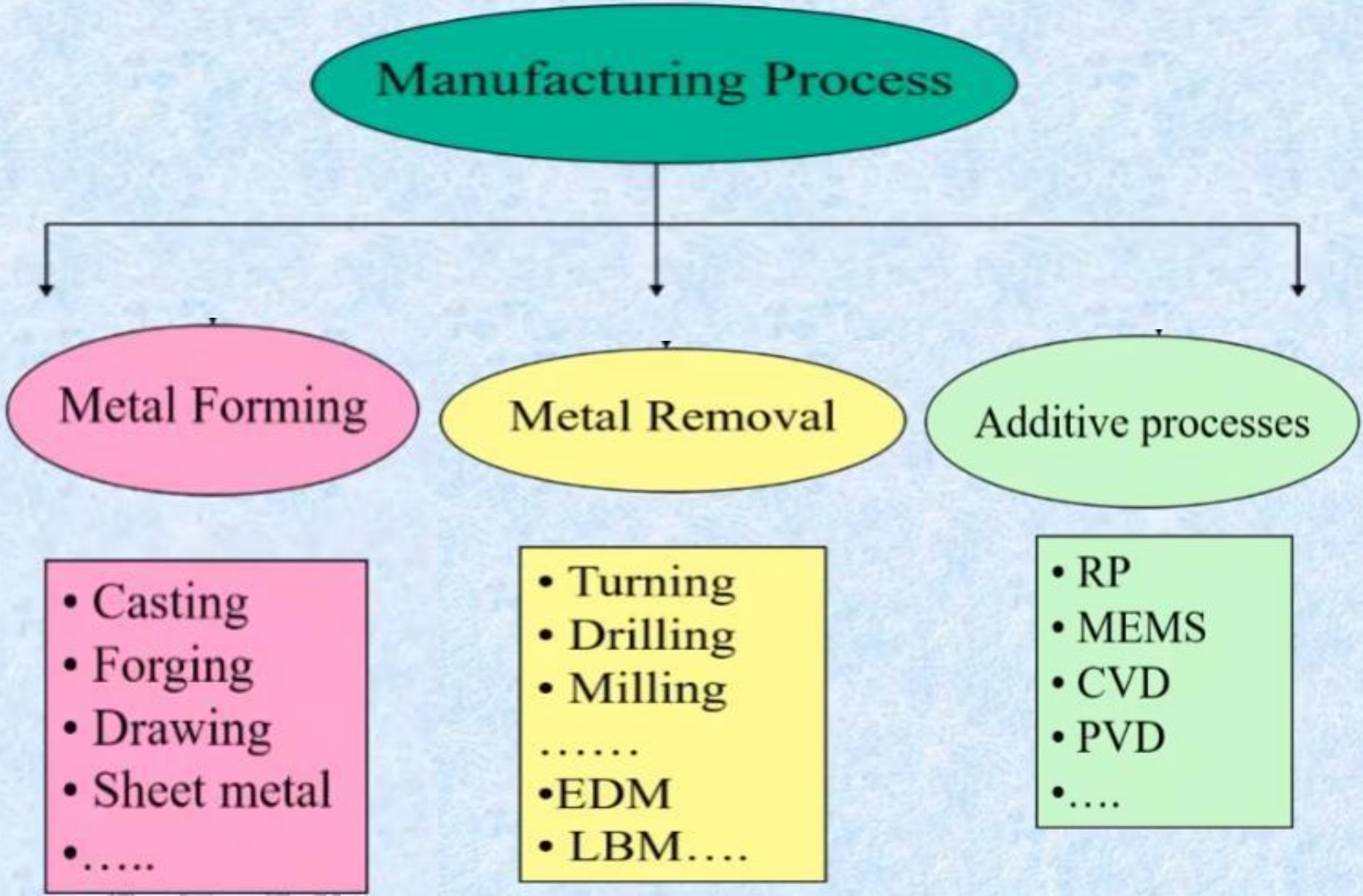
Manufacturing:

- the act of making something (a product) from raw materials
- Attaining shape and size.

What is Manufacturing?

Manufacturing is the making of goods by hand or by machine that upon completion the business sells to a customer. Items used in manufacture may be raw materials or component parts of a larger product. The manufacturing usually happens on a large-scale production line of machinery and skilled labor.

Also, we can define manufacturing as a value addition process, where we convert the raw material into a finished product



Manufacturing Process

Metal Forming

- Casting
- Forging
- Drawing
- Sheet metal
- …..

Metal Removal

- Turning
- Drilling
- Milling

…….

- EDM
- LBM….

Additive processes

- RP
- MEMS
- CVD
- PVD
- ….

Manufacturing: The making of articles on a large scale using Machinery

- Converting raw material, components or parts in to finished goods that meets a customer expectations.

- **Machine and Machine Tool**
- **Machine:** which will do only a particular work. It can’t make its own parts
- example: Washing Machine
- **Machine Tool:** it is also a machine but it can produce its own parts.

Existence of some form of crude machine tool is recorded as early as 700 B.C. However, the most prominent beginning of the machine tool is the **John Wilkinson's** horizontal boring machine towards 1775.

Year	Name	Description
1794	Henry Maudslay	**engine lathe: He** combined a lead screw, a cross slide and change gears in a form, which is almost similar to the current day centre lathe.
1817	Roberts	**Planer**
1818	Eli Whitney	**Milling Machine**
1840	John Nasmyth	**Drilling machine**
1845	Stefen Fitch	first **Turret Lathe**
1869	Christoper Spencer	**Automatic turret Lathe**
1952		**NC lathe**

METAL CUTTING

- Metal cutting/Machining process of removing unwanted material from a block by the use of a tool, in the form of chips.

- **Objective:**
  - ✓ To form objects of desired shape, size and surface finish
  - ✓ Fulfil its basic functional requirements
  - ✓ provide better or improved performance
  - ✓ render long service life

The basic requirements for machining work are schematically illustrated in this flow chart

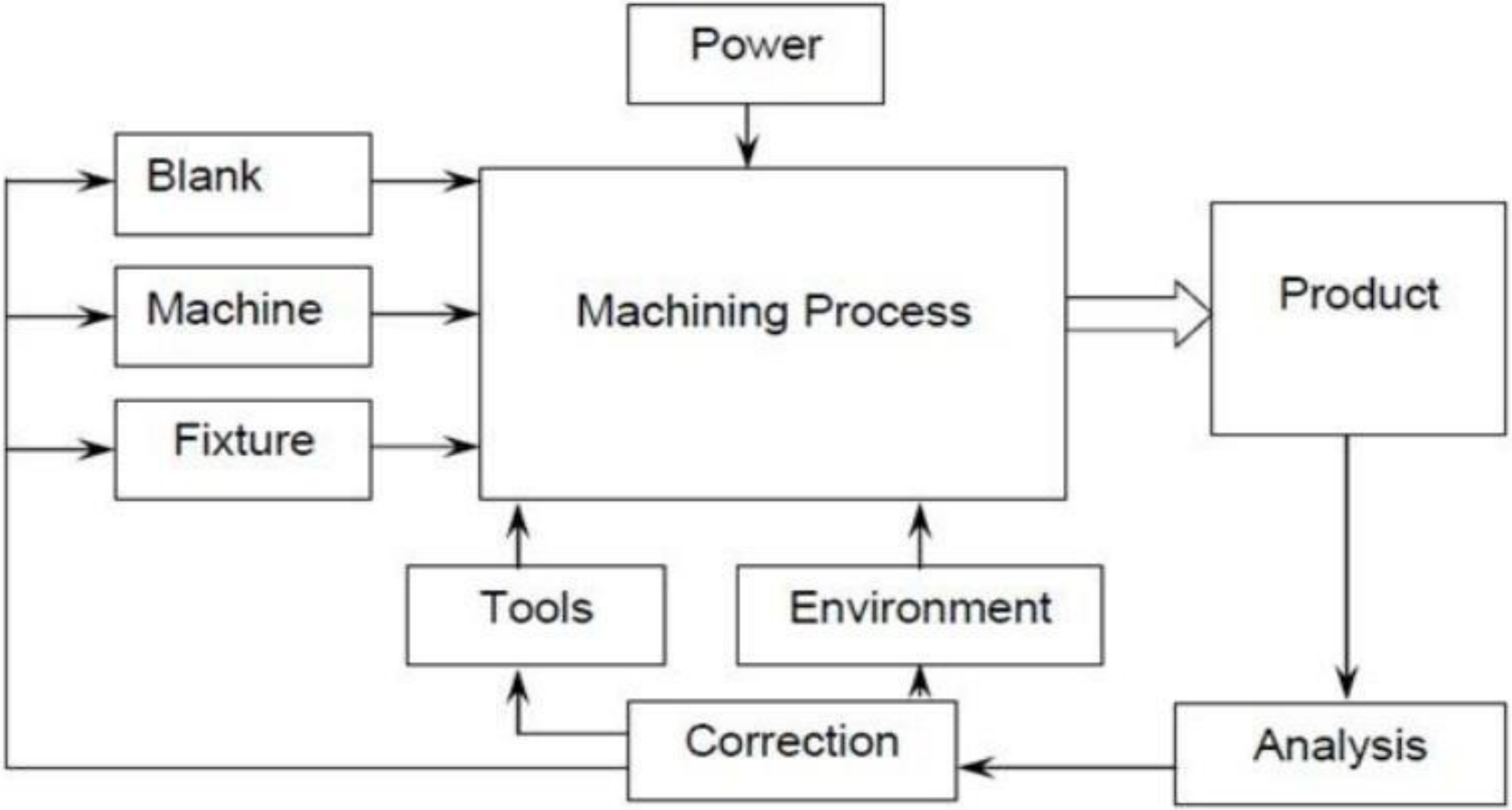


Fig. Requirements for machining

Elements of Cutting Process

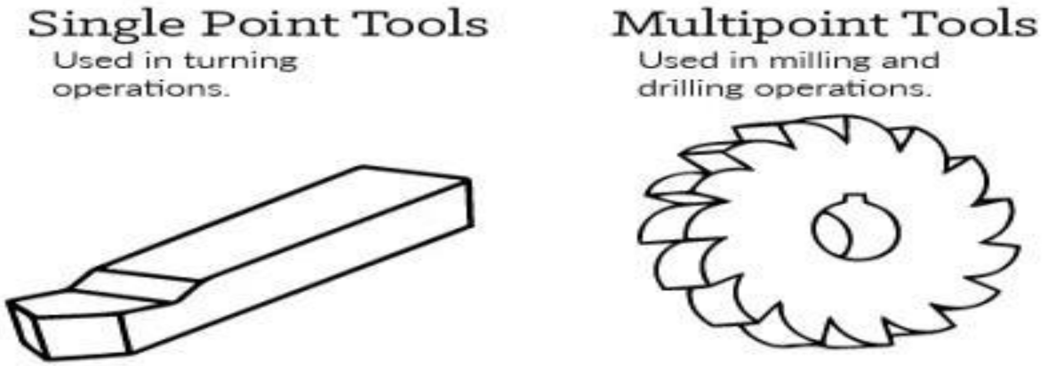
Any cutting process involves:

- Work-piece (material)
- Tool
- Chips
- Cutting Conditions

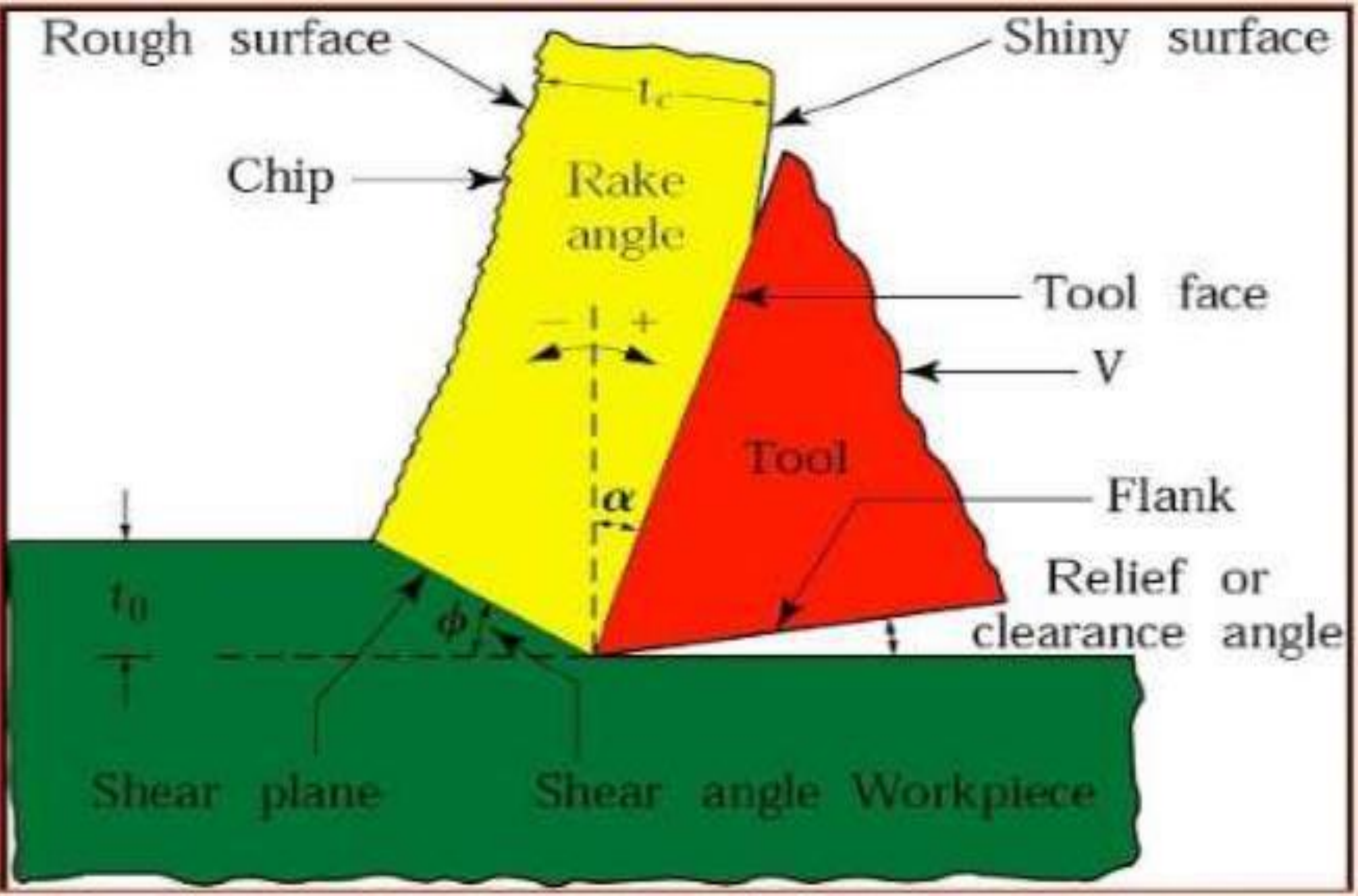
CUTTING TOOLS

- Cutting tools may be classified according to the number of major cutting edges (points) involved as follows

  - **Single point**: e.g., turning tools, shaping, planning and slotting tools



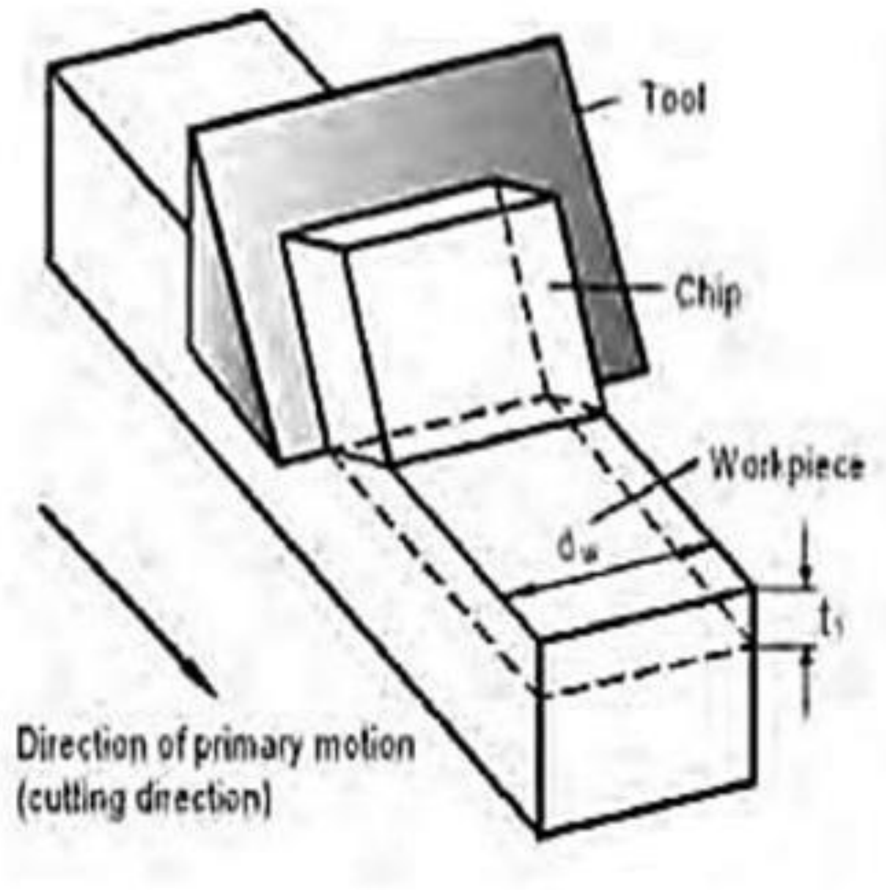
  - **Multipoint (more than one):** e.g., milling cutters, drills broaching tools, hobs, gear shaping cutters etc.


Rough surface
Shiny surface
t_c
Chip
Rake angle
Tool face
−
+
V
Tool
α
Flank
t_0
ϕ
Relief or clearance angle
Shear plane
Shear angle
Workpiece

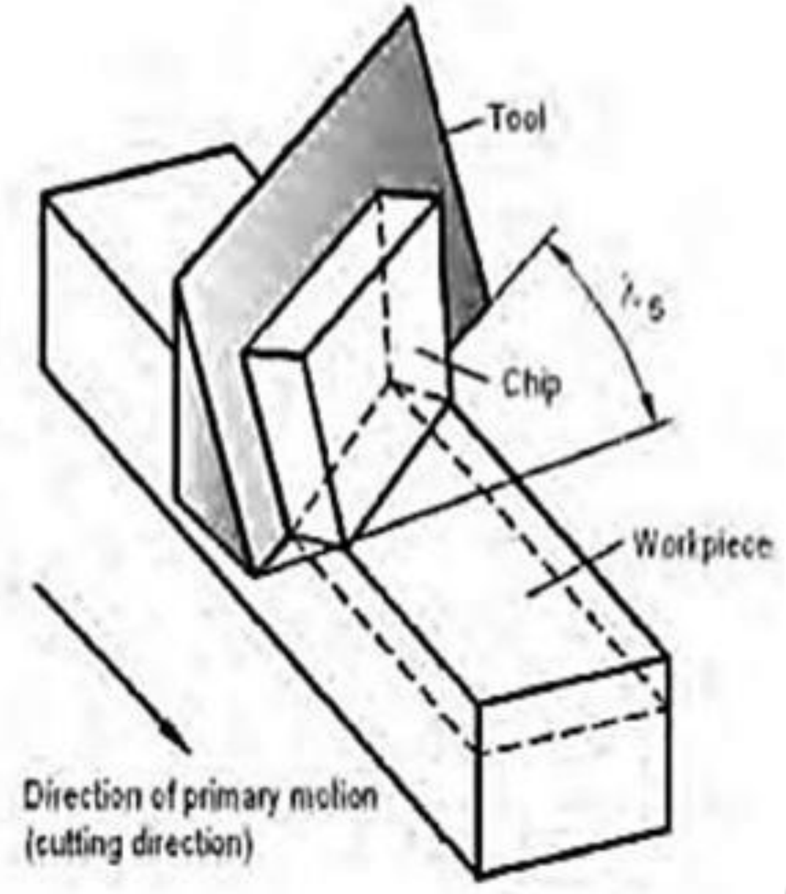
Types of metal cutting

1. **Orthogonal cutting/two dimensional cutting (Fig a)**
   - Cutting edge of the tool is at right angles (90 degrees) to the direction of relative motion b/w tool and the work piece
   - E.g.: turning at the open end of a tube, planing a rib with a tool wider than the rib.
   - Simple process (used as the basis for metal cutting study)

2. **Oblique cutting/three dimensional cutting (Fig b)**
   - Cutting edge of the tool is at an angle (not perpendicular) to the direction of relative motion b/w tool and the work piece
   - E.g.: Most actual cutting operations turning



Orthogonal cutting



Oblique cutting

Method of Metal Cutting

Orthogonal Cutting

cutting face of the tool is at 90^0 to the direction of tool travel

Oblique Cutting

cutting face of the tool is inclined at less than 90^0 to the path of tool travel

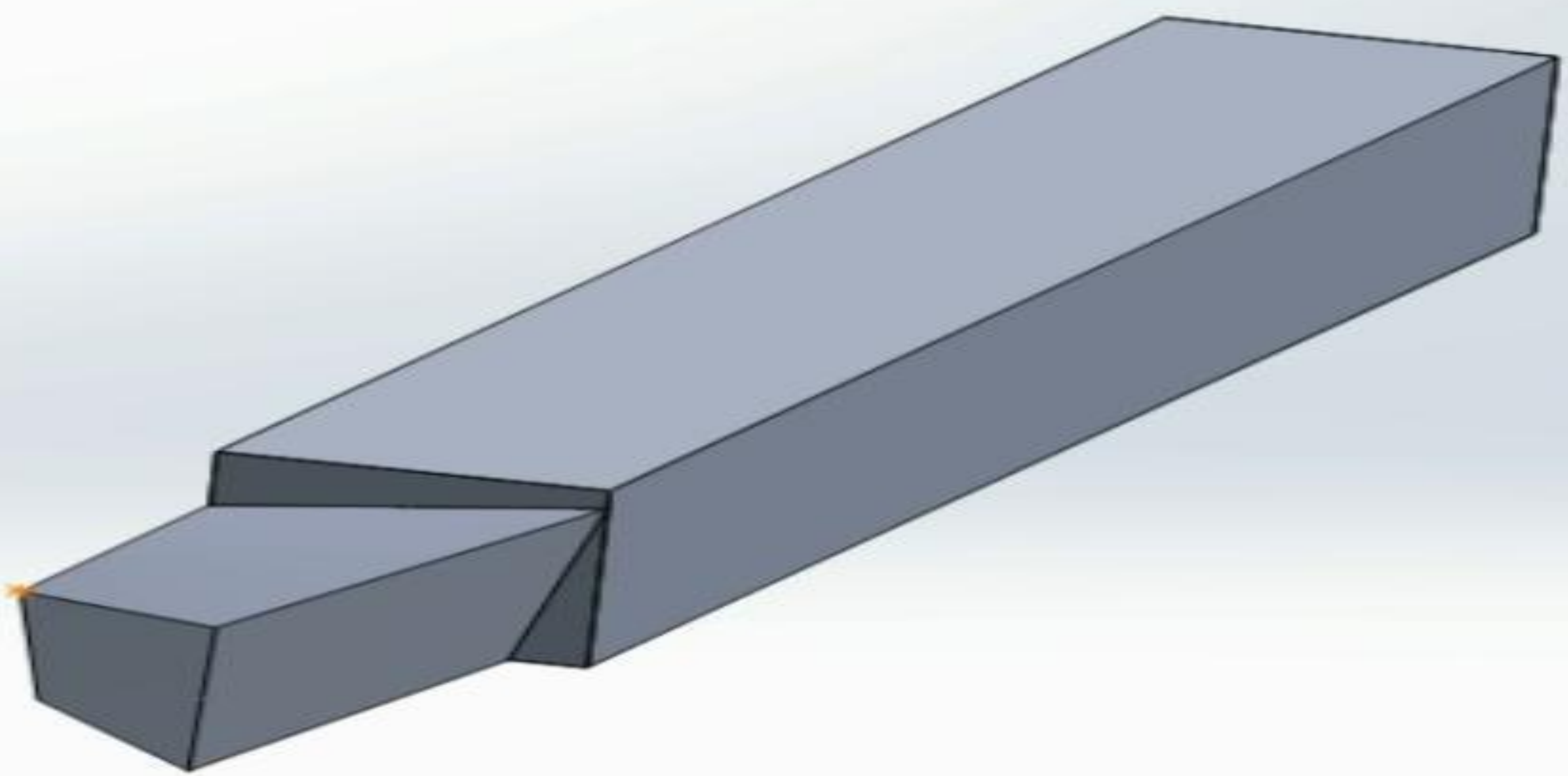
Orthogonal and Oblique Cutting

Orthogonal	Oblique
The cutting angle of tool make right angle to the direction of motion	The cutting angle of tool does not make right angle to the direction of motion
The flow of chip is perpendicular to cutting edge.	The flow of chip is not perpendicular to cutting edge.
The tool has lesser cutting life	The tool has higher cutting life
The shear force per unit area is high which increases the heat per unit area	The shear force per unit area is low which decrease heat per unit area
In this cutting, chip flow over the tool	In this cutting, chip flow along the sideways
In orthogonal cutting, surface finish is poor	In oblique cutting surface finish is good
Two mutually perpendicular cutting force act on the work piece	Three mutually perpendicular forces are involved

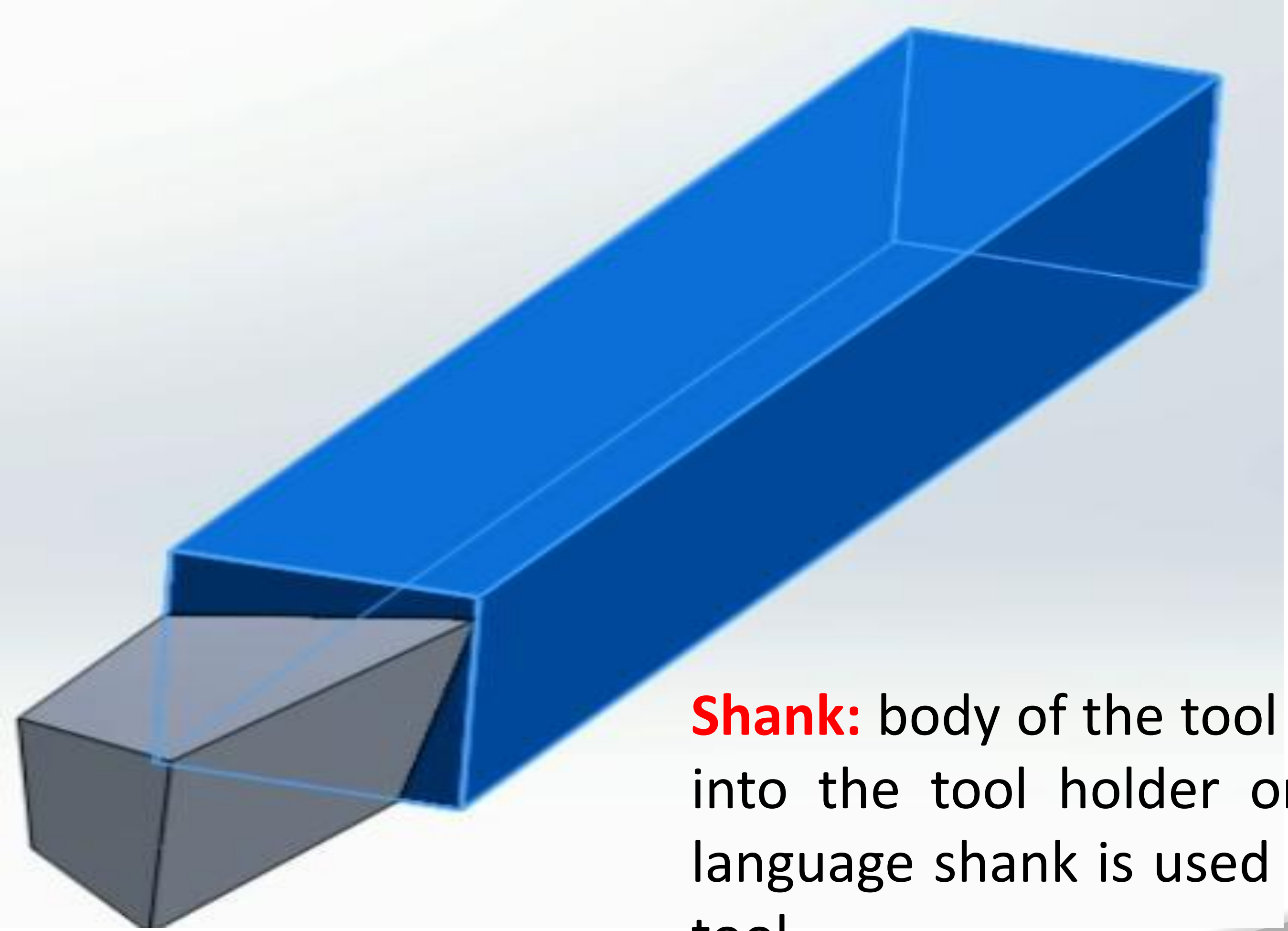
Single Point Cutting Tool

What is Single Point Cutting Tool?

As its name indicates, a tool that has a single point for cutting purpose is called single point cutting tool. It is used in the lathe machine, shaper machine etc. It is used to remove the materials from the work piece



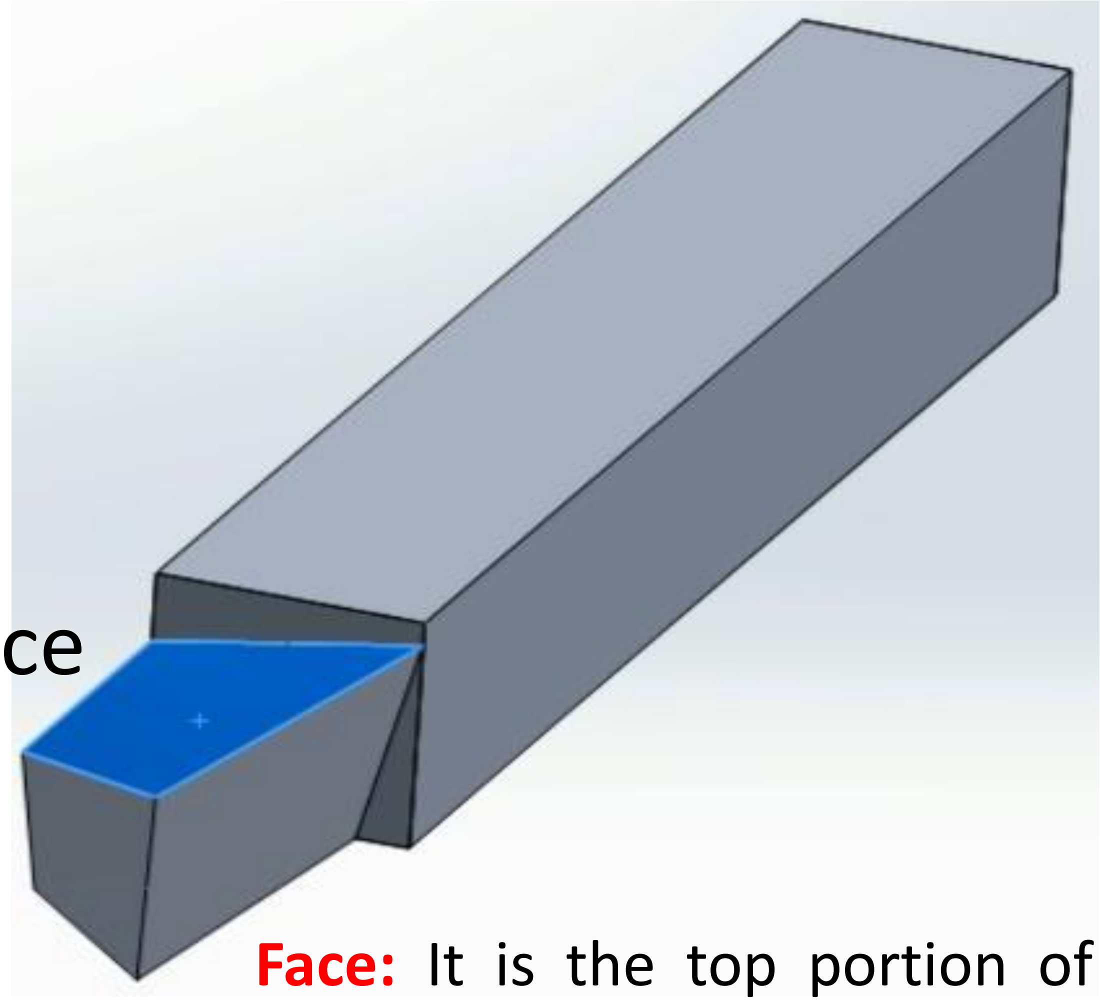
Parts of a Cutting Tool



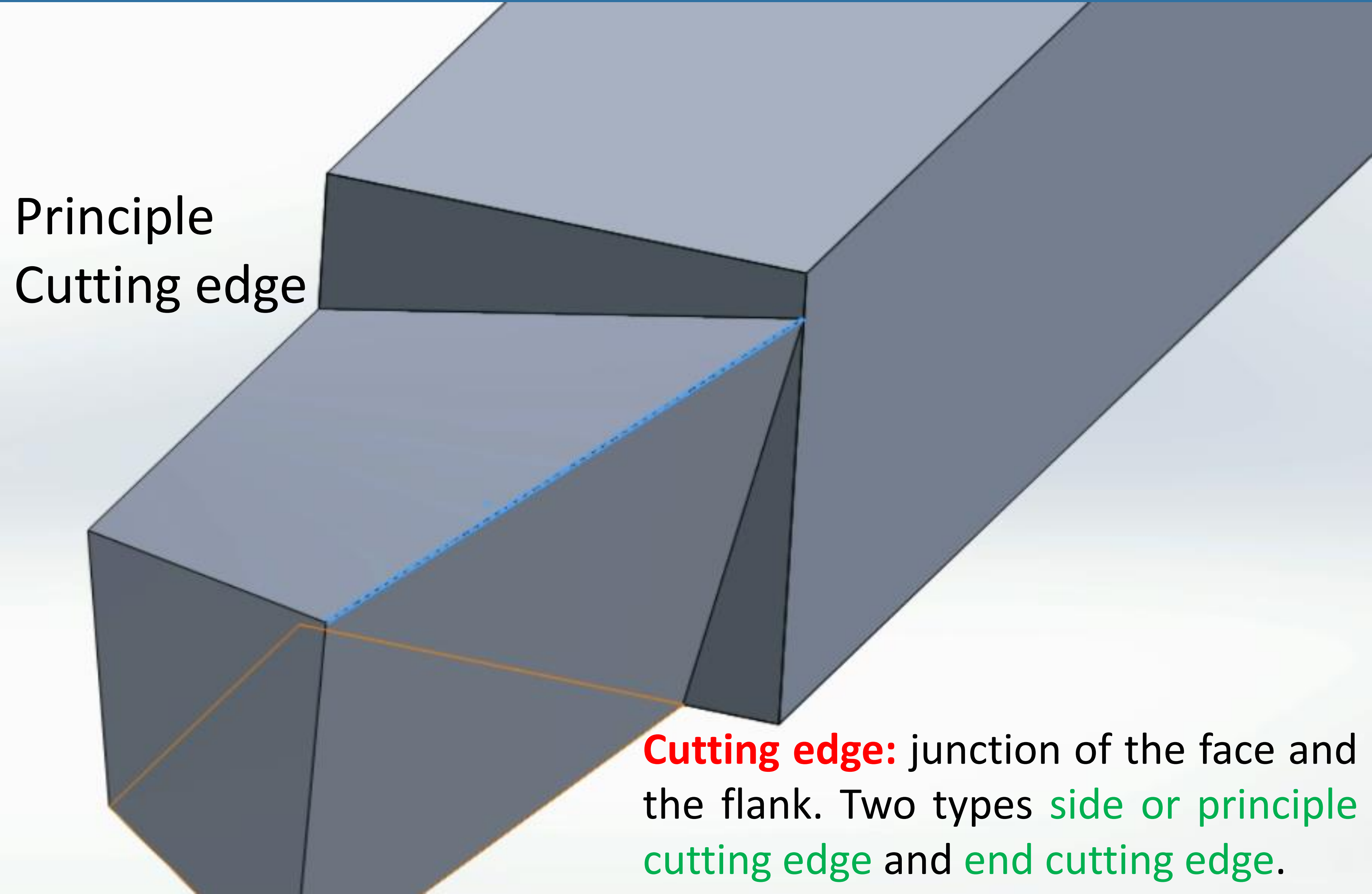
Shank

Shank: body of the tool which goes into the tool holder or in simple language shank is used to hold the tool.

Rake face



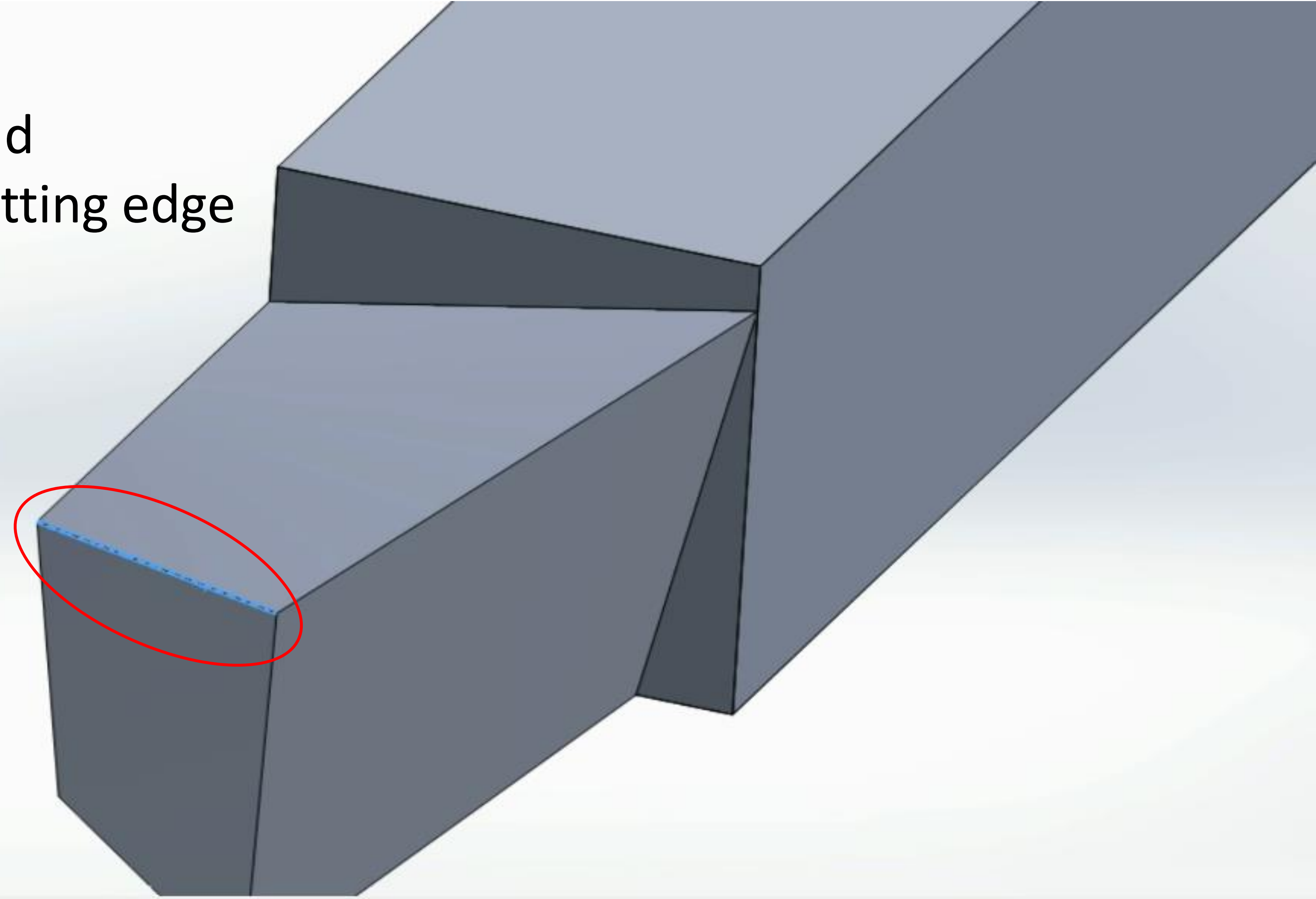
Face: It is the top portion of the tool along which chips slides. It is designed in such a way that the chips slides on it in upward direction

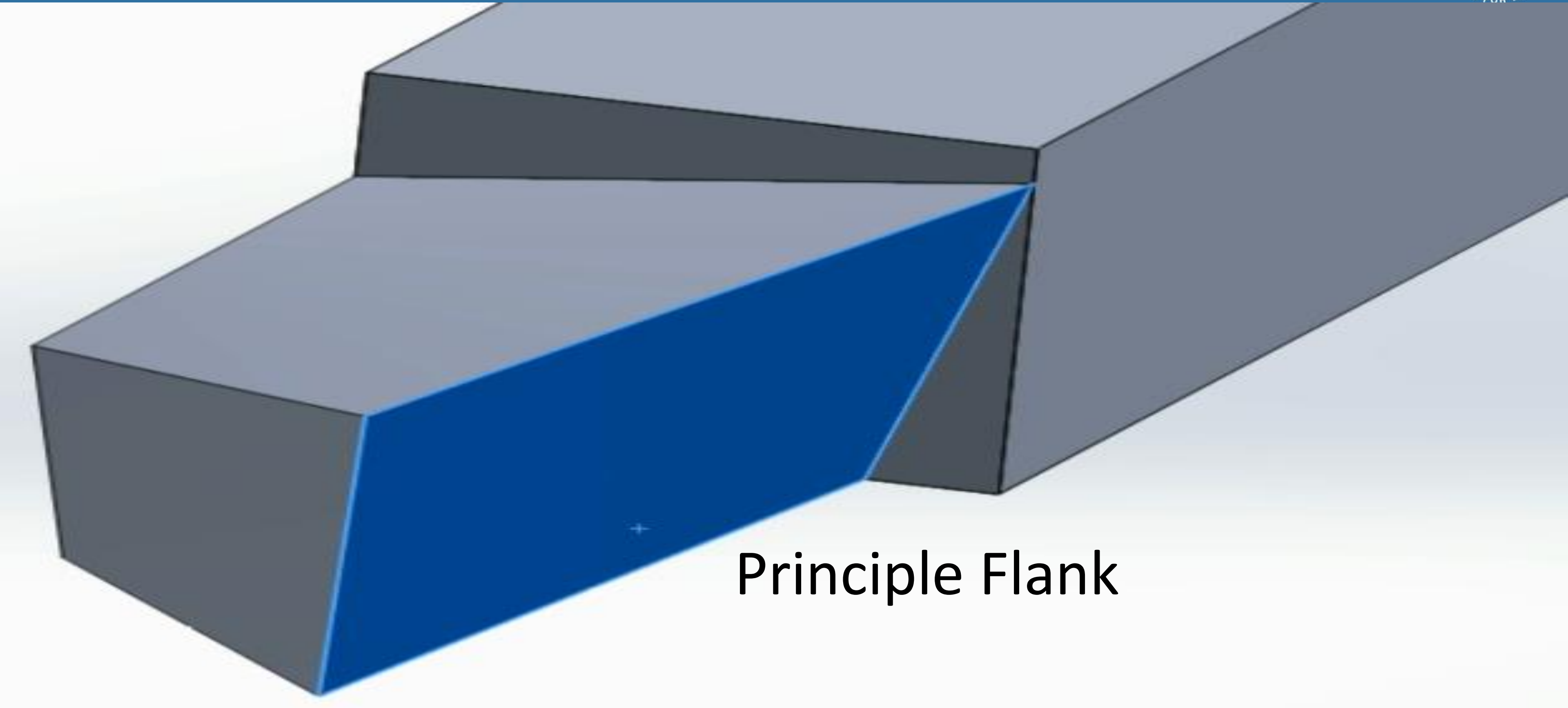


Principle
Cutting edge

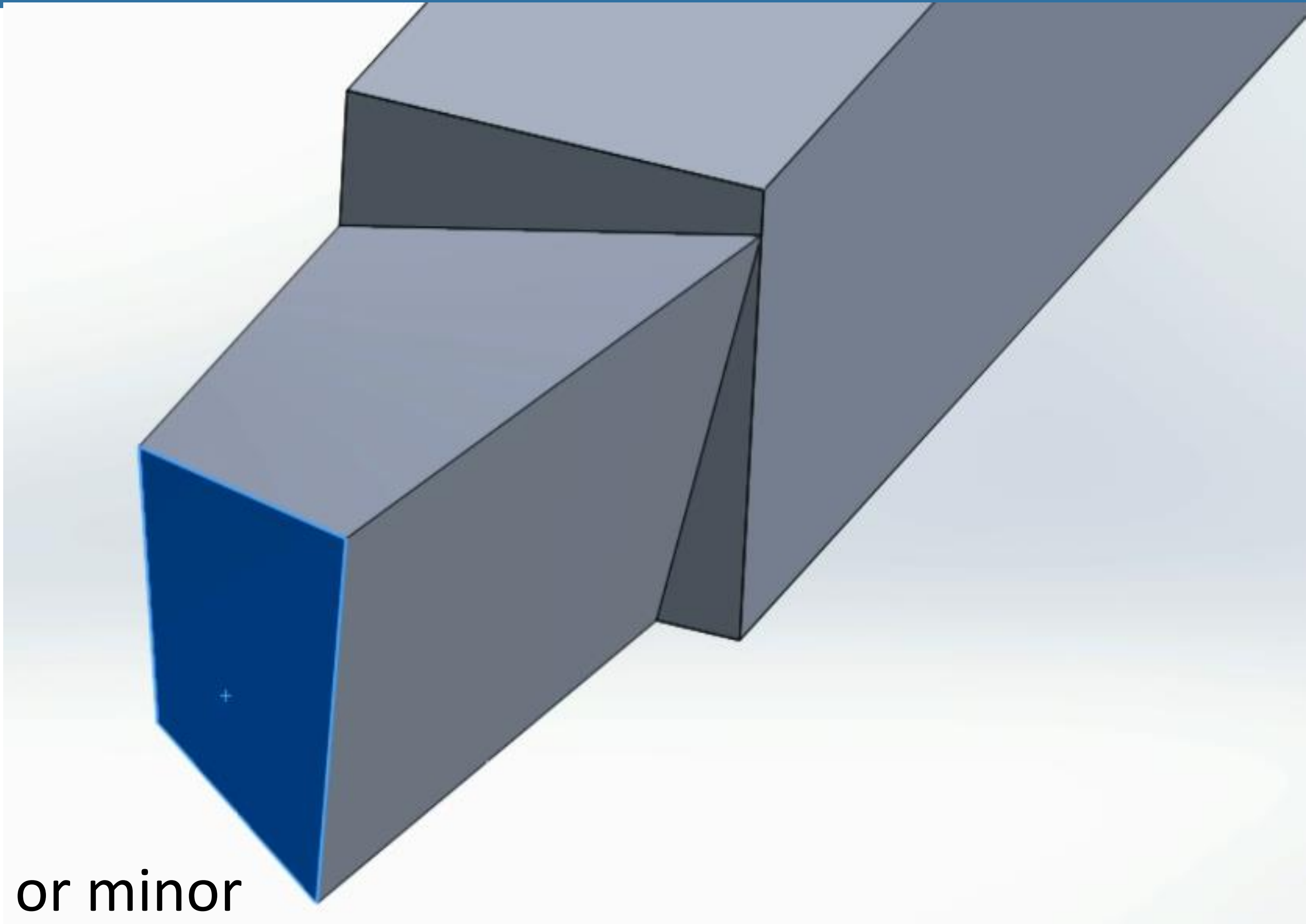
Cutting edge: junction of the face and the flank. Two types side or principle cutting edge and end cutting edge.

End
cutting edge

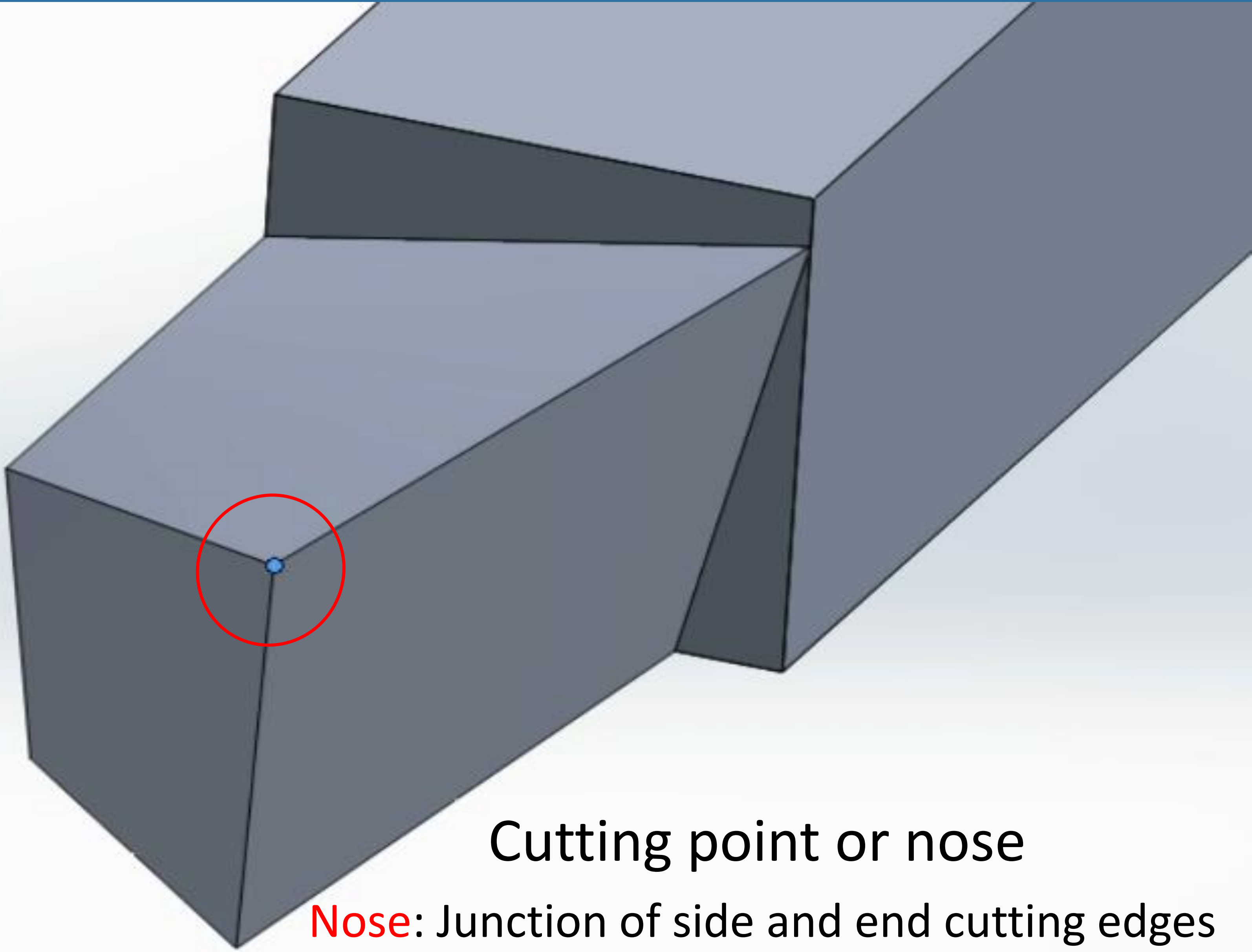




Flank: It is the surface below and adjacent of the cutting edges. There are two flank surfaces, first one is major flank and second one is minor flank. The major or principle flank lies below and adjacent to the side cutting edge and minor flank surface lies below and adjacent to the end cutting edge.



Auxiliary or minor Flank



Cutting point or nose

Nose: Junction of side and end cutting edges

GEOMETRY OF S P C TOOL/ NOMENCLATURE

7. **Nose radius:** It is the radius of the nose. Nose radius increases the life of the tool and provides better surface finish.

8. **Heel:** It is a curved portion and intersection of the base and flank of the tool.

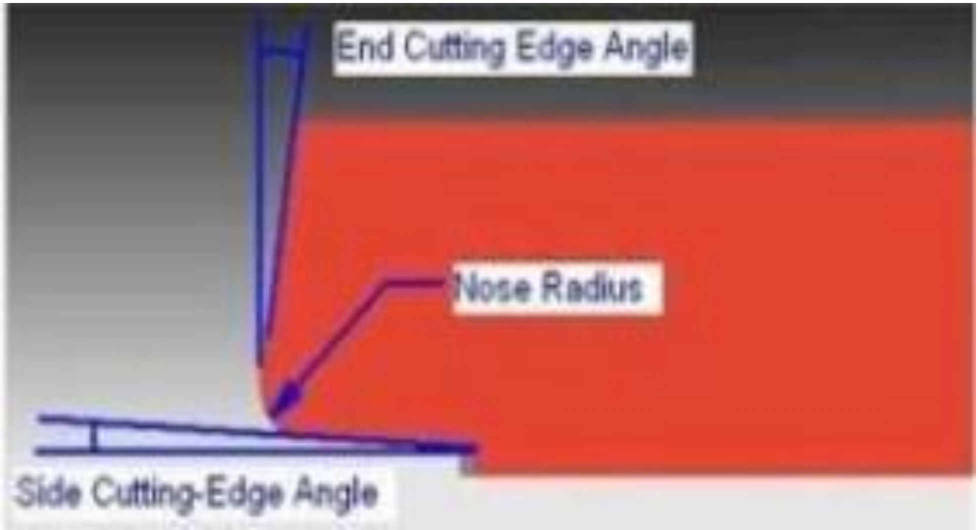
Angles

The various angles of the single point cutting tool have great importance. Each angle has its own function and speciality

GEOMETRY OF S P C TOOL/ NOMENCLATURE

1. End Cutting Edge Angle:

The angle formed in between the end cutting edge and a line perpendicular to the shank is called end cutting edge angle.



2. Side Cutting Edge Angle:

The angle formed in between the side cutting edge and a line parallel to the shank.

GEOMETRY OF S P C TOOL/ NOMENCLATURE

3. Back Rack Angle:

The angle formed between the tool face and line parallel to the base is called back rake angle.

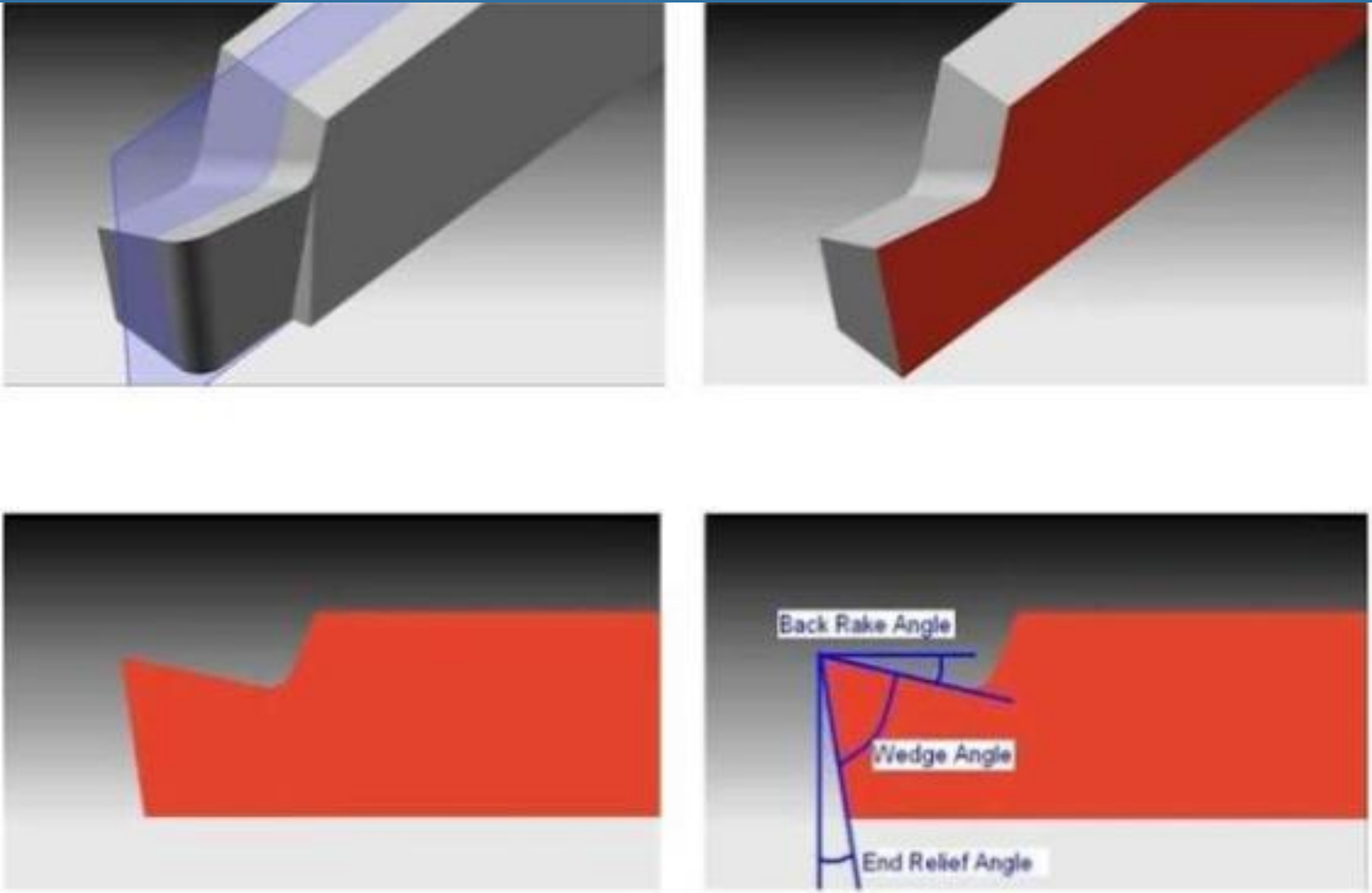
4. End Relief Angle:

The angle formed between the minor flank and a line normal to the base of the tool is called end relief angle. It avoid the rubbing of the work piece against tool.

5. Lip Angle/ Wedge Angle:

It is defined as the angle between face and minor flank of the single point cutting tool.

Tool Nomenclature/Angles



Tool Nomenclature/Angles

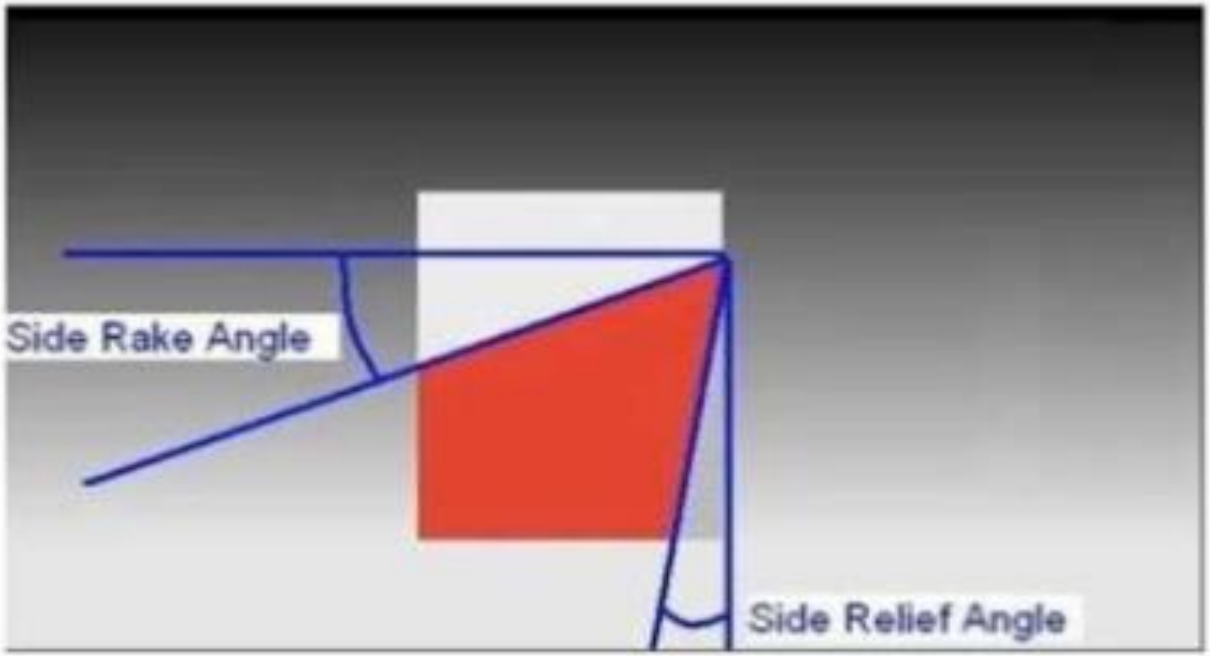
6. **Side Rake Angle:**

   The angle formed between the tool face and a line perpendicular to the shank is called side rake angle.

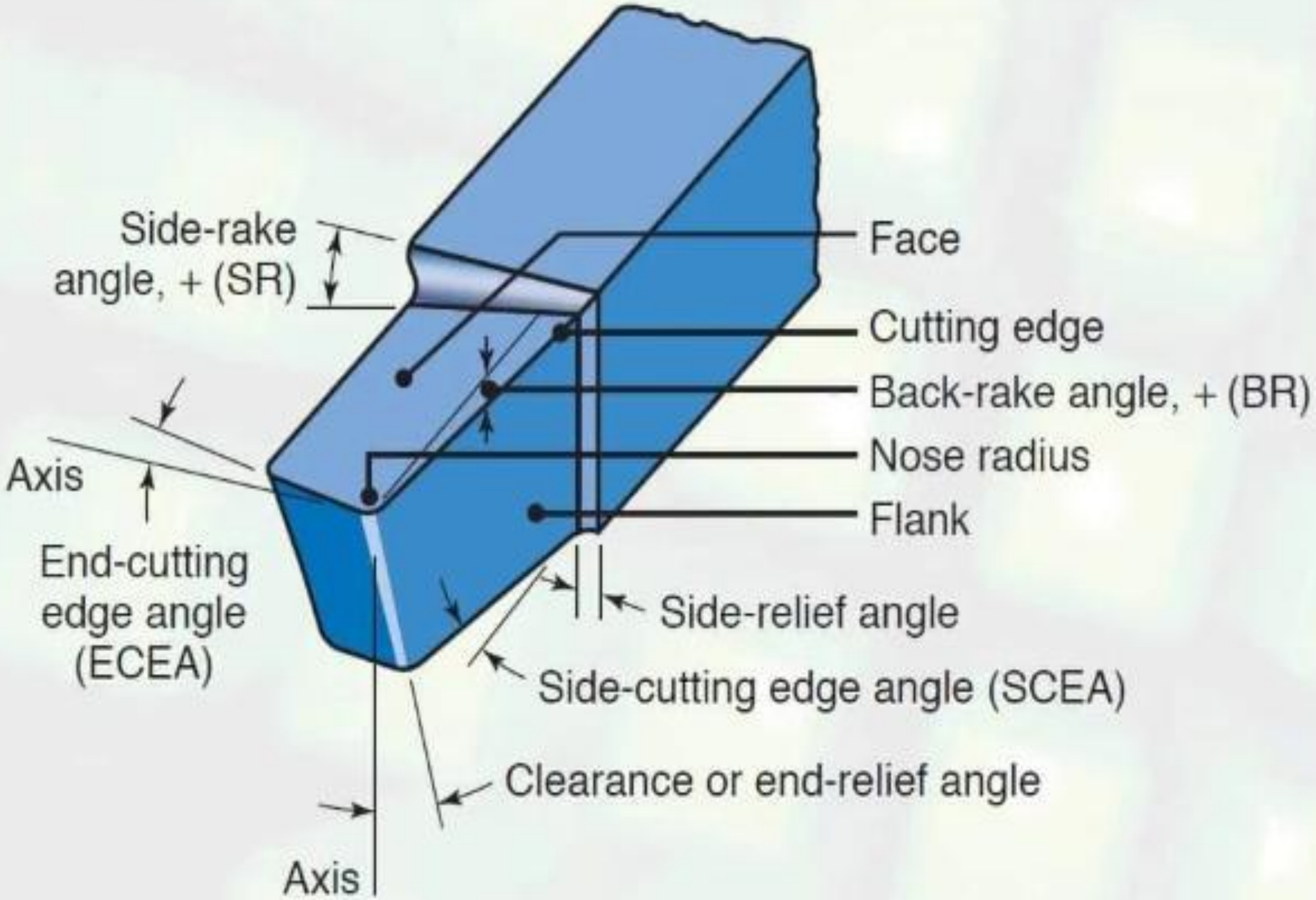
7. **Side Relief Angle:**

   The angle formed between the major flank surface and plane normal to the base of the tool is called side relief angle, This angle avoids the rubbing between workpiece and flank when the tool is fed longitudinally.

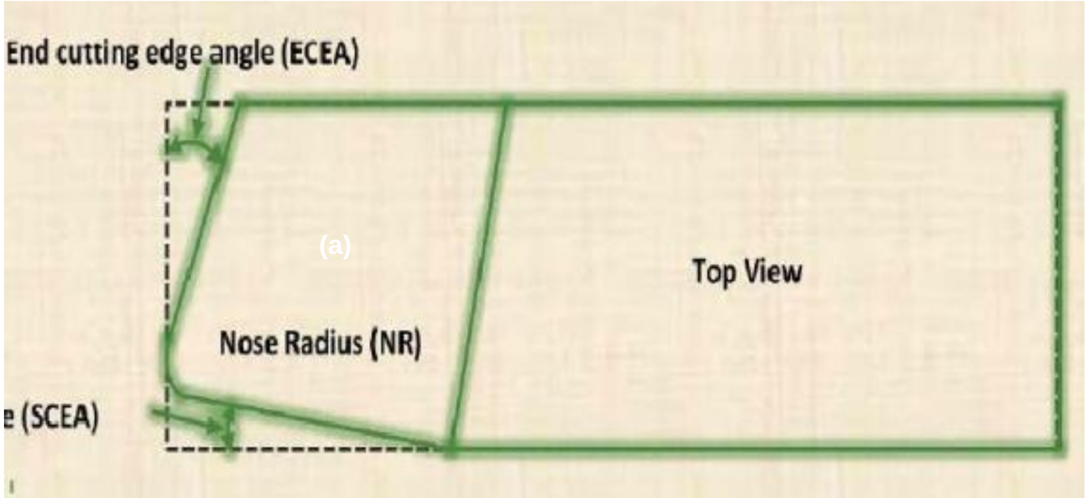
Tool Nomenclature/Angles

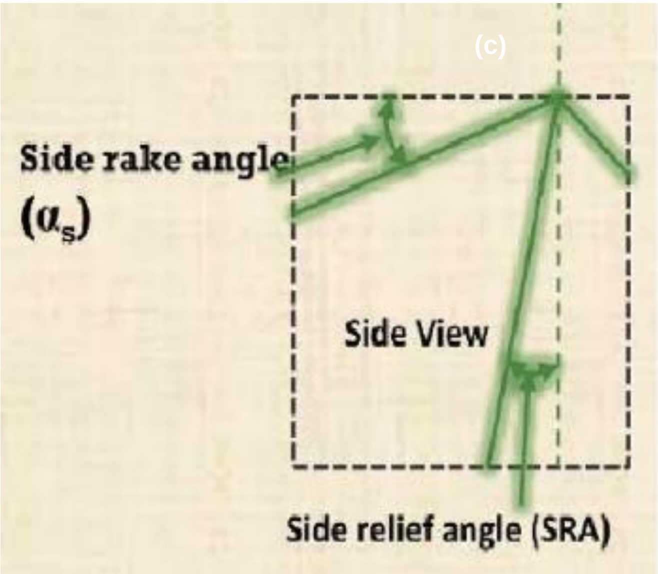


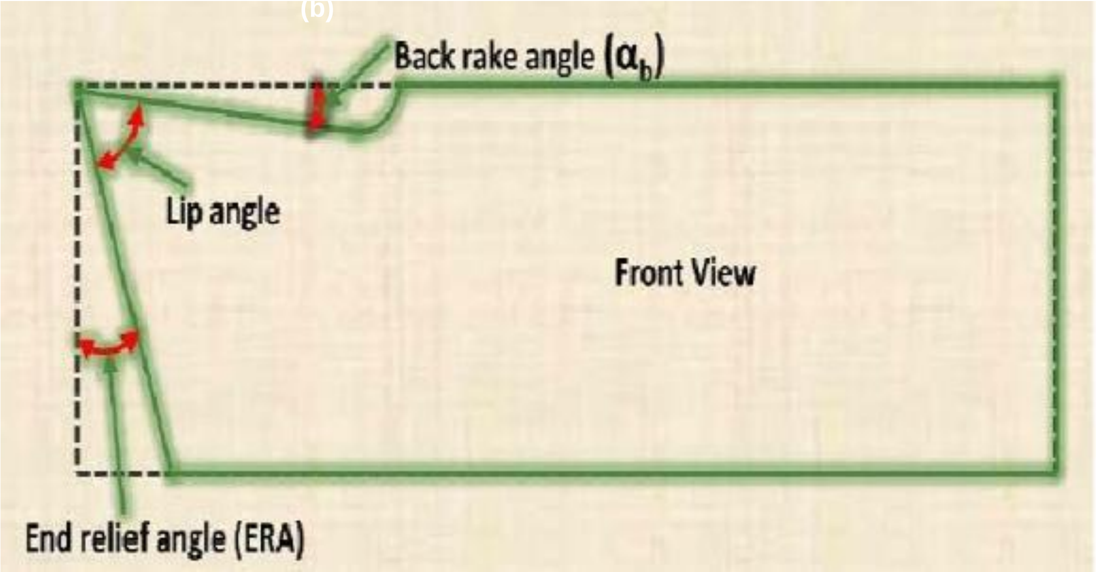
Tool Nomenclature/Angles



Tool Nomenclature/Angles







Important parts of a single point cutting tool are

1. **Shank:** body of the tool which goes into the tool holder or in simple language shank is used to hold the tool.
2. **Face:** It is the top portion of the tool along which chips slides. It is designed in such a way that the chips slides on it in upward direction.
3. **Flank:** It is the surface below and adjacent of the cutting edges. There are two flank surfaces, first one is major flank and second one is minor flank. The major flank lies below and adjacent to the side cutting edge and minor flank surface lies below and adjacent to the end cutting edge.
4. **Base:** bottom surface of the shank or the portion of the shank that lies opposite to the top face of the shank is called base.
5. **Cutting edge**: junction of the face and the flank. Two types side cutting edge and end cutting edge.
6. **Nose:** Junction of side and end cutting edges

Important angles of a single point cutting tool are

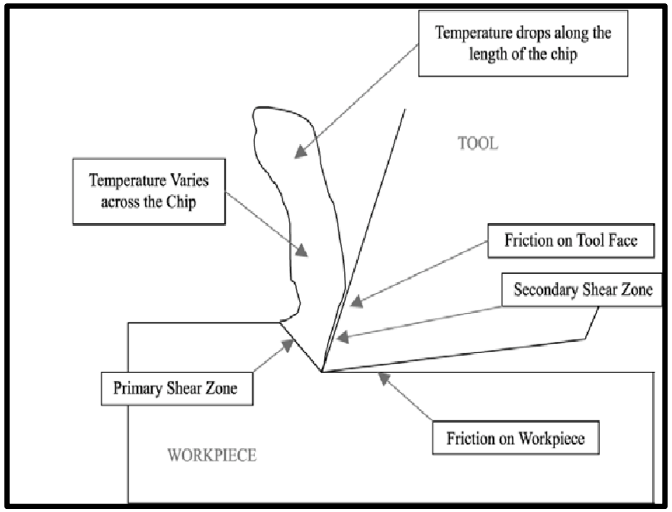
- **Top rake angle:** also called as back rake angle It is the slop given to the face or surface of the tool. The slop is given from the nose along the length of the tool.
- **Side rake angle:** slop given to the face or top of the tool. Slop is given from the nose along the width of the tool. Helps easy flow of chip.
- **Clearance or relief angle:** slops ground downwords from the cutting edges. (a) side clearance (b) end clearance. Given to the tool to prevent rubbing of the job on the tool.
- **Lip angle**: called as cutting angle. It is the angle between the face and end surface of the tool.

- **Nose angle:** Angle between side cutting edge and end cutting edge
- **Cutting edge angles:** two types. side cutting edge : it is angle of the side cutting edge makes with the axis of the tool. End cutting edge angle: cutting edge makes with the width of the tool

CHIP FORMATION

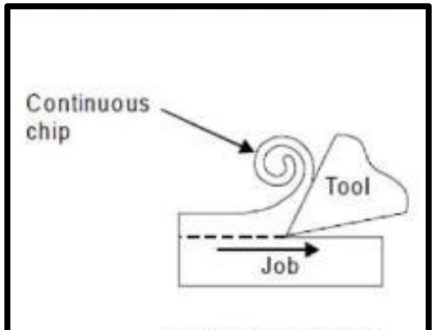
❑ Types of Chips

- ✓ Continues Chips
- ✓ Discontinues Chips
- ✓ Continuous Chips with Built up Edge (BUE)

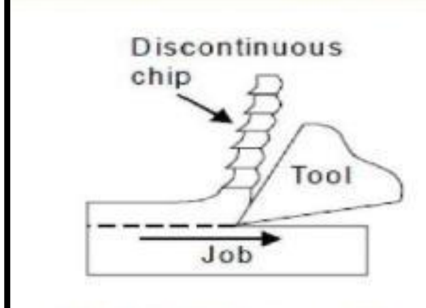


Conditions for Continuous Chips:

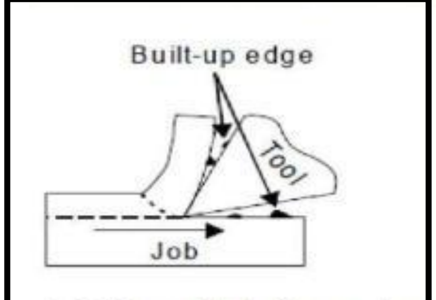
- Sharp cutting edges
- Low feed rate (f)
- Large rake angle (α)
- Ductile work material
- High cutting speed (v=)
- Low friction at Chip-Tool interface



(a) Continuous chips

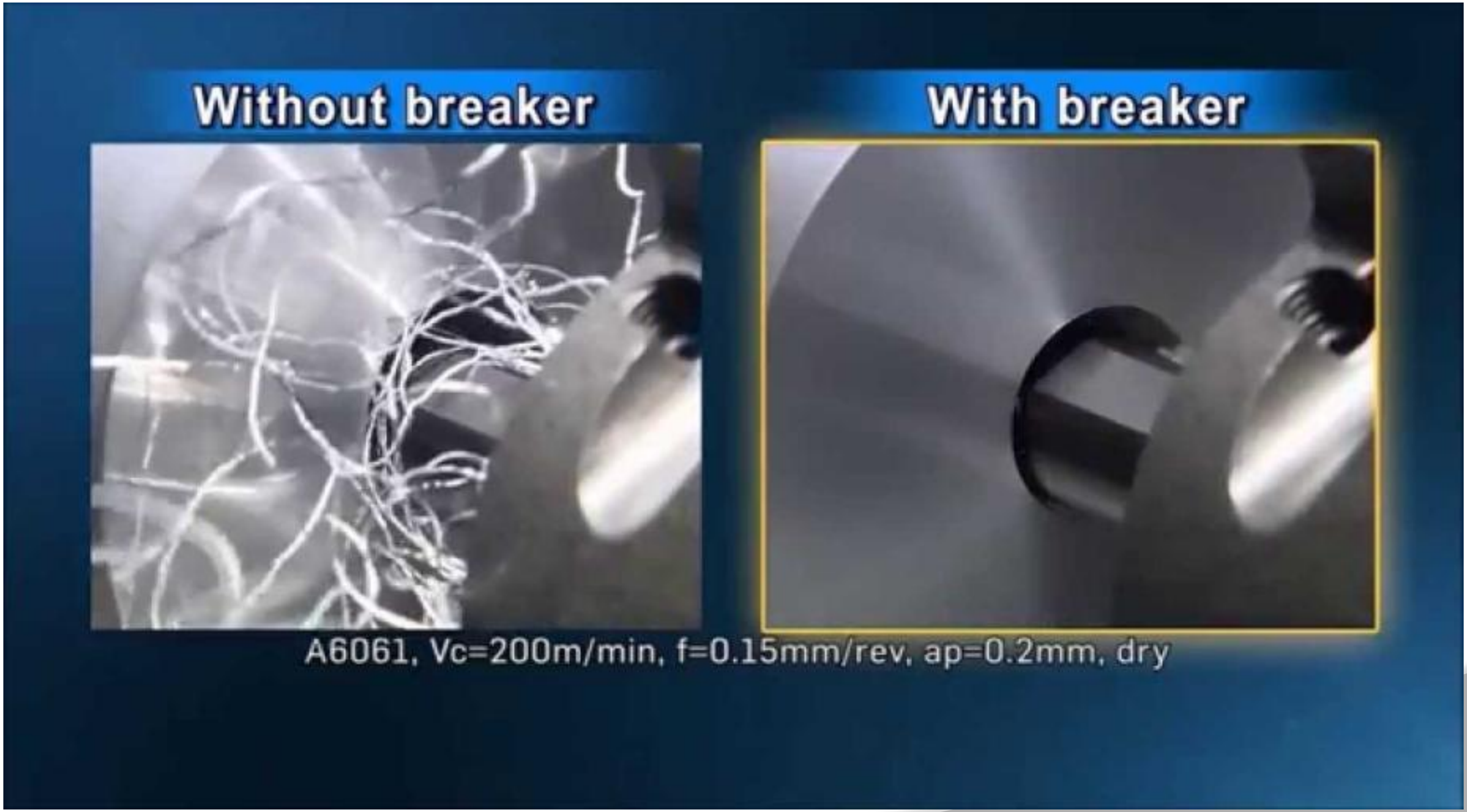


(b) Discontinuous chips



(c) Chips with built-up edge

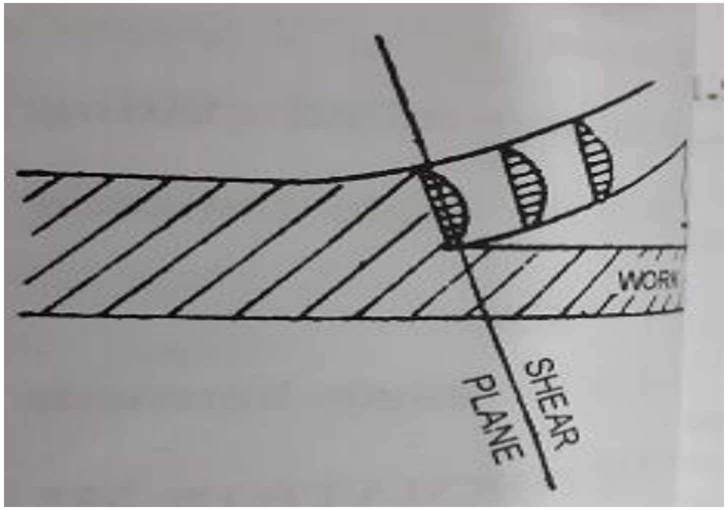
Fig; Schematic of different types of chip


Without breaker
With breaker
A6061, Vc=200m/min, f=0.15mm/rev, ap=0.2mm, dry

Types of chips

Discontinuous chips:

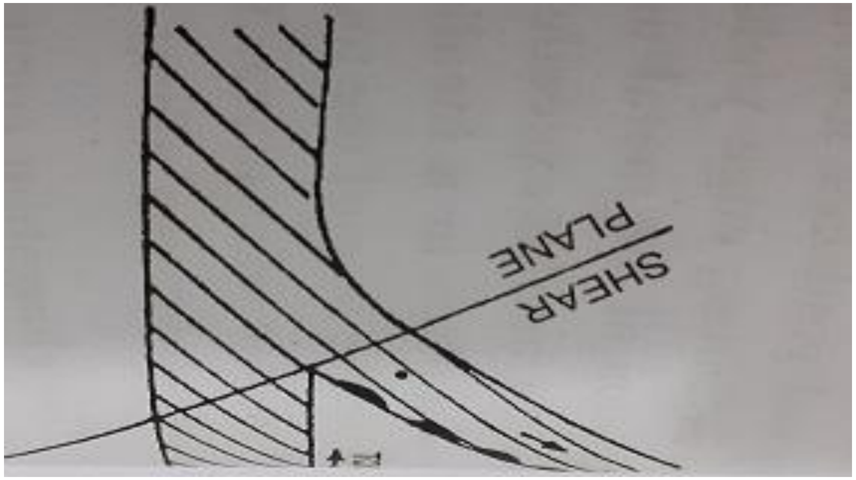
- Also be called as segmental chips.
- Mostly occurs while cutting brittle material (Cat Iron) or low ductile materials.
- Instead of shearing the metal as it happens in previous process, the metal is being fractured like segments of the fragments and they pass over the tool faces.
- Tool life more.
- Power consumption as in the previous case also low.



Types of chips

Continuous Chips:

- When cutting a ductile material, the compression of the metal is followed by the high heat at tool face.
- This in turns enables the part of the removed metal to be welded into the tool. This produces rough surface finish and the tool life may be reduced.



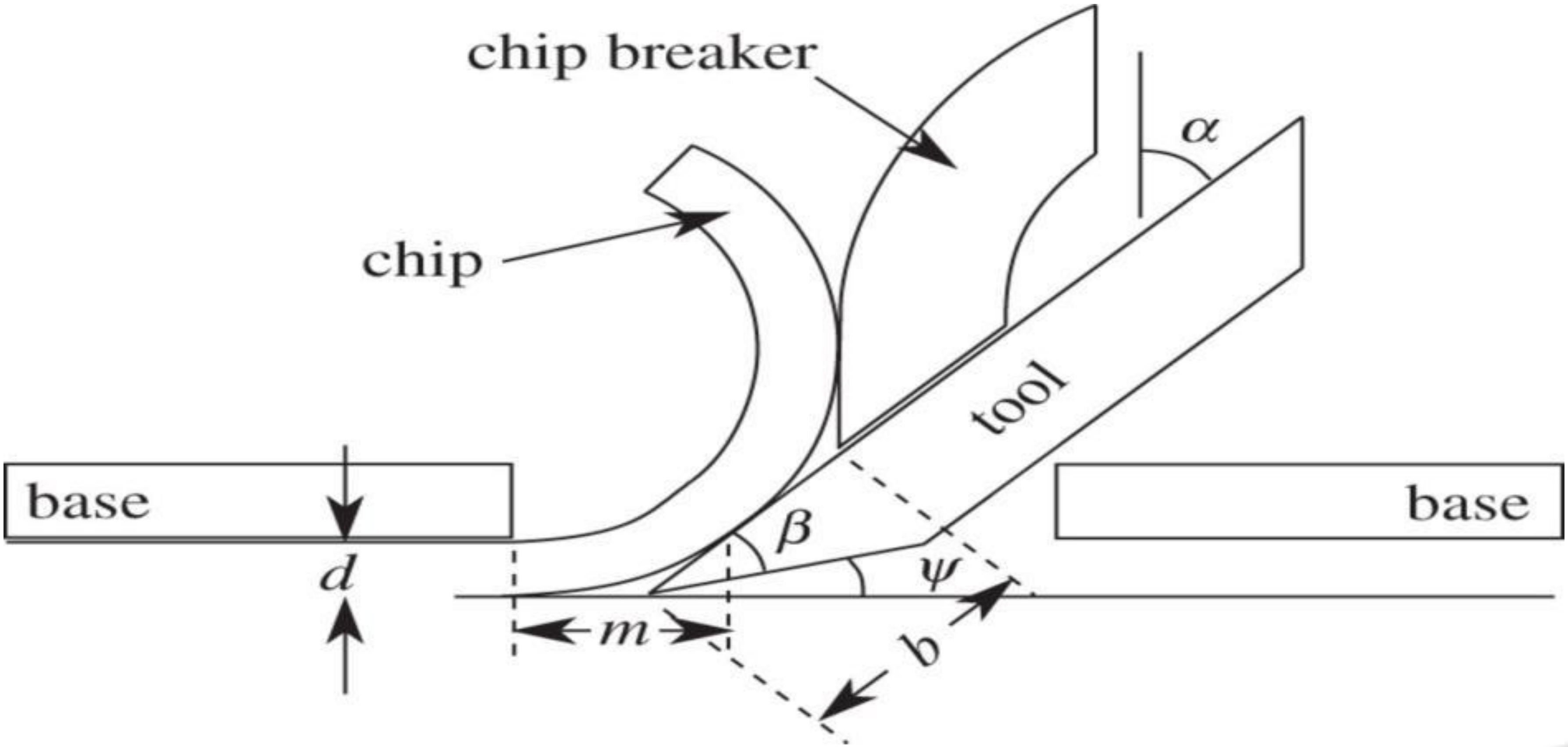
Types of chips

In operation at high cutting speeds, when a large quantity of inconvenient and hazardous steel chips Is produced in a short time, the problem of curling or breaking the chips into small pieces becomes one of primary importance

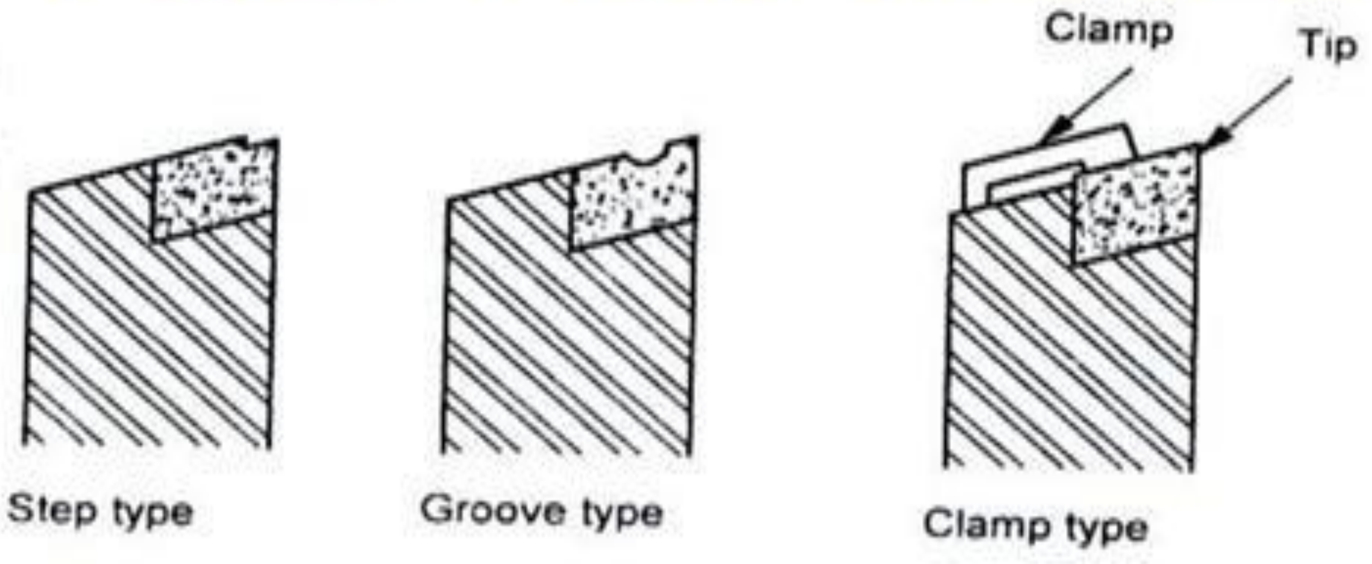
Chip Breakers

- Long continuous chips are undesirable
- Chip breaker is a piece of metal clamped to the rake surface of the tool which bends the chip and breaks it
- Chip can also be broken by changing the tool geometry, thereby controlling the chip flow

Chip Breakers



TYPES OF CHIP BREAKERS



Chip- Breaking

- The chip breaker break the produced chips into small pieces.
- The work hardening of the chip makes the work of the chip breakers easy. When a strict chip control is desired, some sort of chip breaker has to be employed. The following types of chip breakers
  - Groove type
  - Step type
  - Secondary Rake type
  - Clamp type

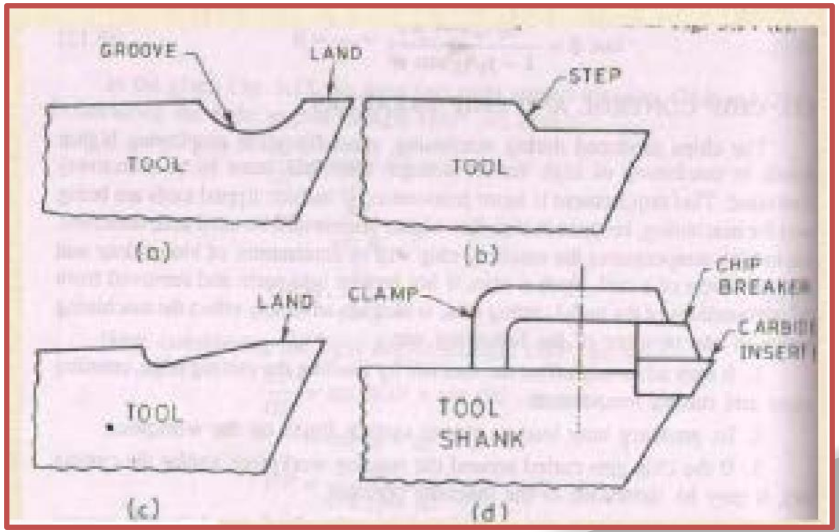


Fig: Schematics of different types of chip barkers

Classification of cutting tools

(1) Single Point Cutting Tool

(2) Multi point Cutting Tool

Single Point Cutting Tool: It has effective cutting edge and removes excess material along cutting edge

Types: (a) Ground Type, (b) Forged Type
(c) Tipped Type, (d) Bit Type

(a) Ground Type: Cutting edge is formed by grinding the end of a piece of tool steel stock

(b) Forged Type: Cutting edge is formed by rough forging before hardening and grinding

Classification of cutting tools

(c) Tipped Type: Cutting edge is in the form of a small tip made of high grade material which is welded to shank made up of low grade material.

(d) Bit Type: A high grade material of square, rectangular or some other shape is held mechanically in a tool holder.

Single point cutting tools are commonly used in Lathe, shapers, planers, boring M/C and Slotters.

Classification of cutting tools

Multi point cutting tool : Having more than a cutting edge Milling cutters, drills, broaches, grinding wheel

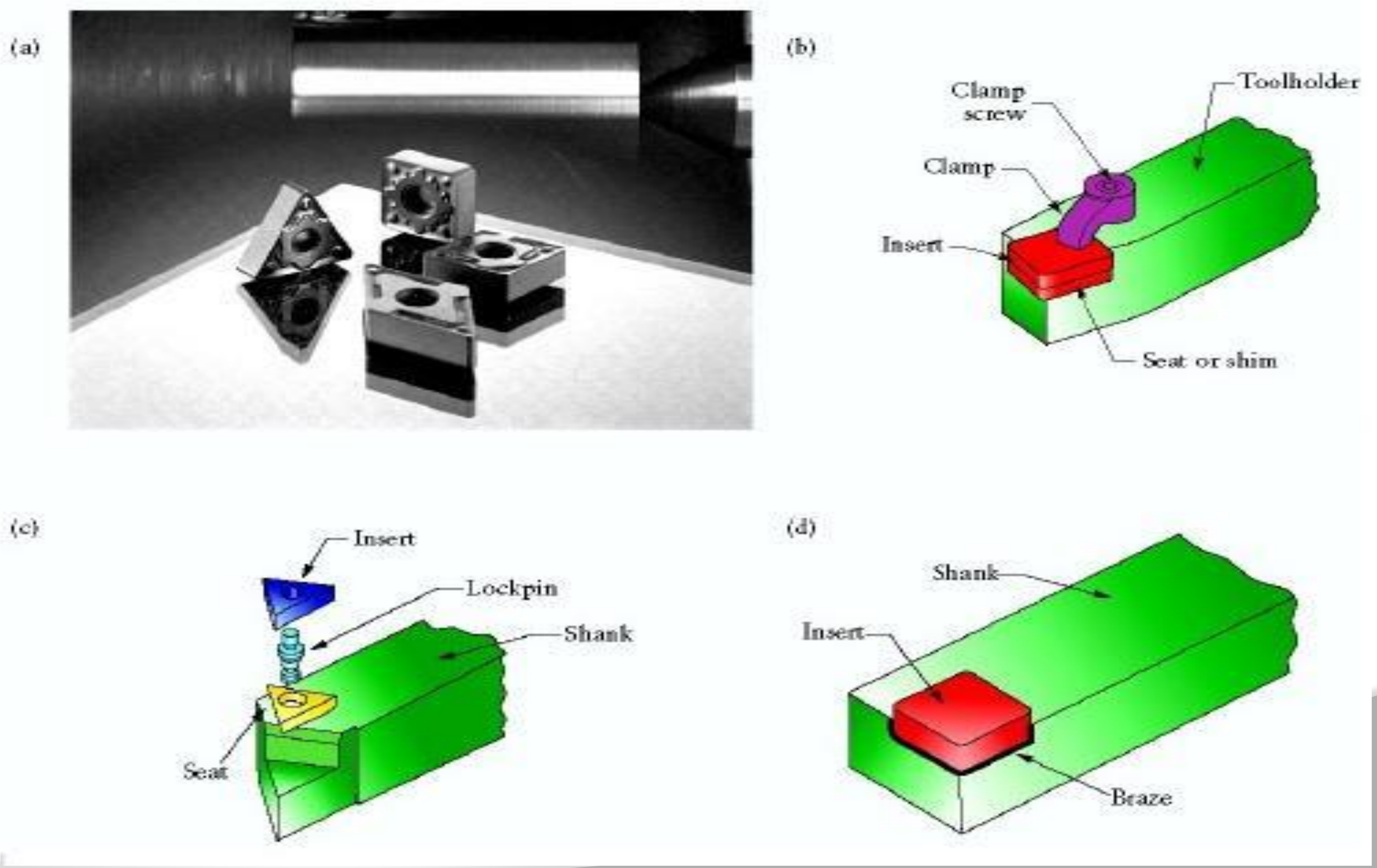
Cutting tools also classified according to the motion as

(1) Linear Motion: Lathe, boring, broaching, planning, shaping tools etc.

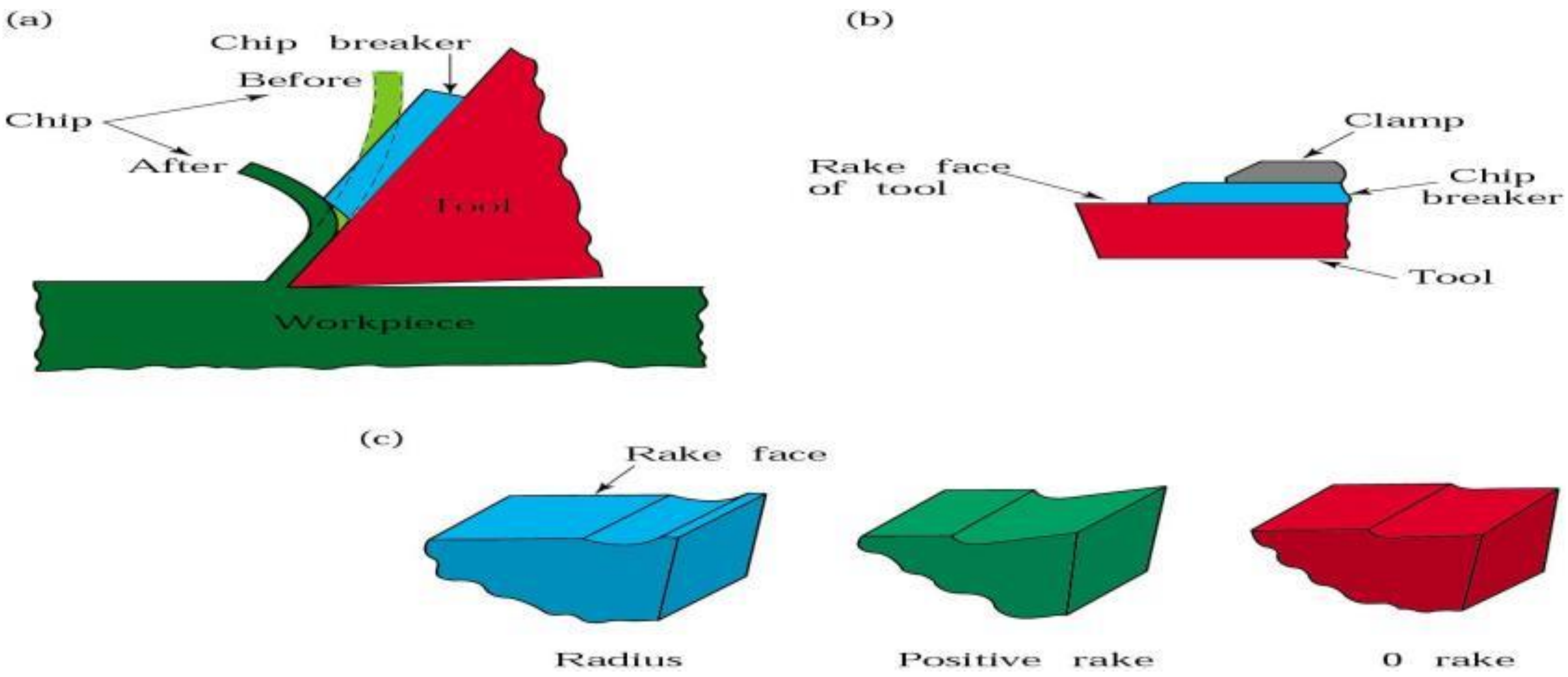
(2) Rotary Motion Tools: Milling Cutters, grinding wheels etc.

(3) Linear and rotary tools: Drills, honing tool, boring heads etc.

Bit Type


(a)
(b)
Clamp screw
Toolholder
Clamp
Insert
Seat or shim
(c)
Insert
Lockpin
Shank
Seat
(d)
Shank
Insert
Braze

Chip Breakers



(a) Schematic illustration of the action of a chip breaker. Note that the chip breaker decreases the radius of curvature of the chip. (b) Chip breaker clamped on the rake face of a cutting tool. (c) Grooves in cutting tools acting as chip breakers.

fig: a

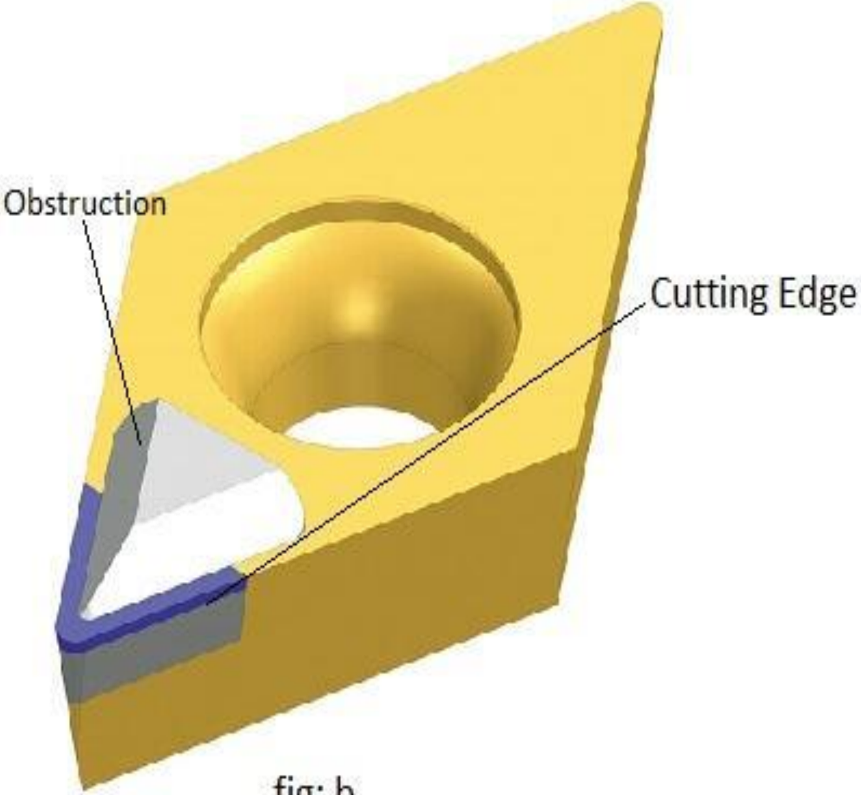


fig: b

MERCHANT THEORY

ORTHOGONAL CUTTING FORCES – **MERCHANT THEORY**

- Considering a 2D/Orthogonal Cutting operation.
- Assumptions:

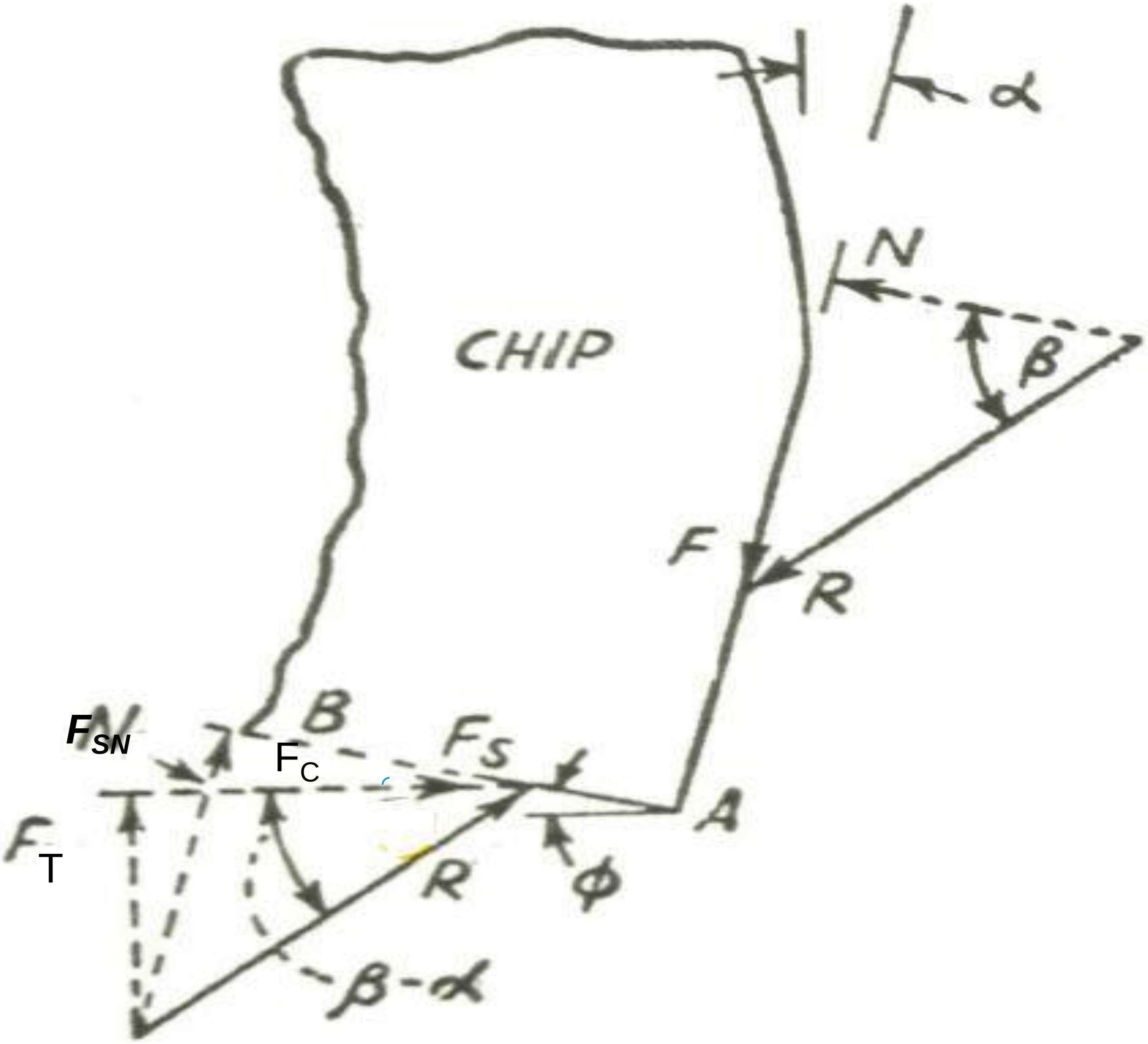
1. The tool is perfectly sharp and there is no contact along the clearance/flank face
2. The cutting edge is a straight line, extending perpendicular to the direction of motion and generates a plane surface as the work moves past it.
3. Width of the tool is greater than that of the work-piece.
4. The depth of cut is constant
5. The work moves relative to the tool with uniform velocity.
6. The shear surface is a plane extending upwards from the cutting edge.
7. The chip does not flow to either sides
8. A continuous chip is produced with no BUE.

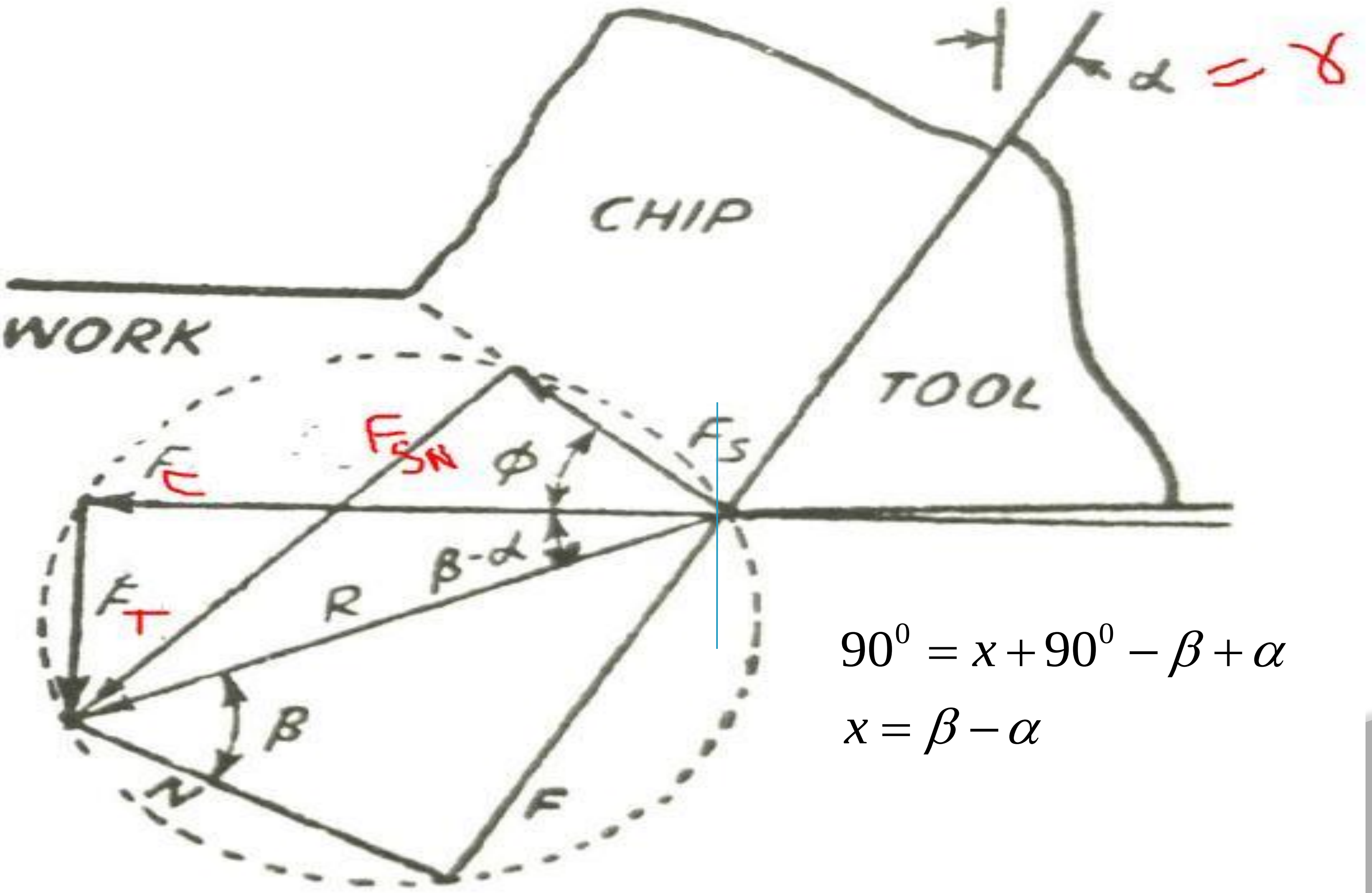
MERCHANT THEORY

9.Plain strain conditions exists, (width of the chip remains equal to work-piece)
10.Chip is assumed to shear continuously across plane AB on which the shear stress reaches the value of the shear flow stress.

The forces acting on a metal chip during the cutting operation are:

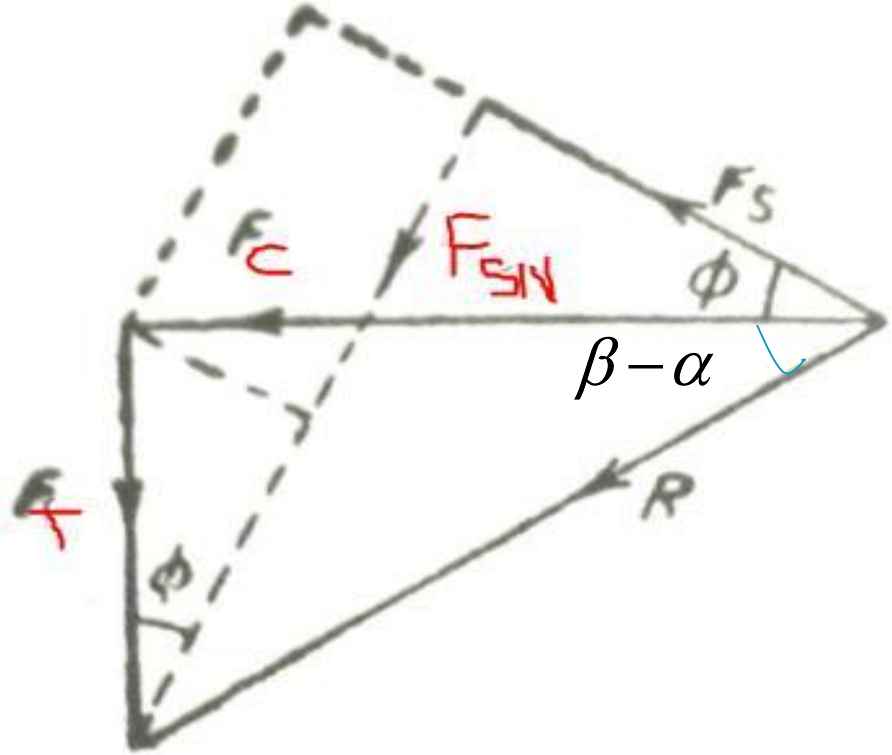
- Fc –resistance to shear of the metal, acting along the shear plane (against the motion of the chip).
- Ns –backing up force on the chip provided by the work-piece, acting normal to the shear plane.
- N –normal to the cutting face of the tool (at the tool chip interface), provided by the tool
- F –frictional resistance of the tool acting on the chip. (downwards, against the motion of the chip)


α
N
β
CHIP
F
R
B
F_{SN}
F_C
F_S
A
F_T
R
φ
β-α



$$90^0 = x + 90^0 - \beta + \alpha$$

$$x = \beta - \alpha$$



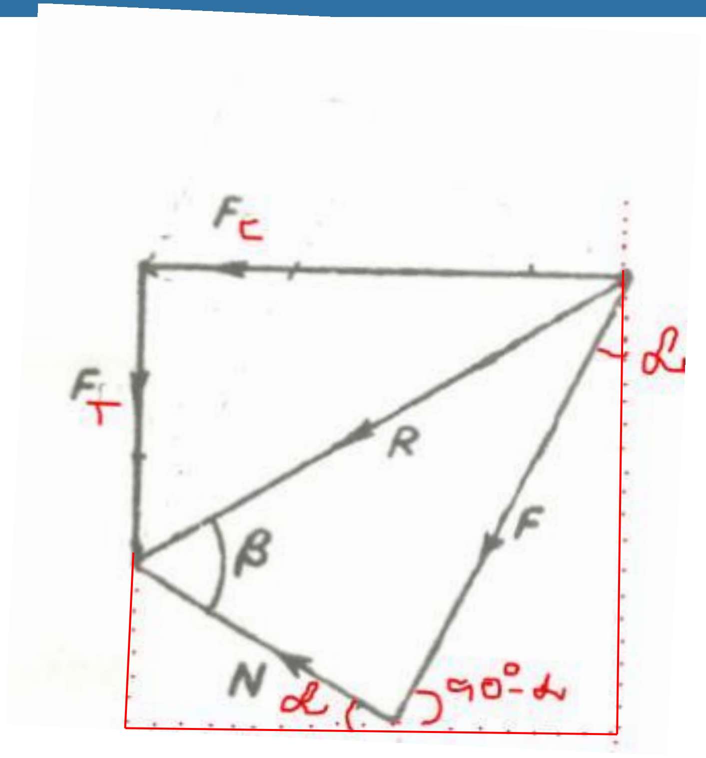
$$F_S = F_C \cos\phi - F_T \sin\phi$$

$$F_{SN} = F_C \sin\phi + F_T \cos\phi$$

$$R = F_C \cos(\beta-\alpha)$$

$$F_S = R\cos(\phi+\beta-\alpha)$$

$$F_{SN} = R\sin(\phi+\beta-\alpha)$$



$$F_C = F\sin\alpha + N\cos\alpha$$

$$F_T = F\cos\alpha - N\sin\alpha$$

$$F_C\sin\alpha = F\sin^2\alpha + N\cos\alpha\sin\alpha$$

$$F_T\cos\alpha = F\cos^2\alpha - N\cos\alpha\sin\alpha$$

$$F = F_C\sin\alpha + F_T\cos\alpha$$

$$N = F_T\cos\alpha - F_C\sin\alpha$$

Stresses & Strains

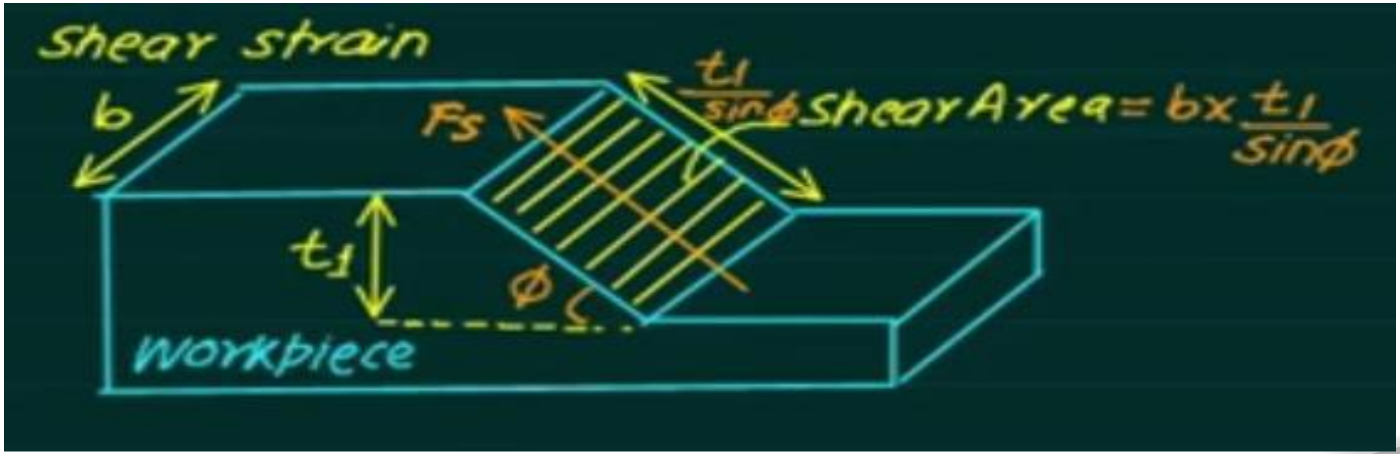
The two stresses acting on the shear plane are:

- Shear Stress τ_s= Shear force/Shear plane area
- Normal stress σ_s= Normal force/Shear plane area

Shear Plane area:

•As = b (t_1/sinΦ)

Hence: $\tau_s = F_s/A_s$; $\sigma s = N_s/A_s$



In orthogonal cutting of a mild steel component if the rake angle of tool is 10^0 and shear angle is 30^0 find the chip thickness ratio

Given Data:

$\Upsilon = 10^0$

$\Phi = 30^0$

Findings: chip thickness ratio (r)

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

$$\tan 30^0 = \frac{\mathrm{r}\cos 10^0}{1-\mathrm{r}\sin 10^0}$$

$$0.577 = \frac{0.985r}{1-0.174r}$$

$$r = 0.53$$

Determine the cutting speed and machining time per cut when the work having 35mm diameter is rotated at 200 rpm. The feed given is 0.2 mm/rev and length of cut is 60mm.

Given Data:

D = 35mm; N = 200 rpm

f= 0.2 mm/rev = 0.0002m/rev

L = 60mm = 0.06m

To find:

Cutting speed (v)

Machining Time (T)

$$V = \frac{\pi DN}{60} = \frac{\pi 0.035 \times 200}{60}$$

$$V = 0.366 m / s$$

$$T = \frac{L}{fN} = \frac{0.06}{0.0002 \times 200}$$

$$T = 1.5 \min$$

In an Orthogonal turning operation, cutting speed is 80 m/min, cutting force 20kg, feed force 8 kg, bach rake angle 15^0, feed 0.2 mm/rev and chip thickness 0.4mm.

Determine the following (a) shear angle (b). Work done in shear (c). Shear strain

Data:

V_C = 80m/min

F_C = 20kg

FT = 8kg

f= 0.2mm/rev; t = 0.4mm

ϒ = 15

$$r = \frac{t_1}{t_2} = \frac{0.2}{0.4} = 0.5$$

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

$$\tan\phi = \frac{0.5\cos 15^0}{1 - 0.5\sin 15^0}$$

$$\phi = 28^0$$

b.work done in shear

$$W = F_S . V_S$$

$$F_S = F_C \cos\phi - F_T \sin\phi$$

$$F_S = 20\cos 28^0 - 8\sin 28^0$$

$$Fs = 13.9kg$$

$$V_S = \frac{V\cos\gamma}{\cos(\phi-\gamma)}$$

$$V_s = \frac{1.33\cos 15^0}{\cos(28^0 - 15^0)}$$

$$V_S = 1.32m/\sec$$

$$W = F_S . V_S = 13.9 \times 1.32 = 18.34kg - m/\sec$$

$$\text{shear strain}$$

$$= \cot\phi + \tan(\phi - \gamma)$$

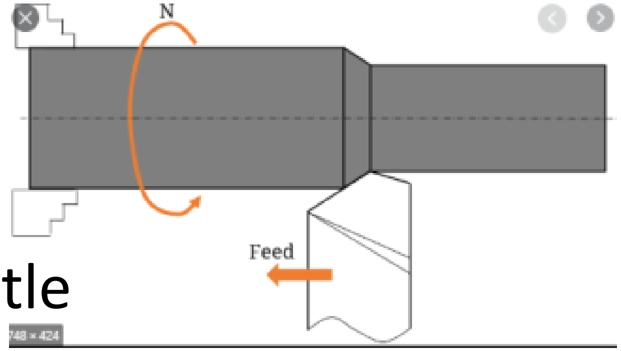
$$= \cot 28^0 + \tan(28^0 - 15^0)$$

$$= 2.11$$

METAL CUTTING PROCESS/PERFORMANCE PARAMETERS

- The different factors that affect the metal cutting operation are:

1. **Velocity (speed rate, feed rate): Affects temp at tool point.**
2. **Size/Depth of cut**
3. Tool geometry
4. Tool material
5. Nature of work-material: Ductile or Brittle
6. Cutting fluids

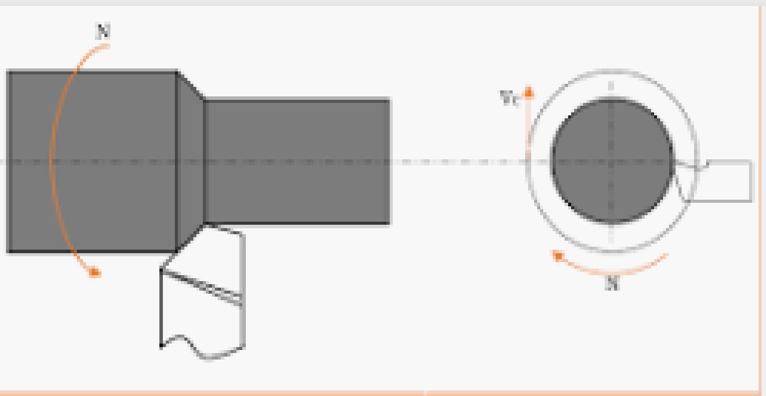


Machining Parameters

Cutting Speed (V): travel of a point on the cutting edge relative to the surface of cut in unit time in the process of accomplishing the primary cutting motion

(or)

Cutting speed for turning is the speed at which the work rotates, known as surface speed



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

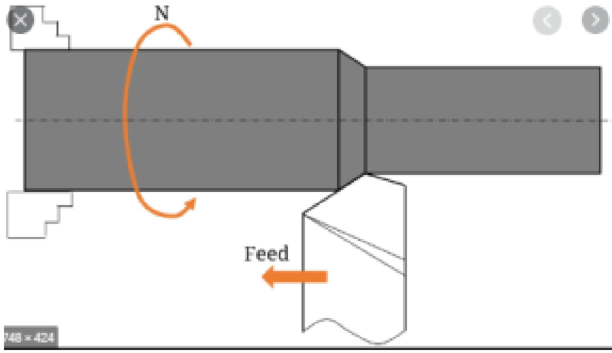
$$V=\frac{\pi DN}{(60\times 1000)}\text{ m/sec}$$

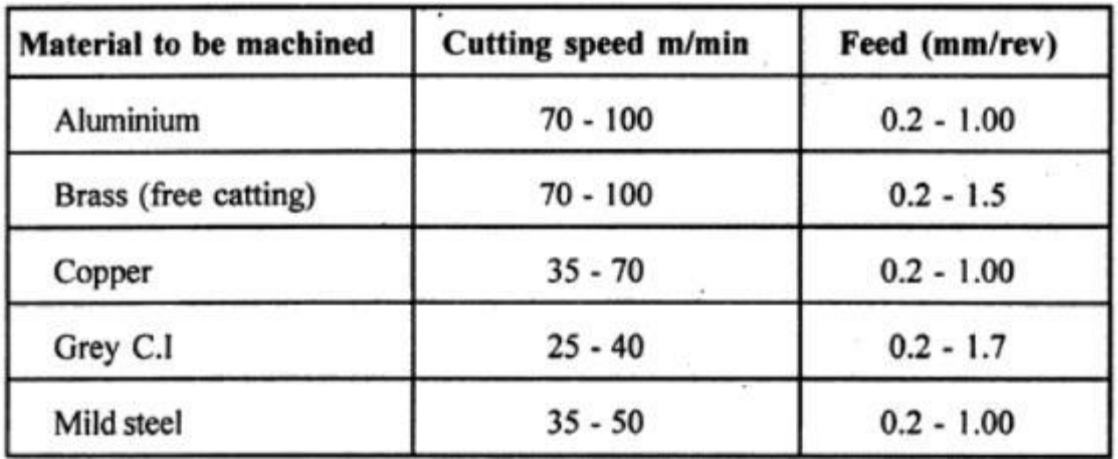
Feed (f):

- is the amount of tool advancement per revaluation of job parallel to the surface being machined
- It is expressed as distance moved by the tool in one minute
- expressed in mm per tooth (for milling cutters and broaches)

it depends on the

- depth of cut, rigidity of cutting tool and tool materials
- Higher feeds are used in rough cuts
- lower feeds are used for finish cuts
- feed various from 0.1 to 1.5mm





Material to be machined	Cutting speed m/min	Feed (mm/rev)
Aluminium	70 - 100	0.2 - 1.00
Brass (free catting)	70 - 100	0.2 - 1.5
Copper	35 - 70	0.2 - 1.00
Grey C.I	25 - 40	0.2 - 1.7
Mild steel	35 - 50	0.2 - 1.00

depth of cut. The thickness that is removed as a work piece is being machined.

Tool Life

- As a machining operation progresses, the cutting edge of the tool gradually wears out and at a certain stage it stops cutting metal efficiently (as per requirement)

- It has to be re sharpened to make it cut
- **Tool life -** useful cutting life of the tool from the start of cut to until such a time when the tool no longer performs the designed function defined by the failure criteria ..(expressed as time)

(or)

- Tool life is defined as ***the length of cutting time that the tool can be used satisfactorily***

- Tool Life: the use full life of the tool
- Time from the start of cut to some end point defined by failure criterion

Tool Life

The various possible indicators of ***end of tool life*** are:

- Failure of Tool
- Extend of Tool wear
- Poor surface finish
- Dimensional instability
- Sudden increase in cutting forces and power
- Overheating and fuming
- Presence of chatter etc.

Factors influencing the tool life

1. Cutting Speed
2. Feed and Depth of Cut
3. Tool geometry
4. Tool Material
5. Cutting Fluid
6. Work Materials
7. Rigidity of work, tool and machine

Factors influencing the tool life

1. Cutting Speed
   - If cutting speed increase , cutting Temperature increase the greater influence on the tool life.
   - Hardness of the tool deceases
   - Hence, tool flank wear and crater wear occurs easily.
   - Due to these reasons tool life decreases.
   - The relation b/w the tool life and cutting speed is expressed by Taylor’s formula

$$VT^n = C$$

T : Tool life

n: exponent (depends on tool and work)

for HSS and MS …… $n = 0.1$

Metal removal rate (MRR)

- Volume of metal removed in unit time. It is
- used to calculate the time required to remove specified quantity of material from the work piece.
- *Higher MRR does not indicate most economical process* since power consumed and cost factors must also be taken into account
- Hence, to compare two processes, the MRR per unit power consumed called SPECIFIC METAL REMOVAL RATE is used ..(Unit- mm 3 /W/min)

For a single point cutting tool,

$$\textbf{Metal removal rate (MRR)} = t.\ f.\ V_C$$

where,

t - Depth of cut (mm), f - Feed (mm / rev) and V_C - Cutting speed (mm / sec).

Cutting Tool Material

Cutting Tool Material

(1) Carbon Steels: Oldest Cutting Tool

Constituents :

Composition	Weight percentage
C	0.7 to 1 %
Si	0.5 % (Max)
Mn	0.5 % (Max)

- It cannot have more hardness
- Hence this cannot be used at higher cutting speed
- Wear resistance is more because of higher carbon percentage.

Cutting Tool Material

(2) Medium Alloy Steels

- Similar to carbon steel
- With the addition of other elements like Cr, Molybdenum, and Tungsten properties are increased.
- Addition of Cr and Mb leads good hardness
- Tungsten leads improve in wear resistance.

Constituents :

Composition	Weight percentage
C	up to 3%
Si	up to 0.4 %
Mn	0.25 to 0.75 %
Cr	0.4 to 0.8%
Tungsten	1.5%
Steel	Balance

(3) High Speed Steels

- Mostly used in industries
- Major difference is permits higher cutting speed
- Also it has good hardness, wear resistance and retention of sharpness at the cutting edge.
- Added elements mainly Cr, Vanadium, Molybdenum and cobalt

Constituents :

Composition	Weight percentage
Tungsten	13 %
Chromium	4%
Vanadium	1%
Cobalt	1%

Simply it is called as 13-4-1 grade steel.

Cutting Tool Material

(4) Cemented Carbide tools

- Cemented carbide tool material is prepared by Powder metallurgy process
- Final powder mixture consisting of varies elements is pressed in order to get required shape
- And sintered in to cemented carbide.

(5) Ceramic tools

- Aluminium oxide is known as ceramic tool. Al_2O_3 powder is prepared in a mould and pressed of about 300 kg/cm^2 is applied and then sintered.

- The tool tip is prepared by this process and is fitted with the tool shank

- It can operate at high cutting speed
- They have high compressive strength
- They are brittle in nature
- They have low bending strength.

(6) Abrasives

- Abrasive grains such as Al_2O_3 and SiC . They are used in grinding wheels
- They are used to remove a very small portion of material in the work piece for final operations

Cutting fluids

Cutting fluids

Either liquid of gas that is used on the tool chip interface during machining is called cutting fluid

Properties and purposes of cutting fluids

(1) To reduce friction:

- Cutting fluid reduces the friction at tool interface and also at the tool work piece interface
- Since friction coefficient is reduced at the tool chip interface so flow of chip increases.
- Otherwise μ and power consumption increases.

(2) To improve surface finish

(3) To cool the tool and work piece

(4) To move the chip quickly ex: drilling

Cutting fluids

Important properties

- It should absorb more heat
- It should reduce friction
- Should not be corrosive in nature
- Should have low viscosity
- Should be economical

Important cutting fluids

- Carbon Tetrachloride
- Acetic acid
- Turpentine
- Kerosene
- Paraffin oil
- Soluble oil
- Water

UNIT - II

MACHINE TOOLS - I

UNIT- II SYLLABUS

- General purpose machine tools – Principle and operation of lathe – Types of lathes and size specification
- Work holding parts of lathes and their functions – Main operations
- Taper turning and thread cutting – Attachments
- Reciprocating machines: Shaping machines – Types – Size – Principal parts – Mechanism
- Cutting speed, feed and depth of cut – Machining time
- Planing machines – Types – Size – Principal parts – Mechanism – Work holding devices
- Slotting machines – Types – Size – Principal parts – Mechanism – Work holding devices

UNIT- II

At the end of the course students are able to :

Course Outcomes		Knowledge Level (Bloom's Taxonomy)
CO 4	**Explain** the operational principles of different lathe machines and various reciprocating machines for quality machining	**Understand (L2)**
CO 5	**Select** a machining operation, corresponding machine tool for a specific application in real time	**Remember (L1)**
CO 8	**Estimate** machining times for machining operations at specified levels of cutting parameters of machine tools	**Apply (L3)**

UNIT- II

Program Outcomes (POs)		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE / Quiz / AAT
PO 2	**Problem Analysis:** An ability to analyze complex engineering problems to arrive at a relevant conclusion using knowledge of mathematics, science and engineering.	1	CIE / Quiz / AAT

Introduction of Lathe

CENTRE LATHE

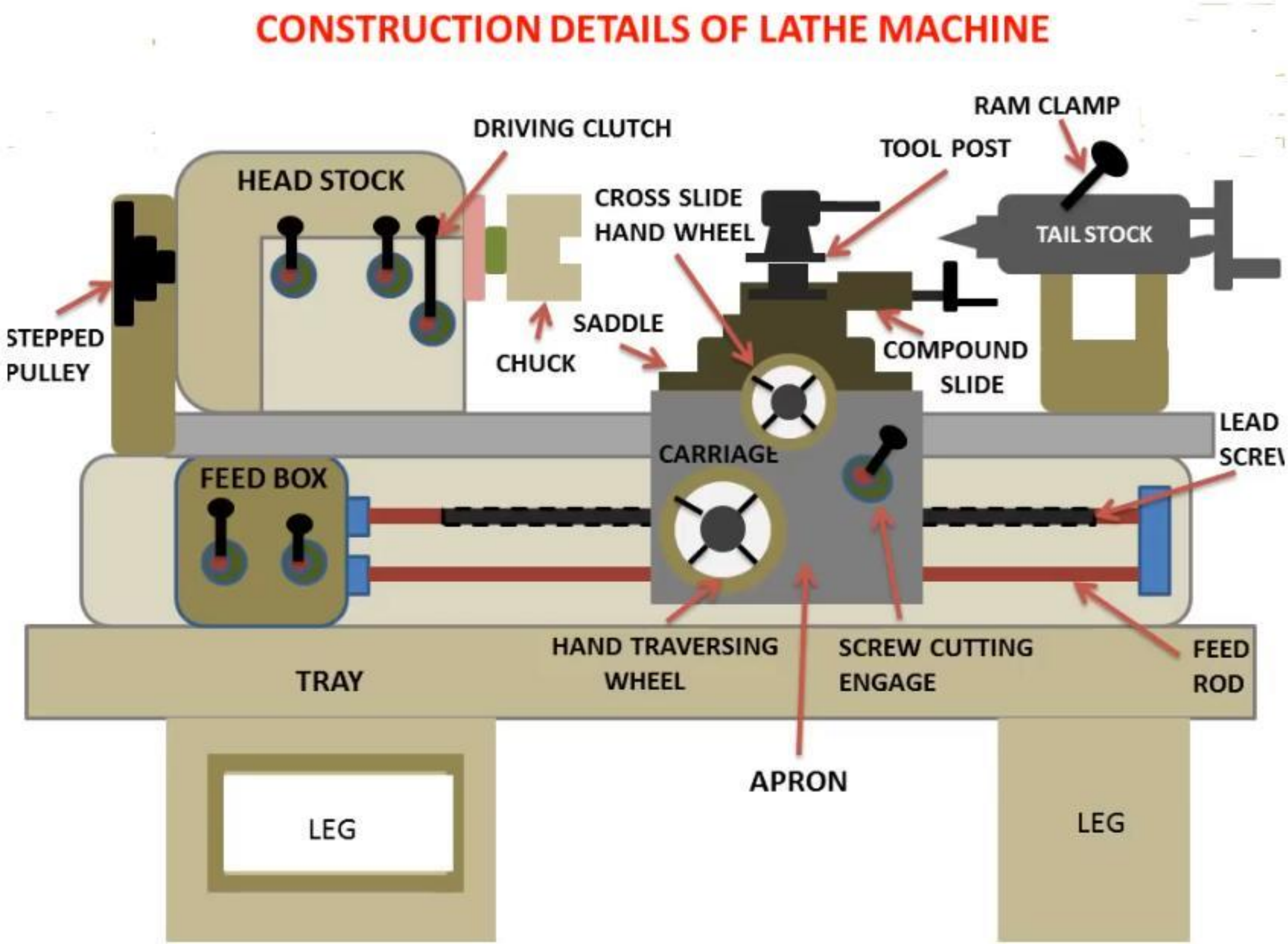
- Lathe is the oldest machine tool, invented (1794, Henry Maudslay)
- Father/Mother of all machine tools.

Purpose: to remove material from a work piece to produce the required shape and size

accomplished by holding the work piece securely and rigidly on the machine and then turning it against the cutting tool which will remove material from the work piece in the form of chips.

It is used to machine cylindrical parts
Generally single point cutting tool is used

Lathe



CONSTRUCTION DETAILS OF LATHE MACHINE
RAM CLAMP
DRIVING CLUTCH
TOOL POST
HEAD STOCK
CROSS SLIDE
HAND WHEEL
TAIL STOCK
STEPPED
PULLEY
SADDLE
CHUCK
COMPOUND
SLIDE
LEAD
SCRE
CARRIAGE
FEED BOX
HAND TRAVERSING
WHEEL
SCREW CUTTING
ENGAGE
FEED
ROD
TRAY
APRON
LEG
LEG

Introduction

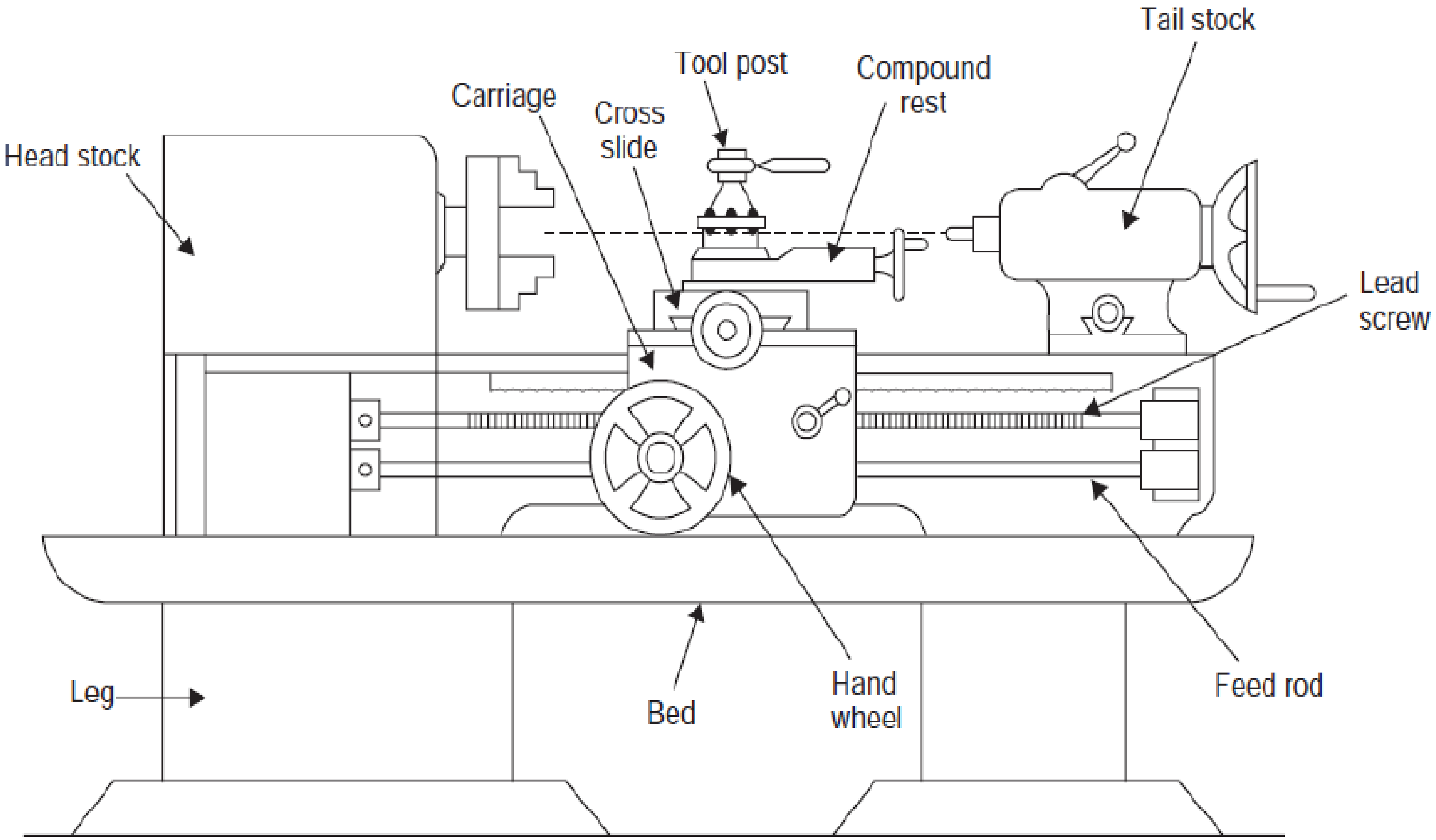
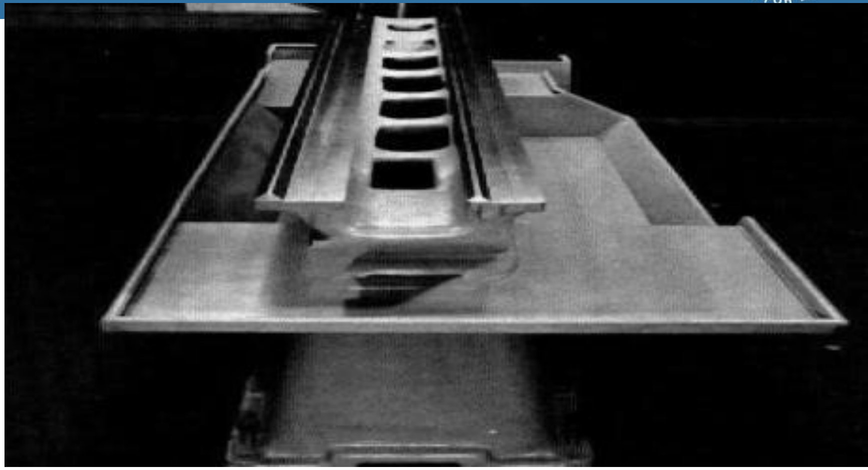


Fig. 1. Lathe Machine.

Lathe parts

Lathe Bed

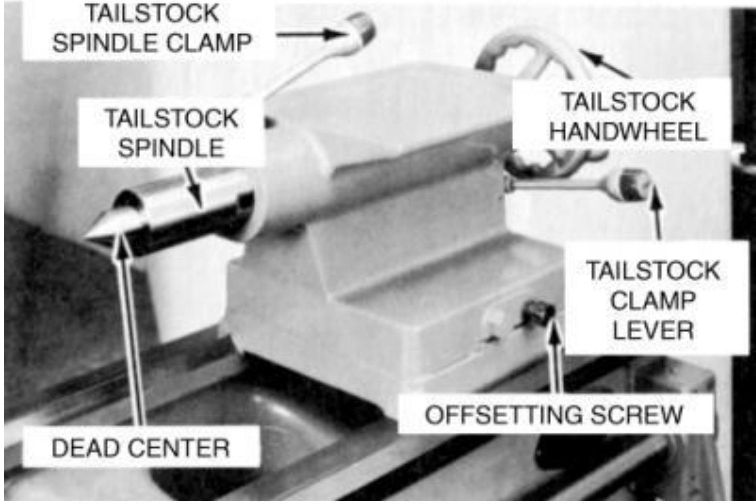


- Base of Machine
- Made to support working parts of lathe
- Head stock , carriage and tail stock are mounted on bed
- carriage and tail stock are move over the bed
- It has guide ways
- it is very strong to resist the cutting forces and vibrations
- Guide ways are very accurate for getting accuracy in jobs
- Made of Cast iron with nickel chromium, alloying additions.
- Heavy, rugged casting

Head stock

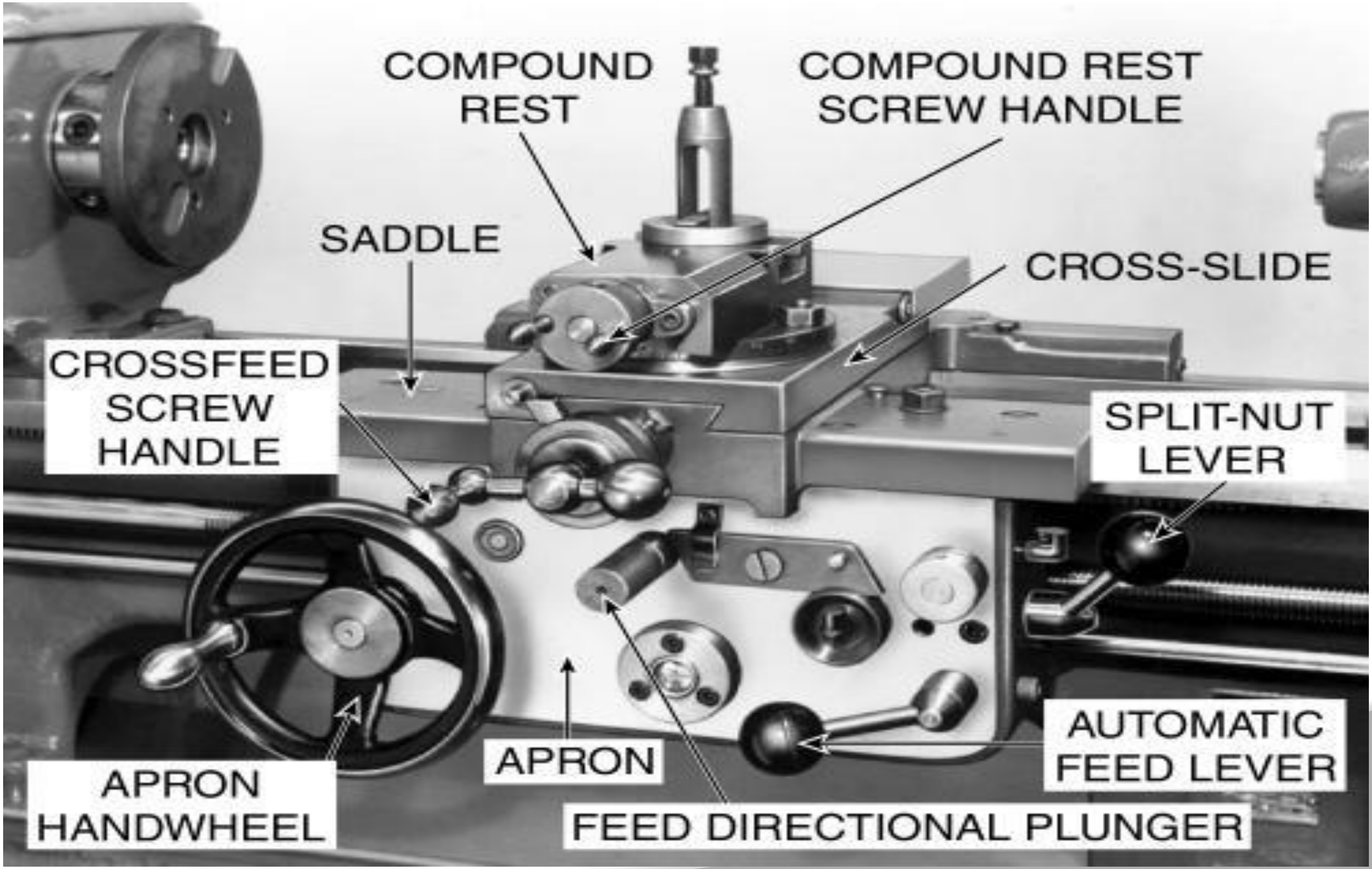
- Mounted on the bed at left side
- It carries a hollow spindle
- The front end of the hole is tapered for holding tapered shanks
- Chucks and face plates can be attached to the nose of the spindle
- It has driving and speed changing mechanism
- Speed changing and feed changing levers are attached to the head stock

Tail stock



- Mounted on the right side of bed
- Used for the supporting of right end of work
- Also used for holding drilling, reamer or tap for drilling operation
- Can be moved and clamped at any position to support different lengths of work
- Tail stock body is bored and tail stock spindle moves through is a dead centre can be fixed in to the taper hole of the spindle for supporting

Saddle


COMPOUND REST
COMPOUND REST SCREW HANDLE
SADDLE
CROSS-SLIDE
CROSSFEED SCREW HANDLE
SPLIT-NUT LEVER
AUTOMATIC FEED LEVER
APRON
APRON HANDWHEEL
FEED DIRECTIONAL PLUNGER

Saddle

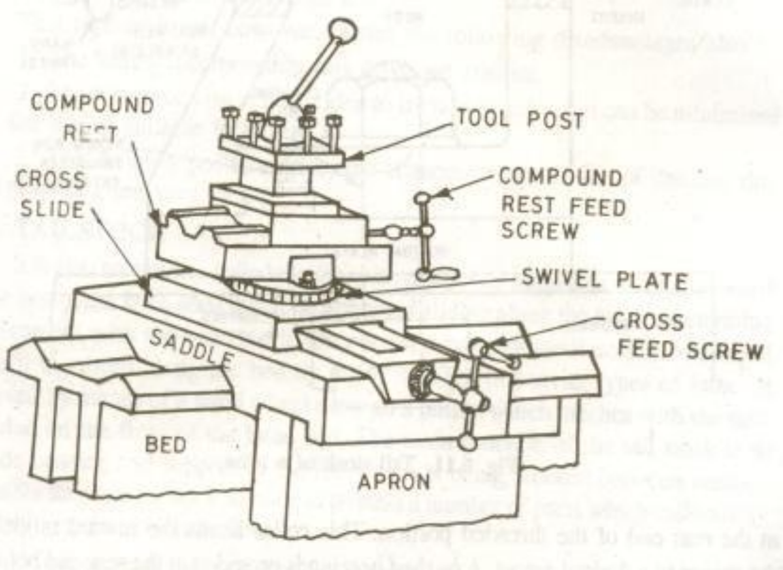


Fig. 6.12. The carriage.

- H shaped casting fitted over the bed
- Moves along the guide way
- It carries the cross slide and tool post
- It can be moved to the required position and locked to the bed.

Cross Slide

- Attached to the saddle
- Carries the compound rest and tool post
- Can be moved by power or by hand
- There is micrometer dial on the cross slide hand wheel with an accuracy of 0.05mm.

Compound rest

- It marked in degrees
- Used during taper turning to set tool for angular cut
- No power feed only hand feed
- The is micrometer dial for showing depth of cut
- Should be locked strongly

Tool Post

Tool is clamped in the tool post

4 types of tool posts

(1) Single crew tool post

(2) Open side tool post

(3) Four bolt tool post

(4) Four way tool post.

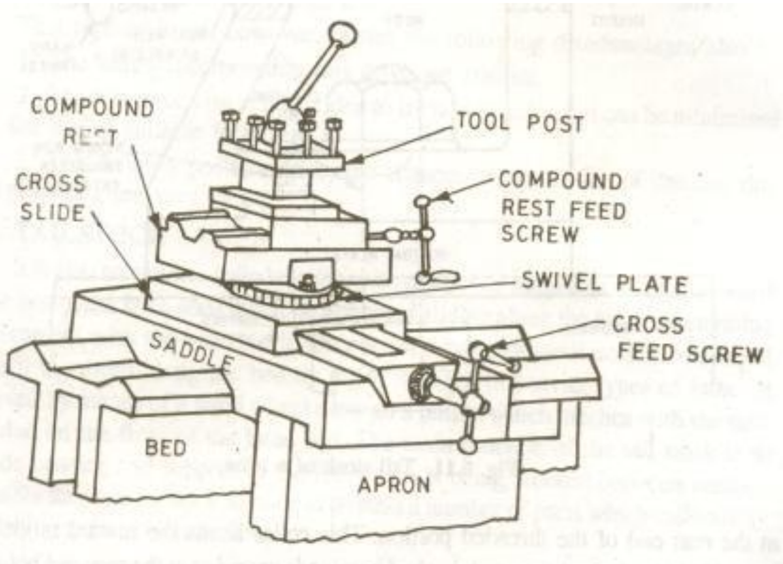


Fig. 6.12. The carriage.

Single crew tool post

- It can hold only one tool
- Tool is clamped by clamping screw
- Tool rests on the top flat surface of the convex rocker
- The convex rocker rests on a concave ring
- This arrangement is used to adjust the height of the tool

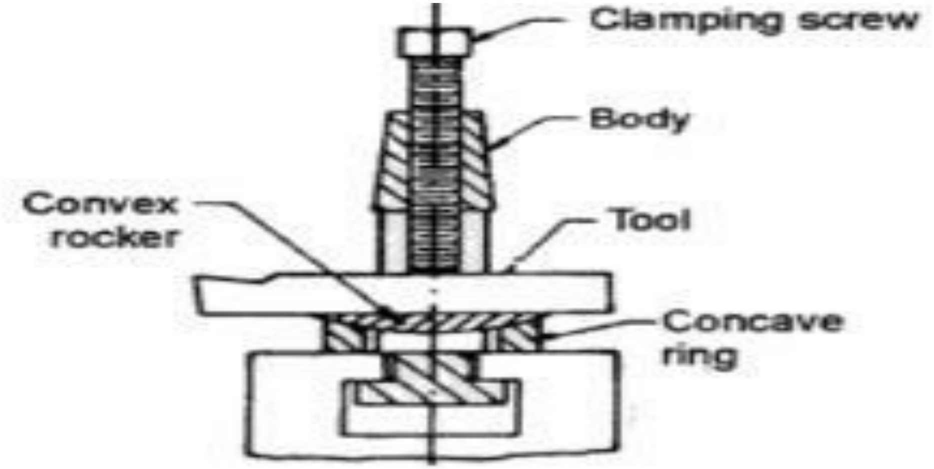


Figure 2.3. Single screw tool post

(2) Open side tool post

- The tool is held in position by two set screws
- parallel packing strips are used to adjust the height of the cutting tool
- The tool post can be tilted to any required position by loosening the clamp bolt.
- The clamping bolt is fitted in a T – slot ; so the tool can be changed quickly.

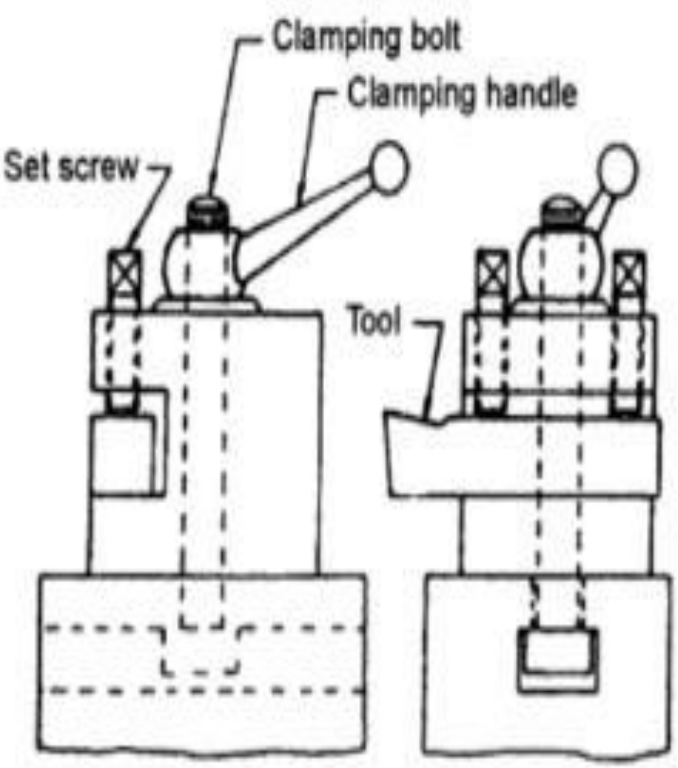


Figure 2.4. Openside Tool Post

Apron

- The apron is attached to the saddle and hangs in front of the bed
- It has gears, levers and clutches for moving the carriage with the lead screw for thread cutting.
- The apron hand wheel is used to move the carriage parallel to the lathe axis.

Feed Mechanism

- The movement of the tool relative to the work piece termed as "feed"
- There are 3 types of feeds namely longitudinal, cross and angular.
- If tool moves parallel to the axis of the lathe is called longitudinal feed, it is achieved by moving carriage
- When the tool moves perpendicular to the axis of the lathe that is cross feed, it is achieved by moving cross slide

- When the tool moves at an angle to the axis of the lathe that is called angular feed.

- angular feed is achieved by moving compound slide, after swiveling it at an angle to the lathe axis.

Feed Rod:

- It is a long shaft, used to move carriage or cross slide for turning, facing, boring and all operations except thread cutting

- Power is transmitted from the lathe spindle to the apron gears through the feed rod via large number of gears

Principle of working of a Lathe

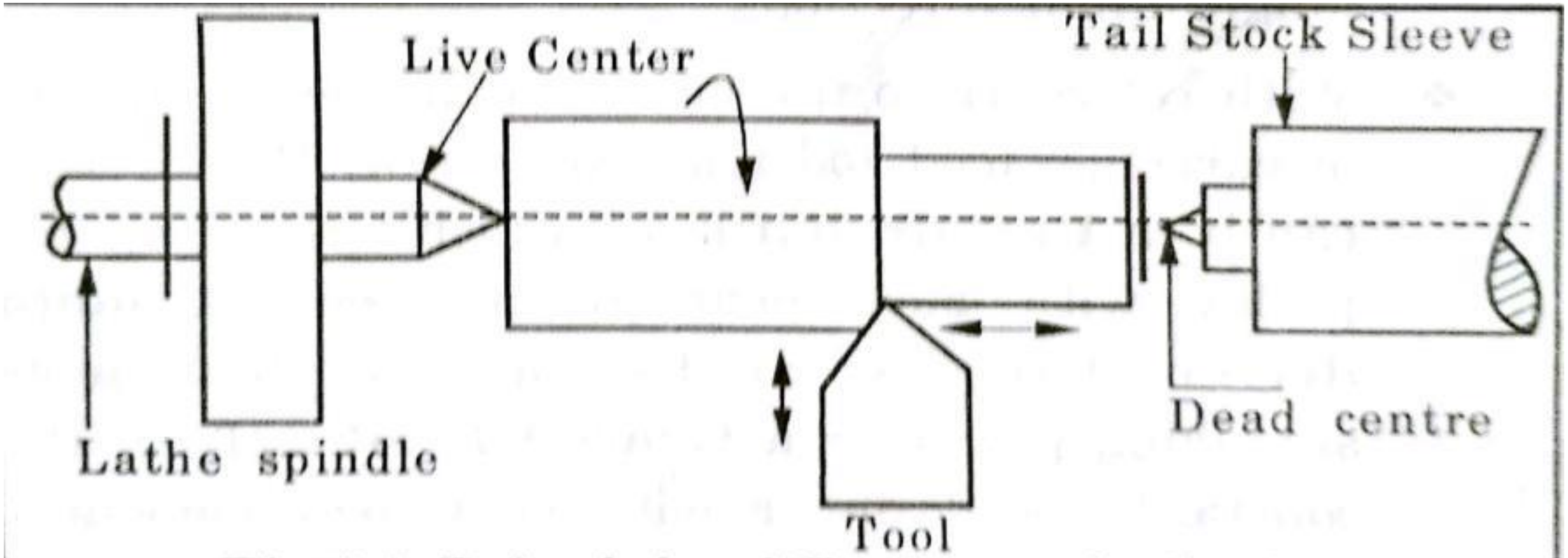


Fig.6.1. Principle of Working of a Lathe

- It holds the work between two supports called centres
- Chuck or Face plate is also used for holding the work
- Cutting tool is held and supported on a tool post
- Movement of the job is rotation about spindle axis
- Tool is fed against the revolving work
- Movement of the tool is either parallel to or at any inclination to the work axis

Lathe Operations

A single point cutting tool removes material from a rotating work piece to generate a rotationally symmetric shape

Machine tool is called a ***lathe***

Types of cuts:

(1) Facing,

(2) Turning

 (a) plain (b) step turning (c) taper turning

(3) Drilling

(4) Boring

(5) Reaming

(6) Knurling

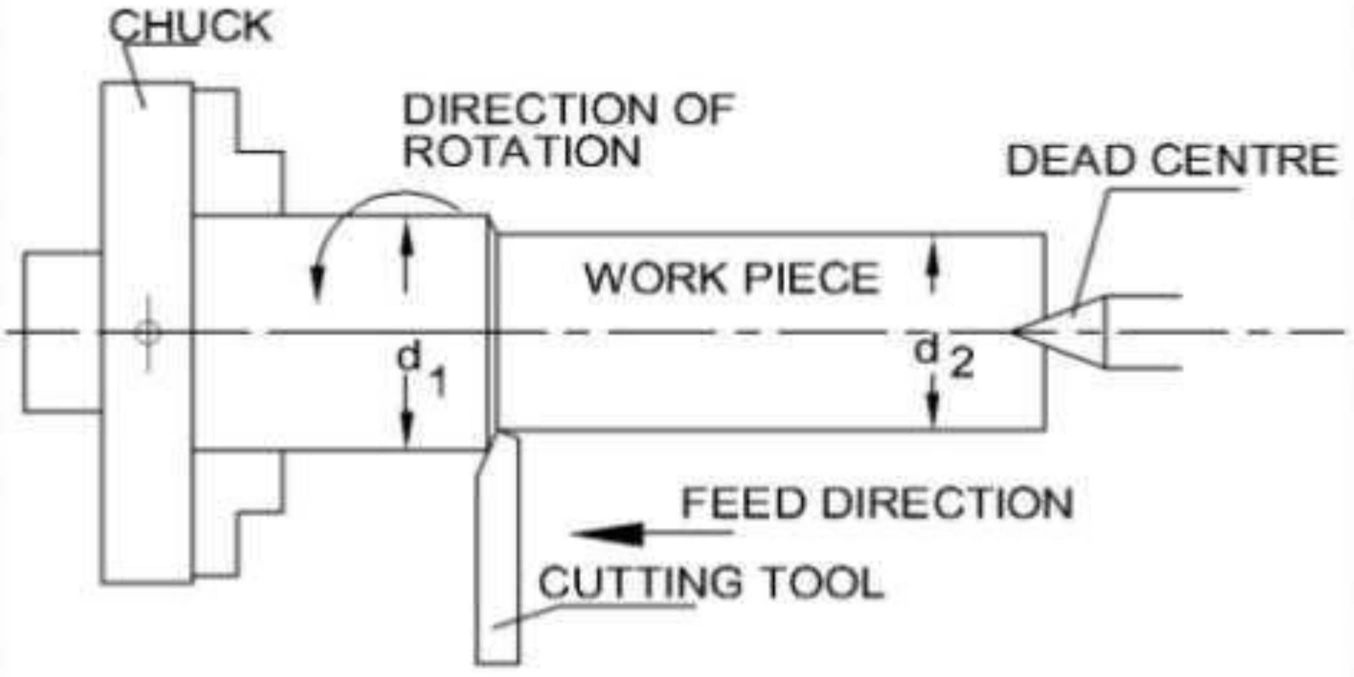
(7) Chamfering

(8) Parting off

(9) Thread cutting

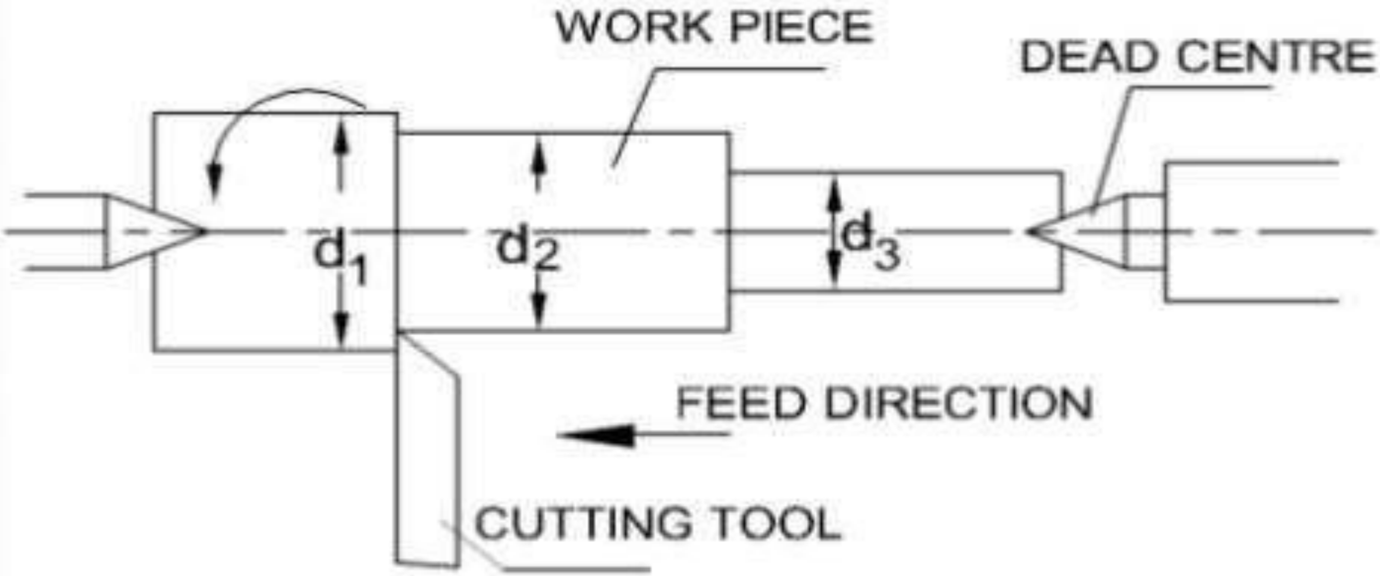
(10) Forming

Plain turning on lathe machine



PLAIN TURNING

Fig.- step turning on lathe machine



STEP TURNING

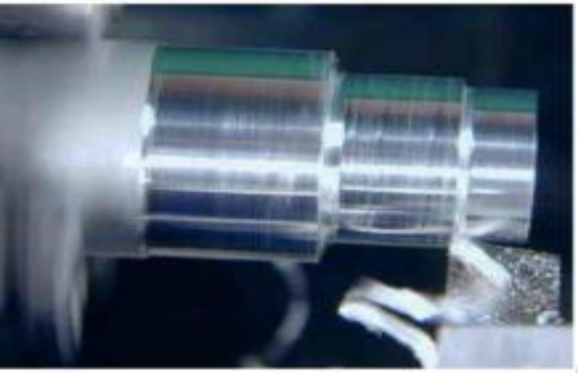


FIG.- KNURLING

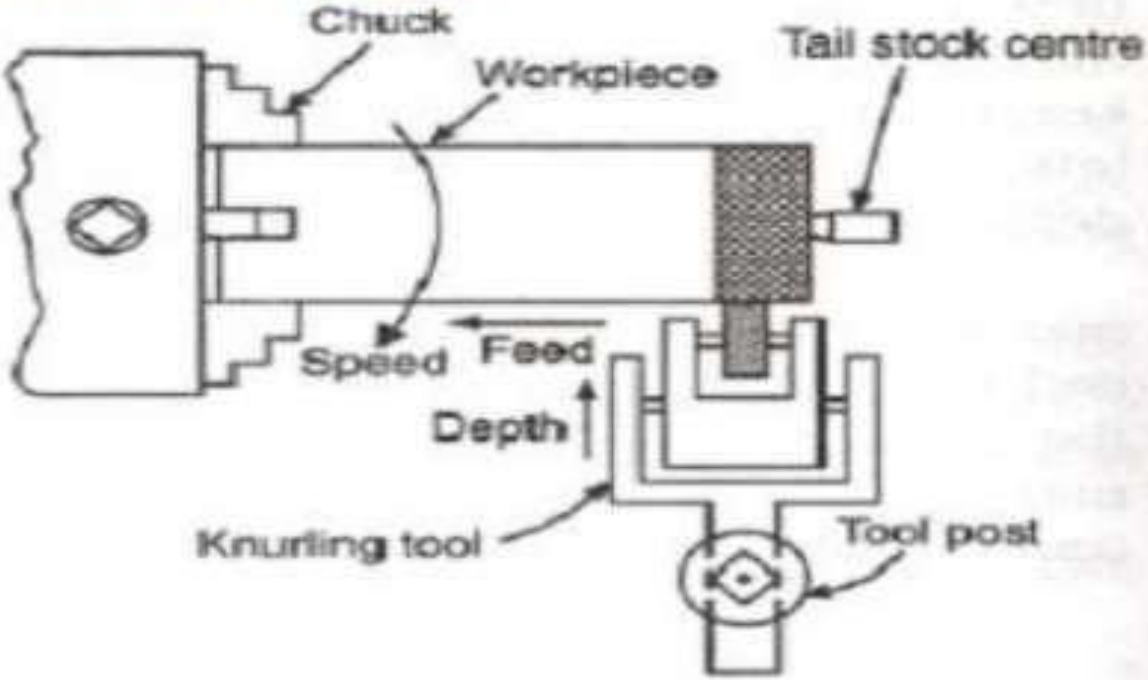
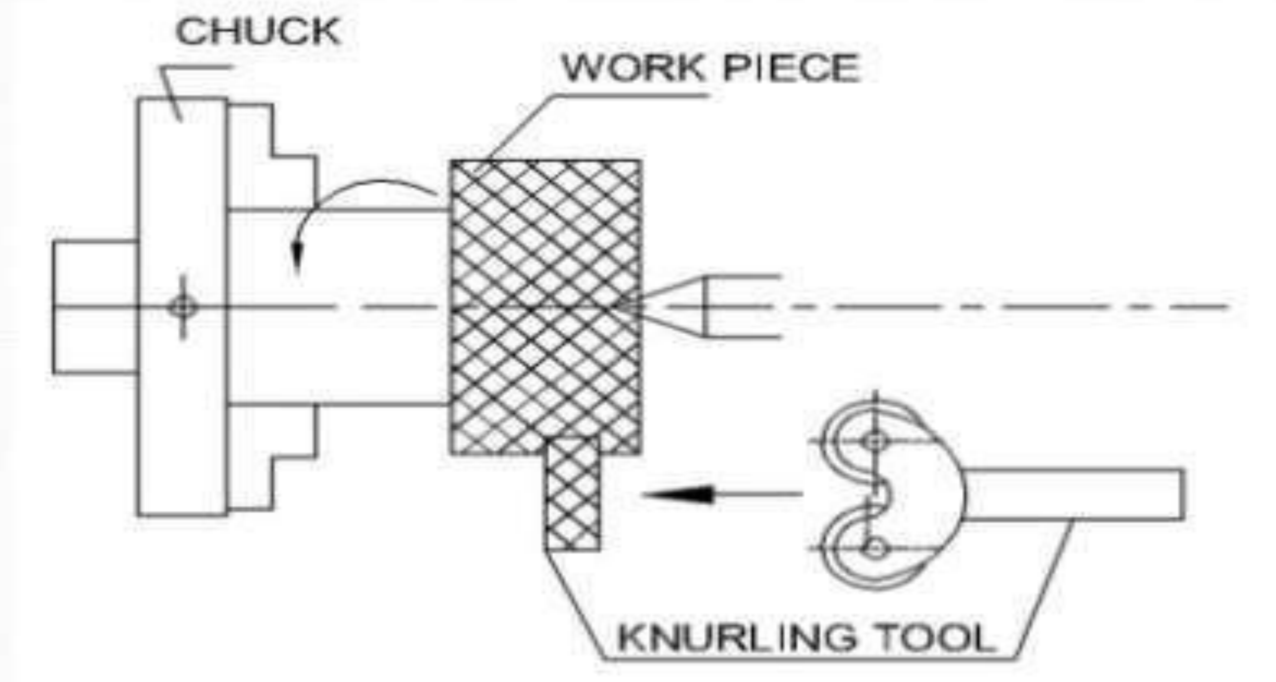


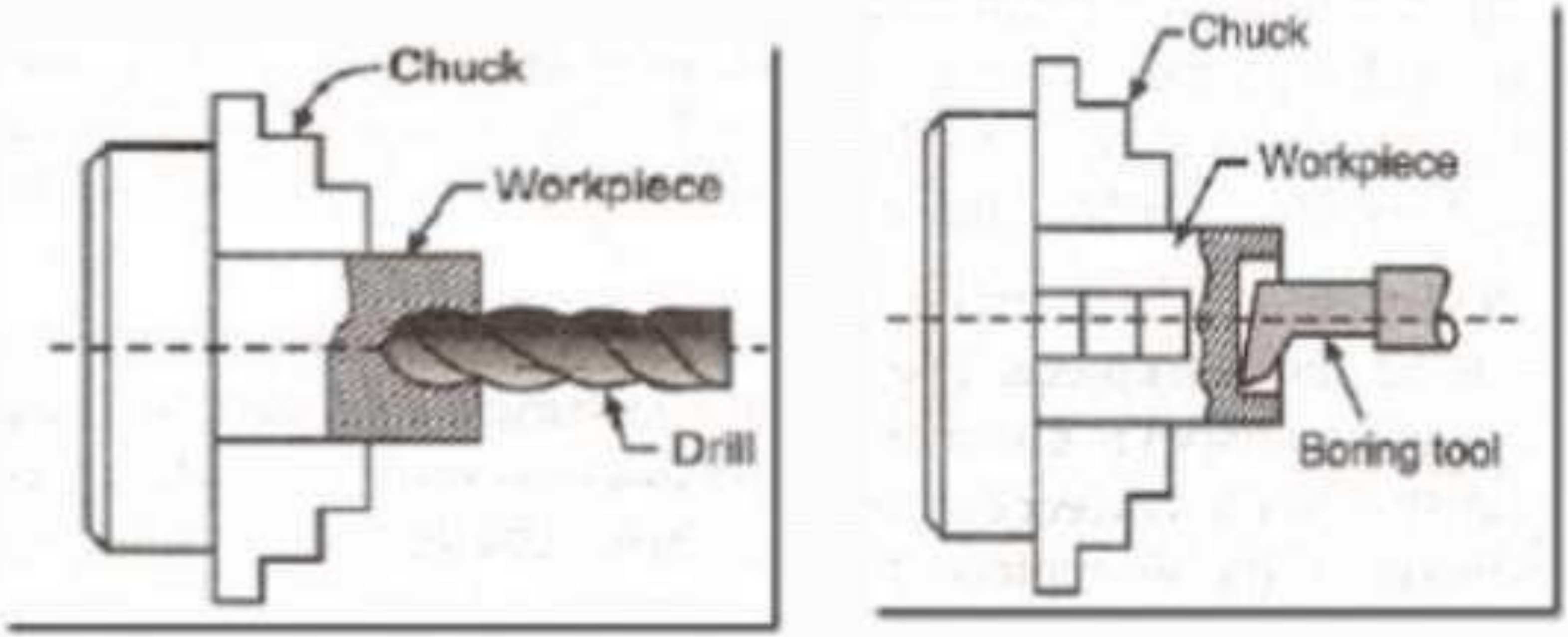
Fig. 7.17. Knurling

Knurling on lathe machine

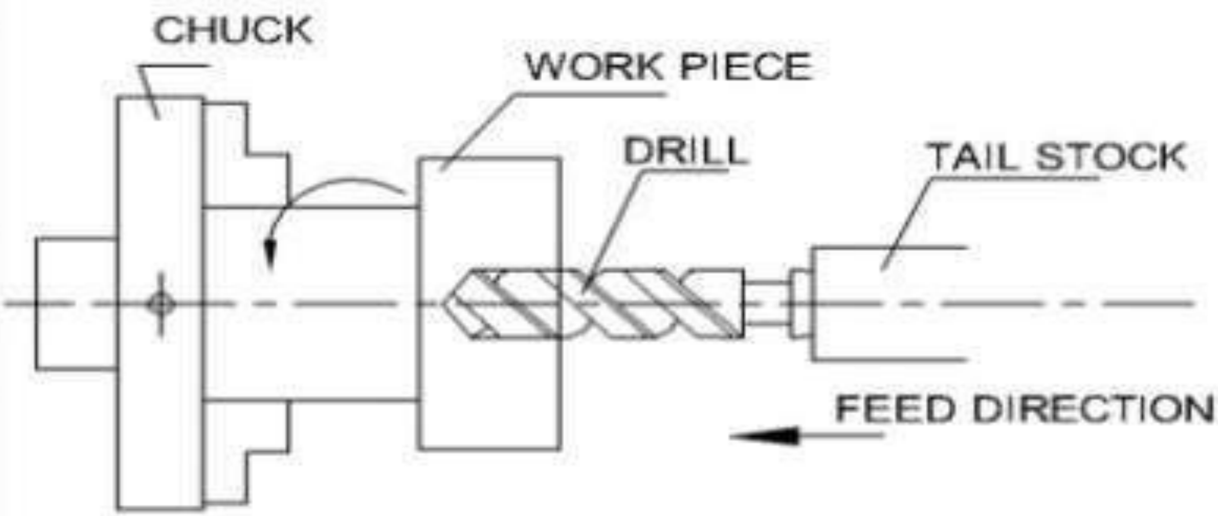


KNURLING OPERATION

FIG.- DRILLING AND BORING

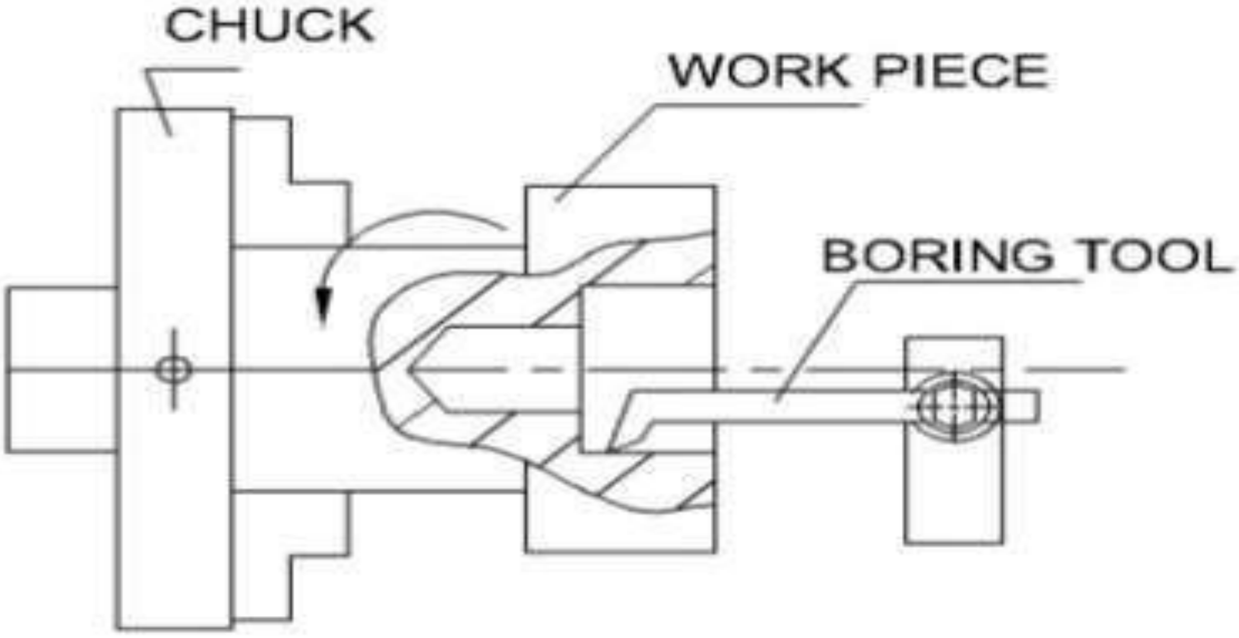


Drilling on lathe machine



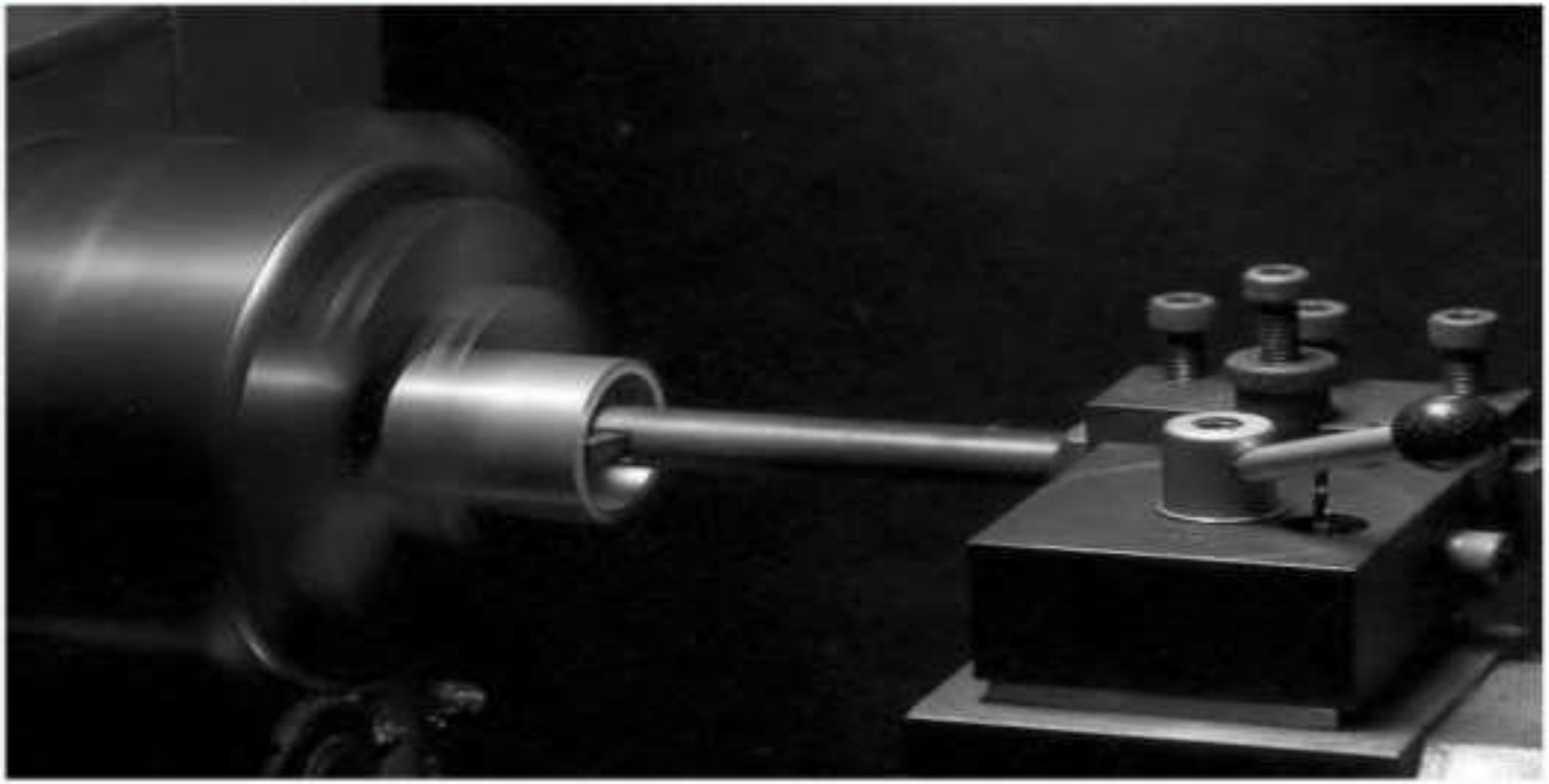
DRILLING OPERATION

Boring on lathe machine

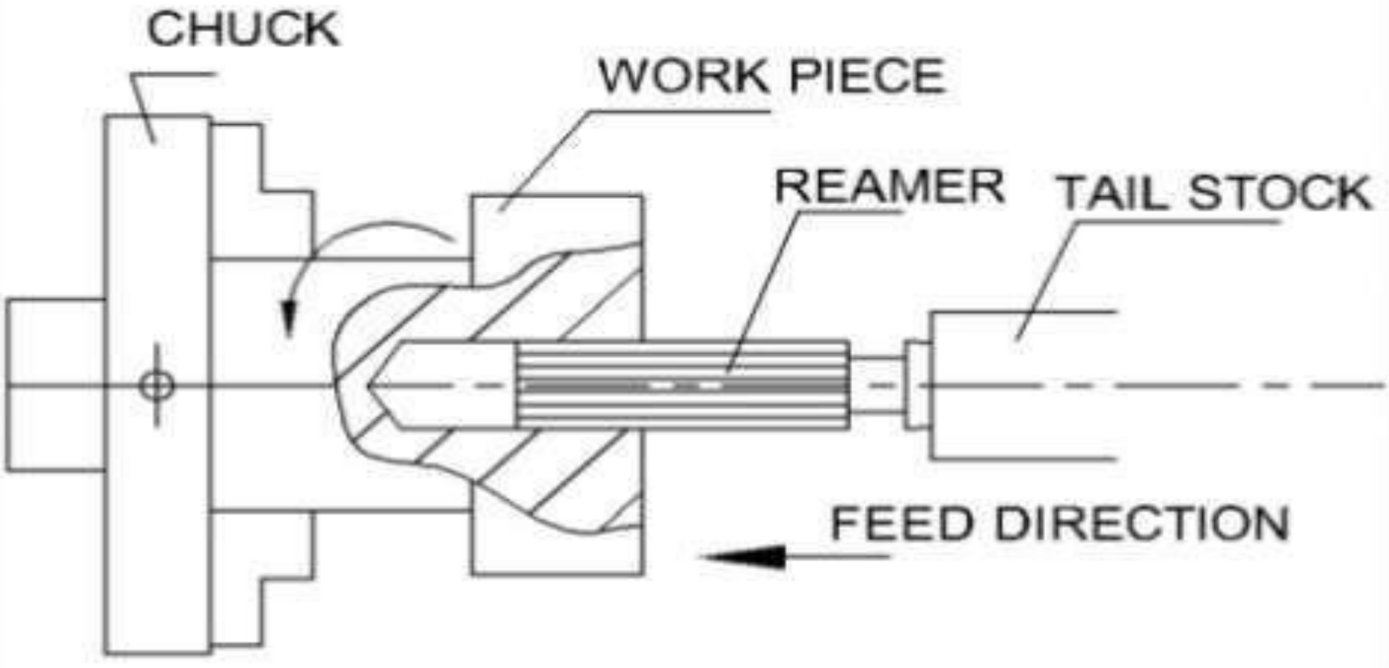


BORING OPERATION

Boring on lathe



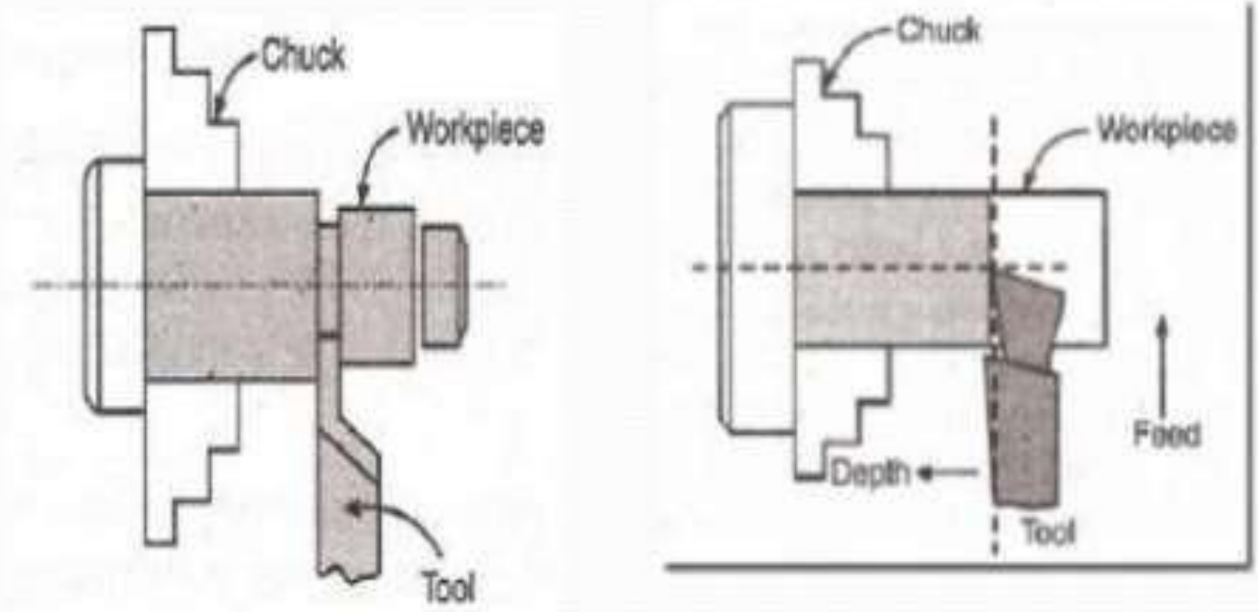
Reaming on lathe machine



REAMING OPERATION

Reaming on lathe using reamer tool

FIGURE – GROOVING AND PARTING



Parting (Cutoff) / Grooving

Tool is fed radially into rotating work at some location to cut off end of part, or provide a groove

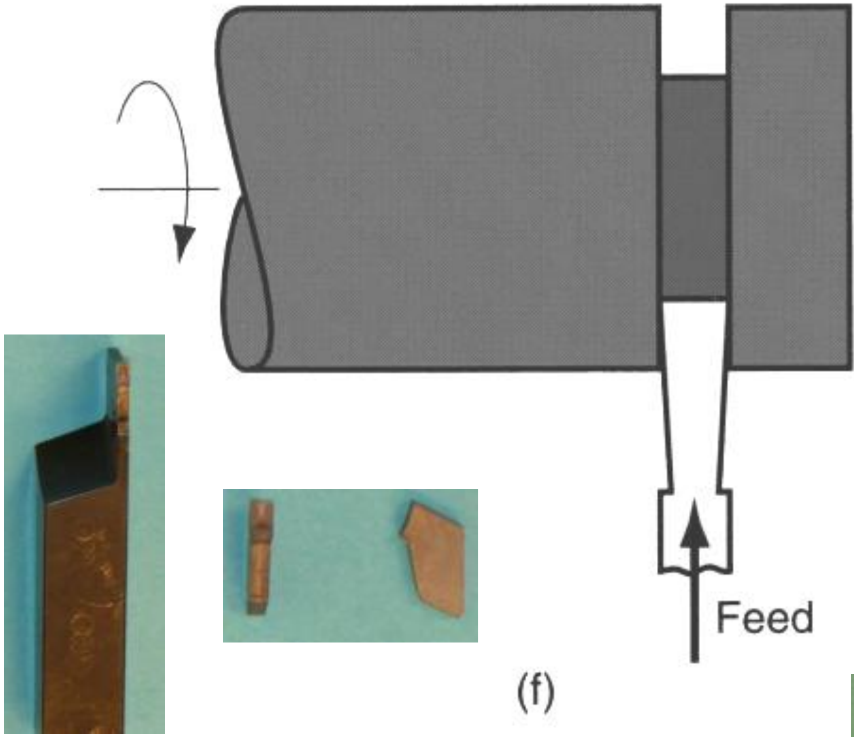
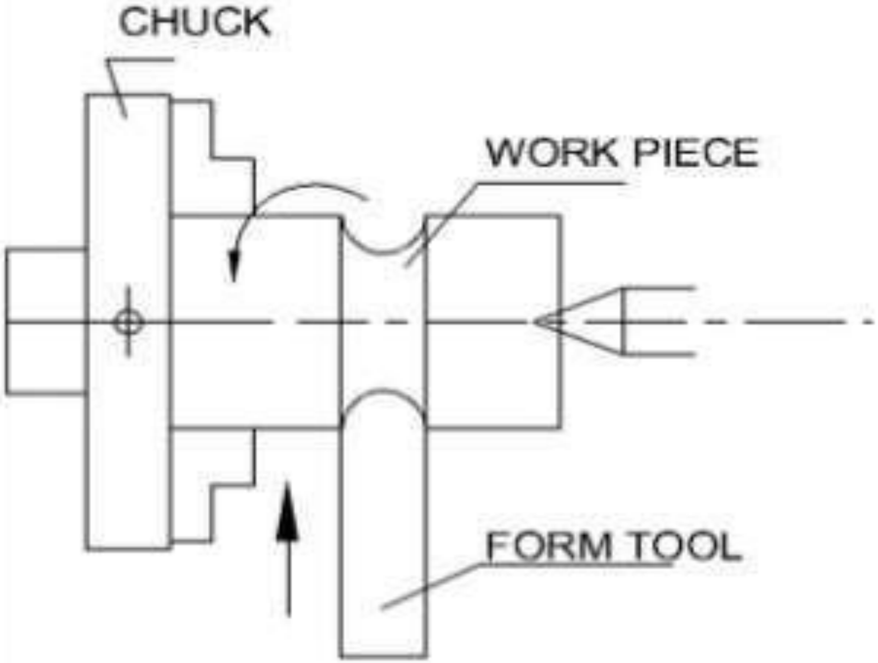


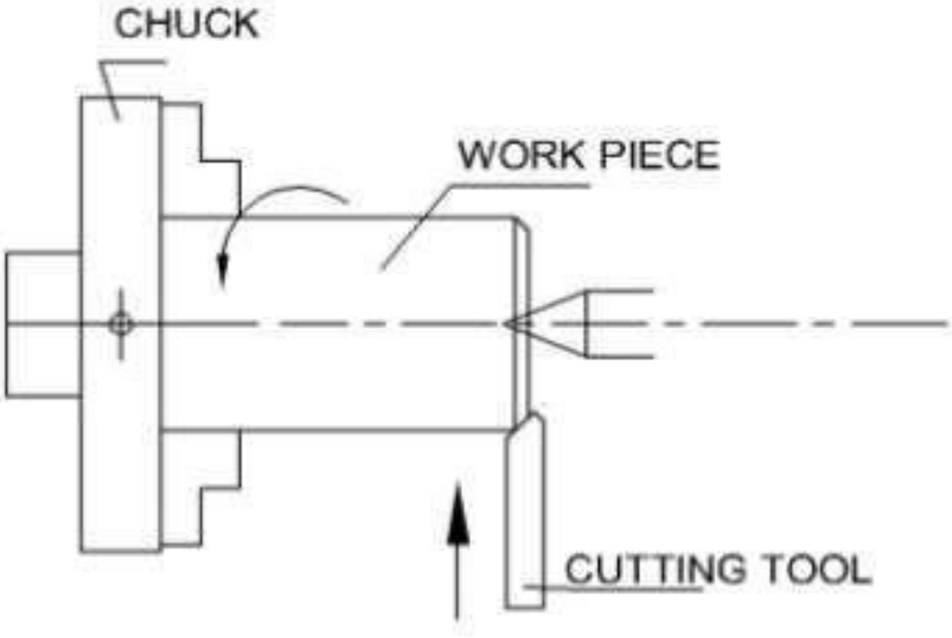
Figure 22.6 (f) cutoff

Forming on lathe machine



FORMING OPERATION

Chamfering on lathe machine



CHAMFERING

Threading

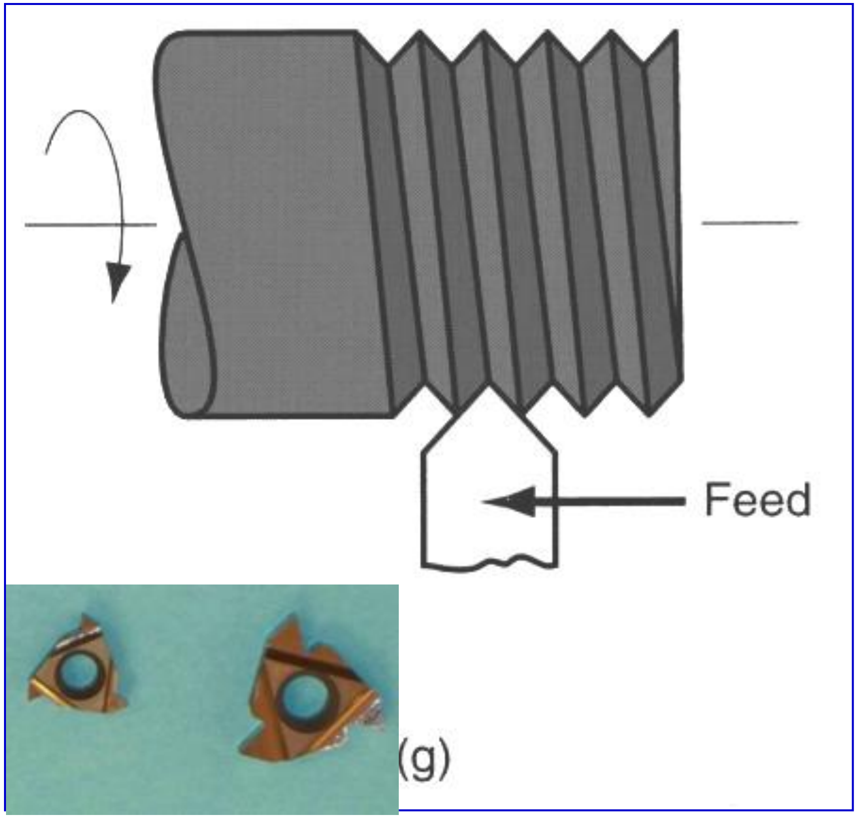


Figure 22.6 (g) threading

Pointed form tool is fed linearly across surface of rotating work part parallel to axis of rotation at a large feed rate, thus creating threads

Specifications of Lathe

Size of lathe is specified as follows

1. *The length between the centers*

   maximum length of job that can be mounted between the centers
2. *The length of the bed*

   this gives approximate floor area that the lathe can occupy
3. *Height of the centers*

   it is measured from the lathe bed.
4. *Maximum diameter over carriage*

   this is the diameter of the work or bar that may pass through the hole of the head stock spindle.
5. *The swing diameter of the bed*

   maximum dia of the work that may revolve over the bed ways
6. *The swing diameter over carriage :* max dia of work that may rotate over the saddle

Work holding devices

The work holding devices are the device that is using to hold and rotate the work pieces along with the spindle.

Work can be held on a lathe by the following ways

1. Work held b/w centres and *driven by catch plate and carriers*
2. *Work held in chuck*
3. *Work held on face plate*
4. *Work held on angle plate*
5. *Work held on mandrel*
6. *Work held in turning fixtures*

Work holding devices

1. Work held b/w centers and *driven by catch plate and carrier*

- Long shafts are generally held between centers
- Driving plate or catch plate is screwed to the nose of the head stock spindle
- The live centre is inserted in the head stock spindle
- Tail stock carries the dead centre
- The work piece is supported between the centers
- The driving dog is clamped to the work piece by a screws
- The tail of the dog (carrier) is attached to the catch plate
- When the spindle rotates, the w/p will rotate through the catch plate and carrier

Work holding devices

- A chuck is a specialized types of clamp used to hold the work piece.
- Chuck is mounted on the spindle which rotates within the head stock.

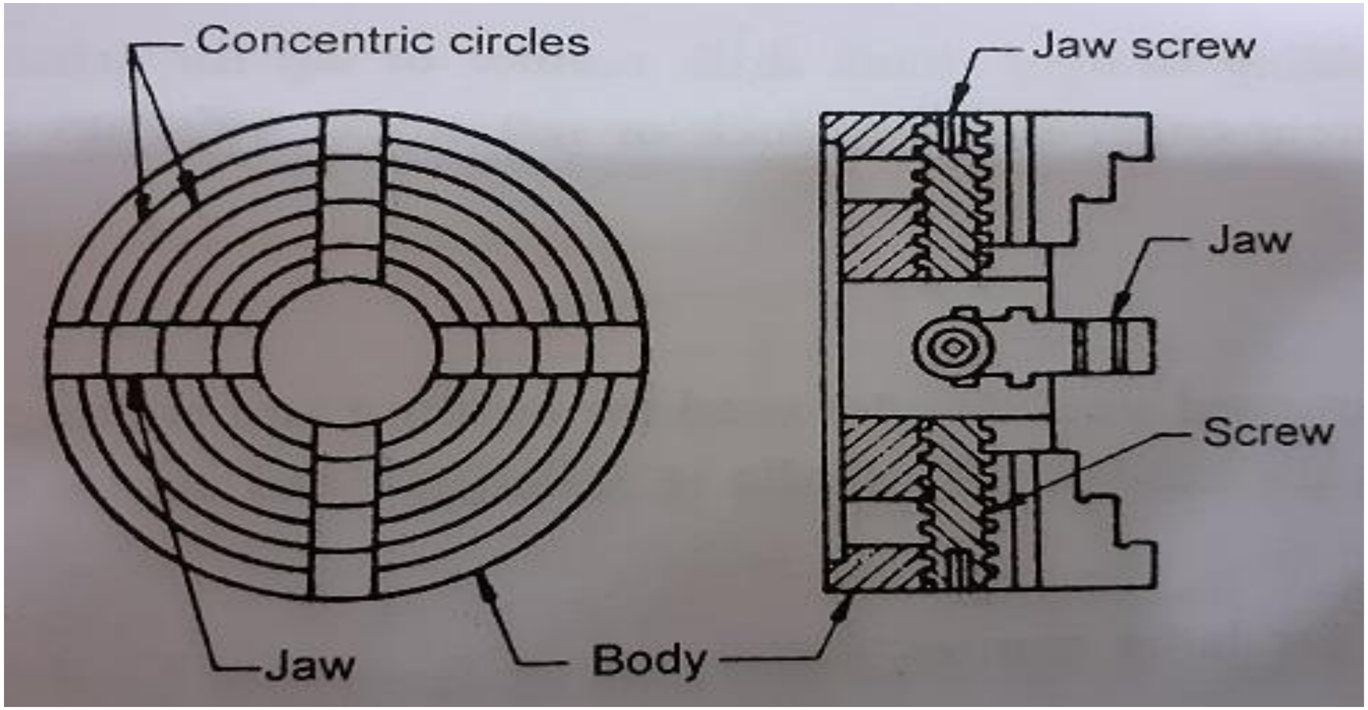
THREE JAW CHUCK

2. Work held in chuck

- Works of short length, works of large diameter and works of irregular shapes can be held in chucks
- The chuck is attached to the spindle of the lathe
- Work is fixed b/w the jaws of the chuck and the jaws are tightened.
- The right end of the work may be supported by the dead centre if needed.

Work holding devices

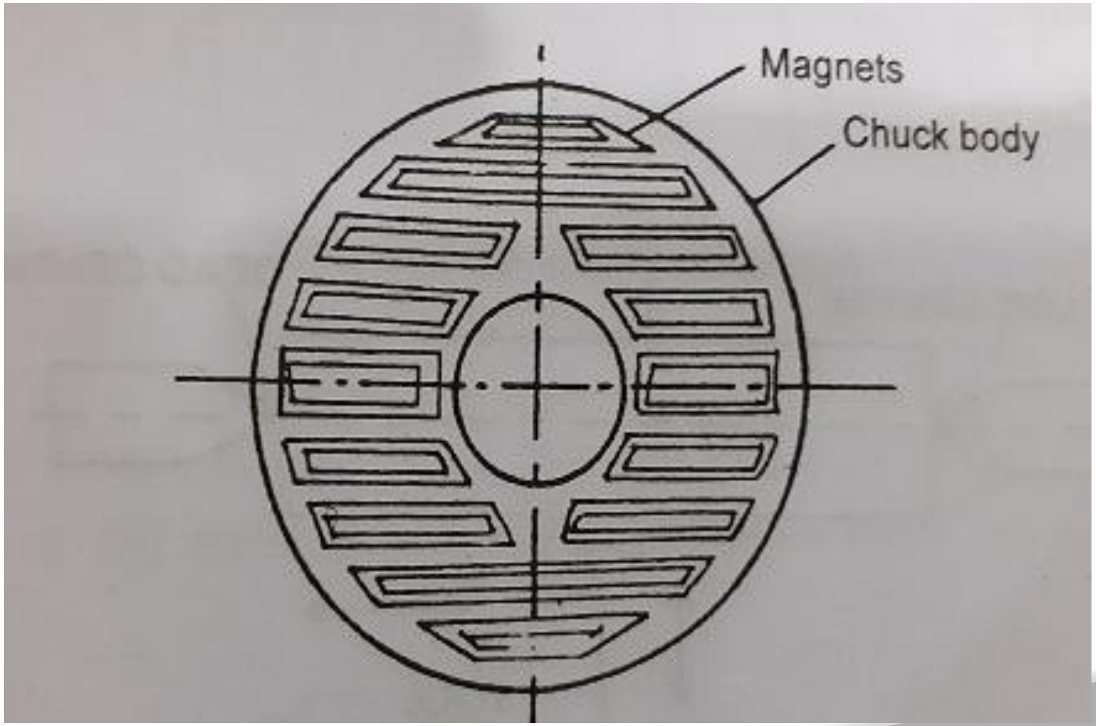
Four jaw independent chuck



Work holding devices

Magnetic chuck

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



Work holding devices

Collet chuck

- Used for holding bars of small sizes, below 63mm
- It is normally used where mass production work is required ex: in capstan turret lathe and automatic lathe

- *Drill chuck*
- Used for holding straight shank drill, reamer or tap for drilling, reaming or tapering operations
- This may be held either in head stock or tail stock
- This has the self centering jaws and is operated by key.

centres

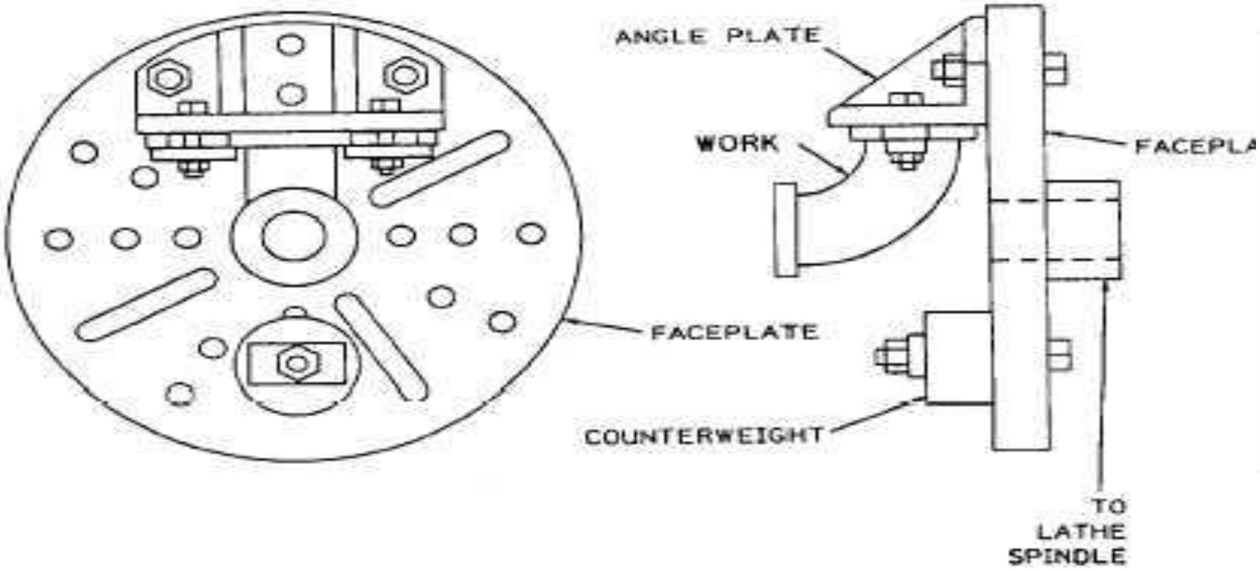
- ☐ Lathe centres are hardened steel devices used for holding the work piece to be turned
- ☐ The centre that is fitted in the head stock is called live centre
- ☐ The centre that is fitted in the tail stock is called dead centre

Varies forms of lathe centres

- Ordinary centre
- Ball centre
- Tipped centre
- Half centre
- Revolving centre
- Pipe centre
- Insert type centre

Work held on face plate

- Face plate is circular plate , screwed to the lathe spindle
- Many holes and slots on the face of the face plate
- The w/p is mounted on the face of the face plate by “T” bolts, clamps and nuts
- Spindle rotate --- face plate will rotate --- so that work will rotate
- Large, irregular, heavy jobs which can’t be held b/w centres or in chucks can be held on the

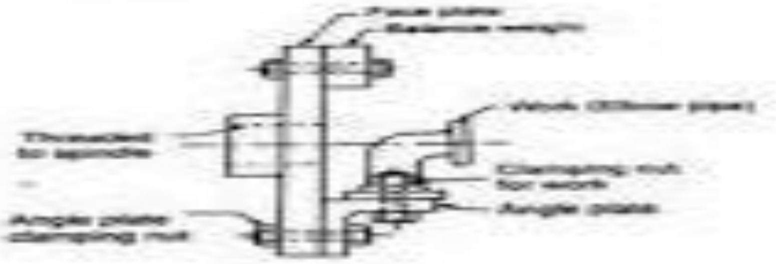


Face plate

Work held on angle plate

- Angle plates are two accurately machined faces at right angles
- The w/p is clamped to the one of the face of the angle plate and other plate of the angle plate is attached to the face plate
- It is used for holding jobs like elbow pipes which can not be held by chucks on the face plate directly for M/c.

Face plate & Angle plate



Work held on face plate

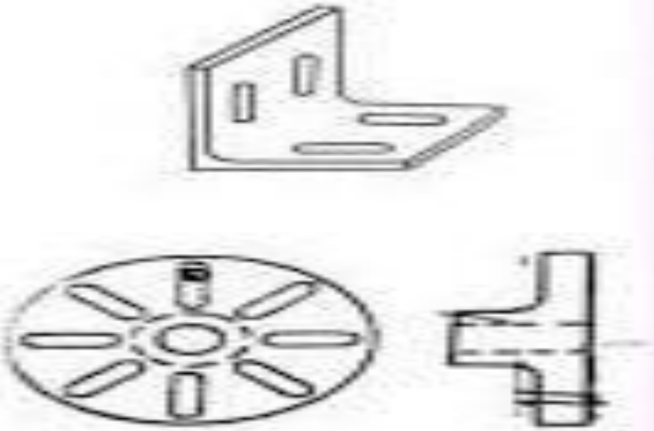


Figure 3.31 Faceplate

Types of Lathe

1. **Speed lathe**
   - (a) Wood working lathe
   - (b) Centering lathe
   - (c) Metal spinning lathe
   - (d) Polishing lathe

2. **Engine lathe**
   - (a) Belt drive
   - (b) Gear head drive
   - (c) Individual motor drive

3. Bench lathe

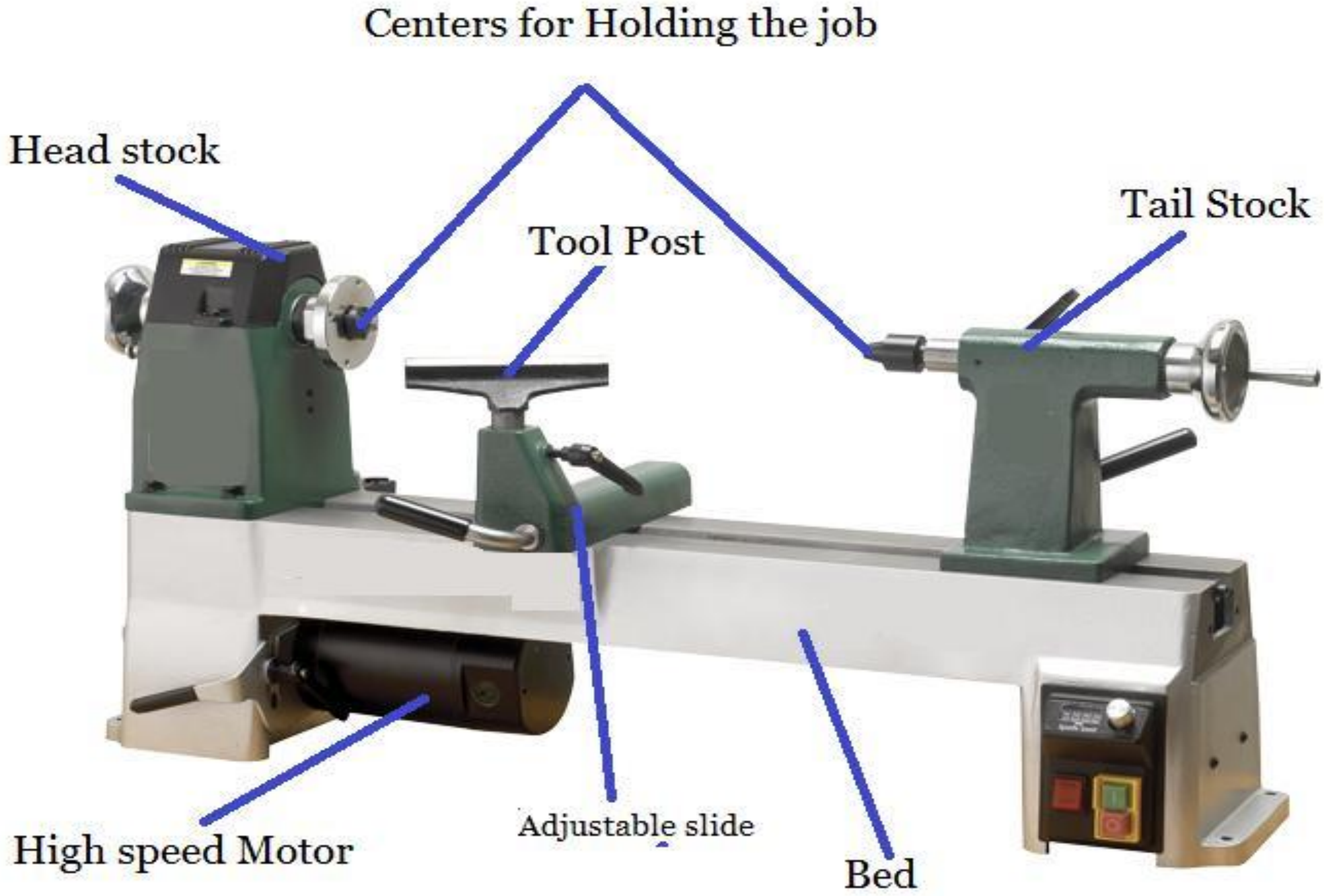
4. **Tool room lathe**

5. **Semi Automatic lathe**
   - (a) Capstan lathe
   - (b) Turret lathe

6. **Automatic lathe**

7. **Special purpose lathe**
   - (a) Wheel lathe
   - (b) Gap bed lathe

Types of Lathe



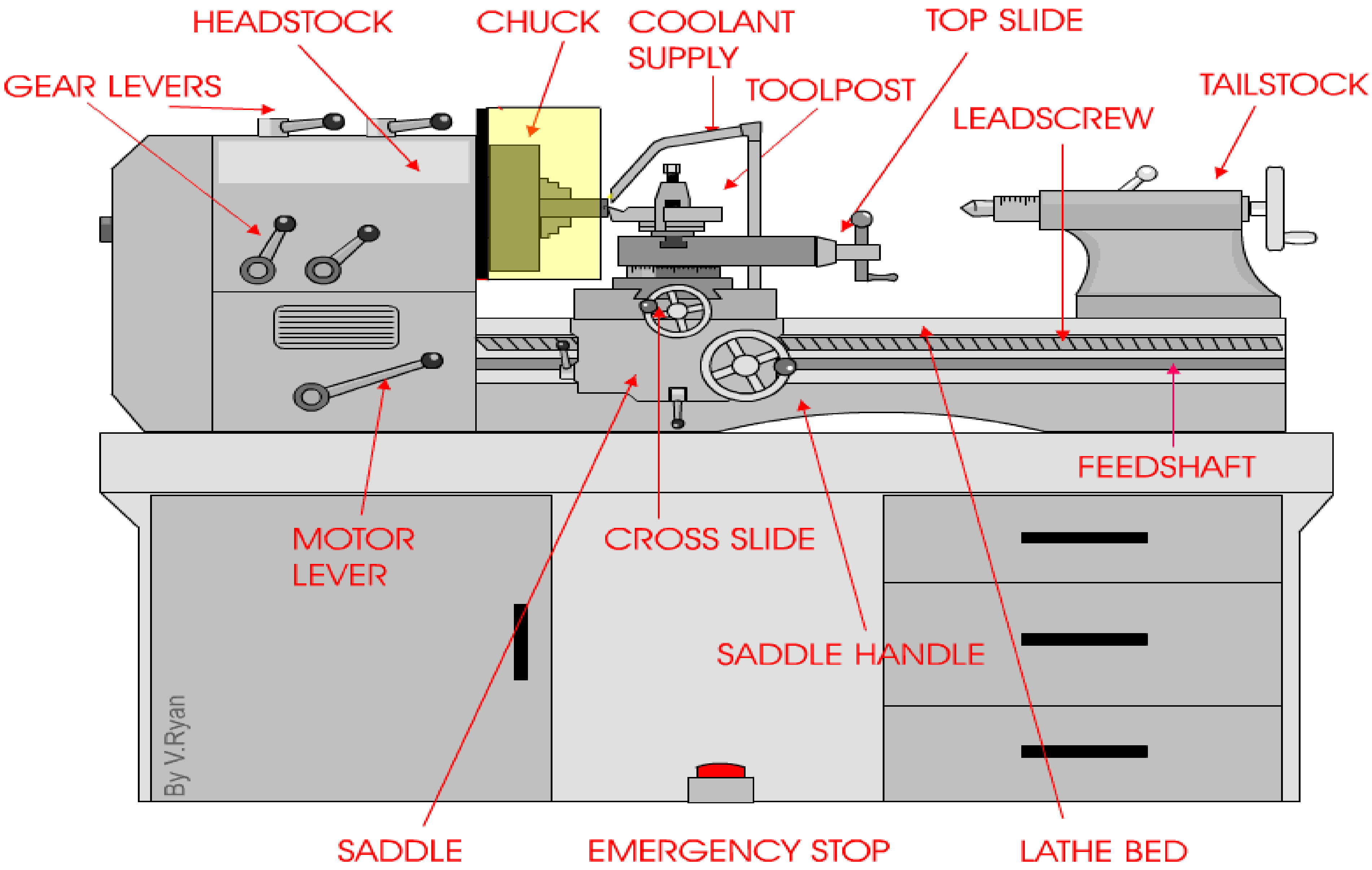
Speed Lathe

Specifications of Lathe

1. *Speed Lathe*

- it consist of a bed, a head stock , a tail stock and an adjustable tool post.
- As the speed of the spindle is very high, it is called as speed lathe
- Spindle is driven by a high speed motor through belts
- Two or three range of spindle speeds are obtained by step cone pulleys
- The work is mounted between centers or in a face plate screwed in the main spindle
- Mainly it is used for wood turning or polishing a work and for metal spinning.

Specifications of Lathe



Types of Lathe

2. Engine Lathe

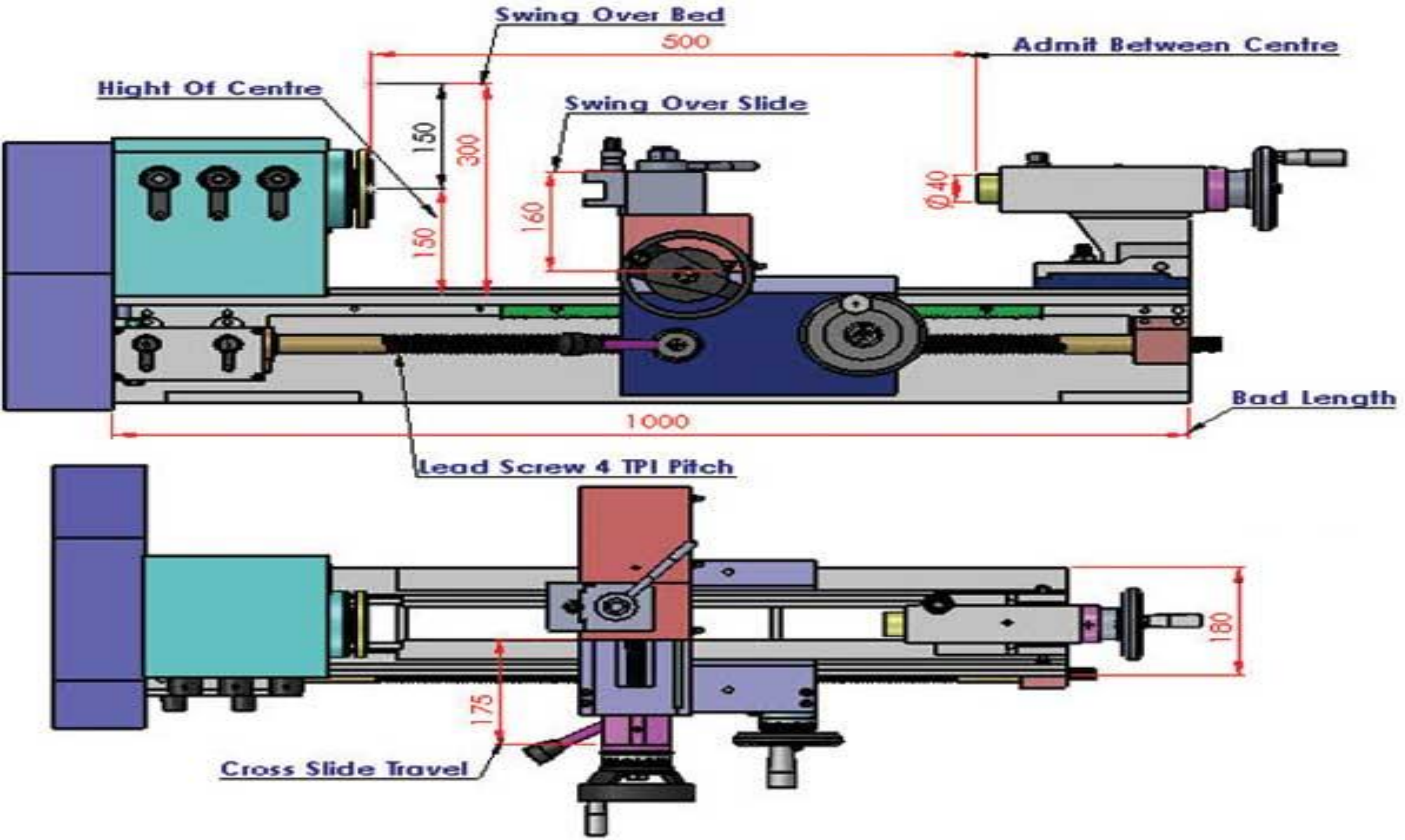
- important and widely used type of lathe
- Early day, it was driven by steam engine so it is called as engine lathe some times called as centre lathe
- It consists of a bed, a head stock, feed shaft and lead screw mechanism and carriage
- Work is mounted on the head stock. Tool is mounted on the carriage
- the tool may be fed cross wise or in longitudinal direction by hand or automatically.
- More than six range of spindle speeds can be obtained by change gears

Types of Lathe

3. Bench Lathe

- It is very small size lathe
- It is mounted on a work bench
- Used for small and precision work
- It is provided with all parts and mechanisms as in an engine lathe
- It performs all the operations that can be done in an engine lathe.

Types of Lathe



Types of Lathe

Tool room Lathe

- it is nothing but an engine lathe built up more accurately with certain extra attachments
- Thus it is designed for more accurate and precision work
- It has more range of speeds and feeds
- It is equipped with centers, steady rest, quick change gears, taper attachments, collet attachment, pump for coolant etc.
- Hence its cost is more,
- This lathe is mainly used for making tools, test gauges, dies and other precision parts

Types of Lathe

Semi automatic Lathe

- some operations are performed manually and some by automatic means
- These are used in mass production
- Example: capstan and turret lathe
- They may be horizontal or vertical type
- It has turret head instead of tail stock
- Many number of tools may be fitted in the turret head
- It has a front tool post for fixing four tools
- It has rear tool post for fixing parting tool
- Thus production time is reduced
- More suitable for the production of identical parts

Types of Lathe

Automatic Lathe

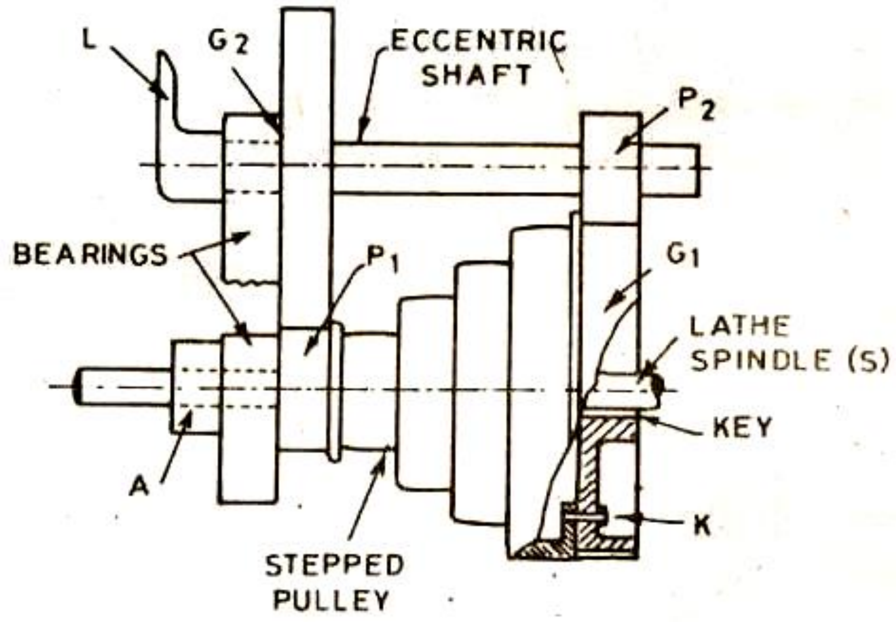
- These are mass production lathes
- All operations and job handling movements are done automatically
- Changing of tools, feeds and speeds are also done automatically
- This lathe has two or more cam shafts
- these cam shafts carry many cams to change the speed, feed and tool
- After initial setting of tools, it perform the operations automatically
- i.e it needs no operator during operation
- After completing the one job, the machine continuous to repeat the cycle of operations
- Thus it produces identical parts

Headstock

- It is permanently fastened to the left hand end of the lathe. It serves to support the first operative unit of the lathe, i.e. spindle. It's also called as live centre because it turns with the work.
- The headstock is that part of the lathe which serves as a housing for the driving pulleys, back gears & spindle.

It consist of main parts:

1) Cone pulley,
2) Back gears & lever,
3) Main spindle,
4) Live centre, &
5) Feed reverse lever.



Geared Head Stock

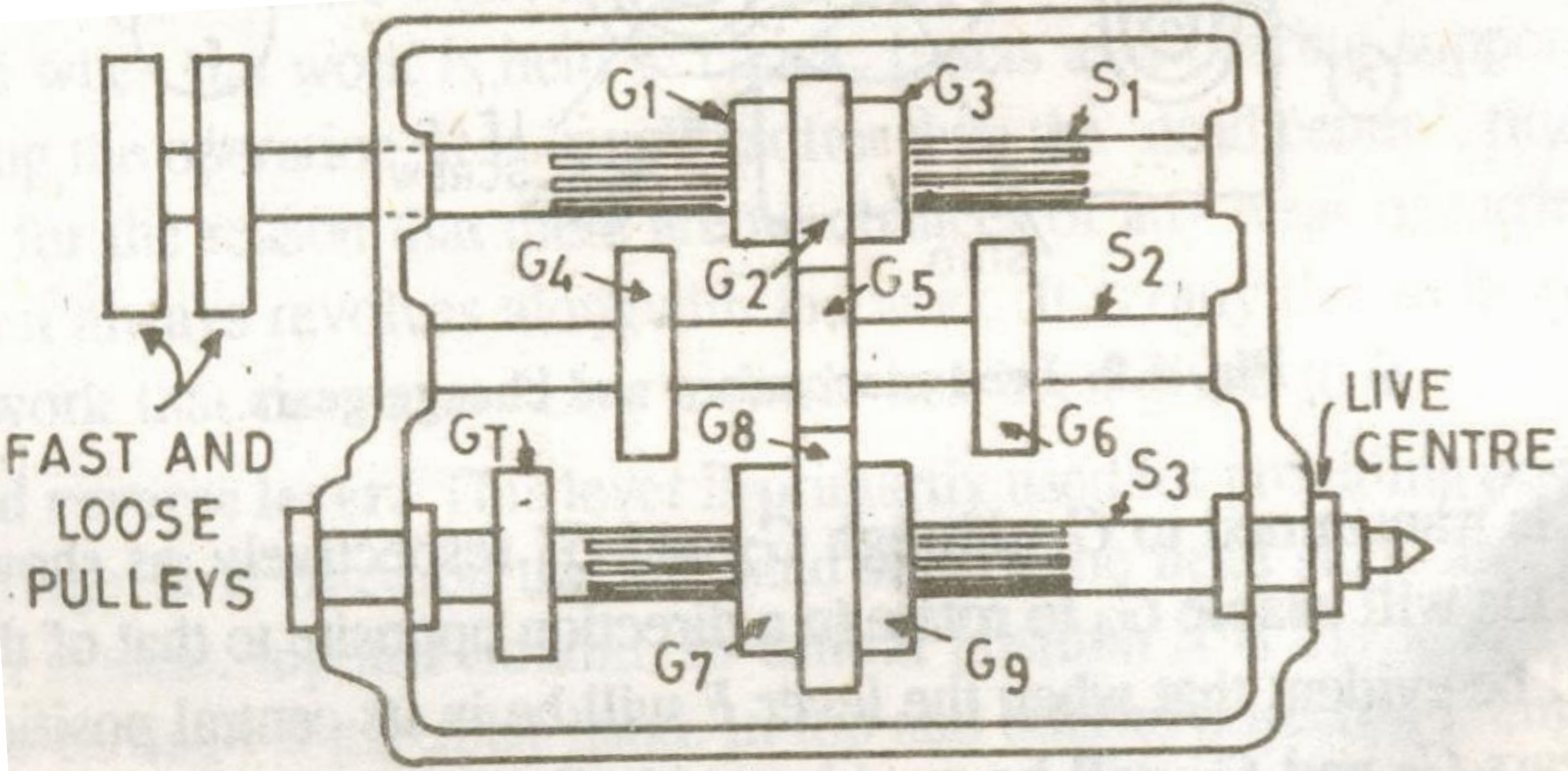


Fig. 6.10. A Geared head stock.

SEMI-AUTOMATIC AND AUTOMATIC LATHES

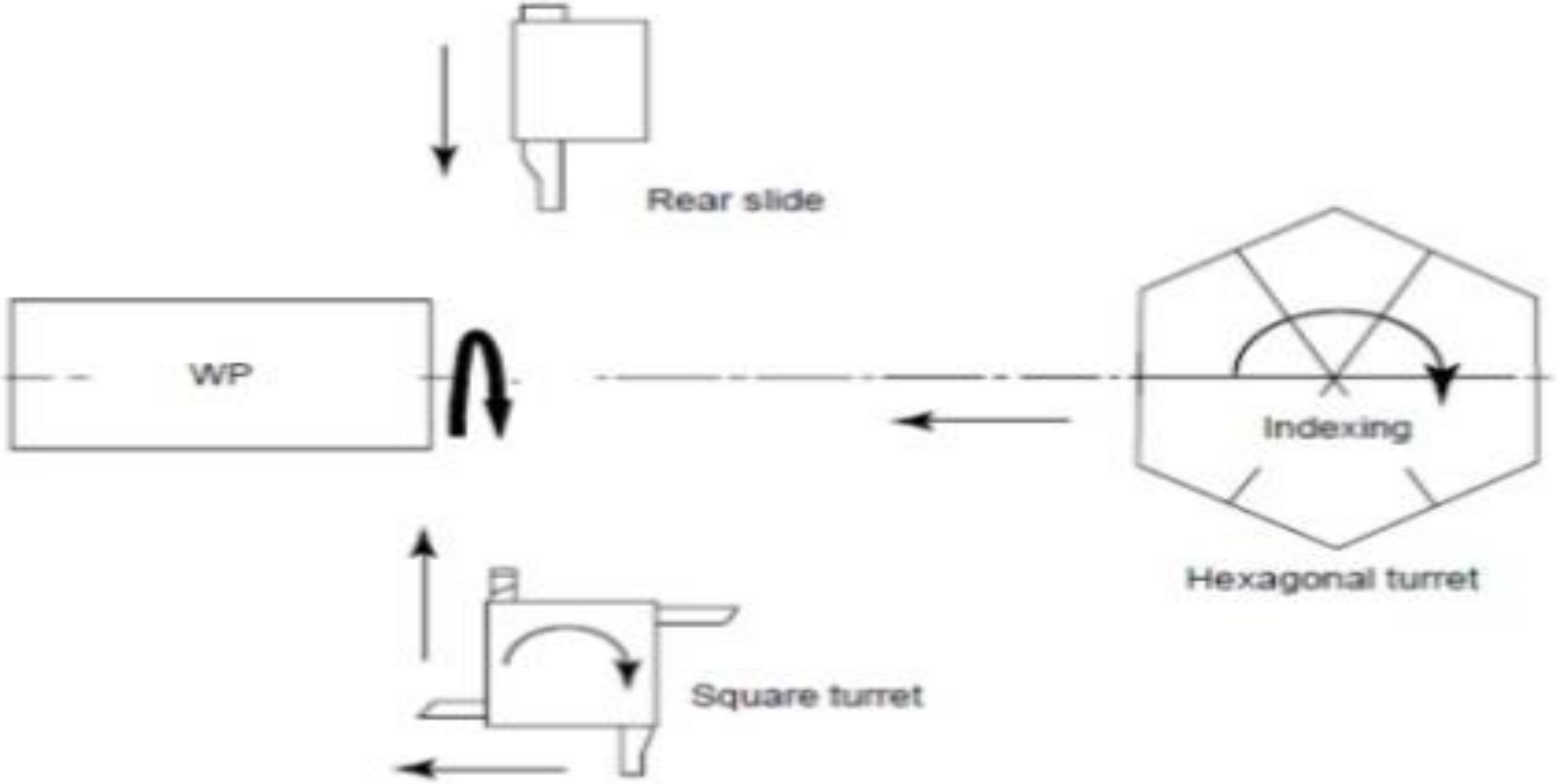
- In any ordinary centre lathe, generally cylindrical components are produced.
- For every new operation we have to change the tool.
- When a large number of identical components are to be produced, an ordinary lathe is not suitable because changing and setting of tools will take more time
- And the rate of production will also be reduced and the cost of production will be high
- So the rate of production can be increased by reducing the time spent in changing and setting the tool
- This is done by single setting of tools, more than one tool (multiple tools) an be applied at a time
- Capstan and turret lathes have these facilities these are called semi automatic lathes

- In Capstan and turret lathes, operations like loading, feeding of bar stock, bringing the different tools to correct position are done manually.
- These manual operation increase the production time.
- To remove this wastage of time, automatic lathes are used
- In automatic lathes, all operations right from the loading of stocks to unloading of finished products are done automatically.
- These automatic lathes produce large quantity of identical parts at faster rate.

SEMI-AUTOMATIC LATHES

In which, all machining operations are done automatically, but the loading and unloading operations are done manually

(a) Turret or saddle type lathe (b) capstan or ram type lathe


Rear slide
WP
Indexing
Hexagonal turret
Square turret

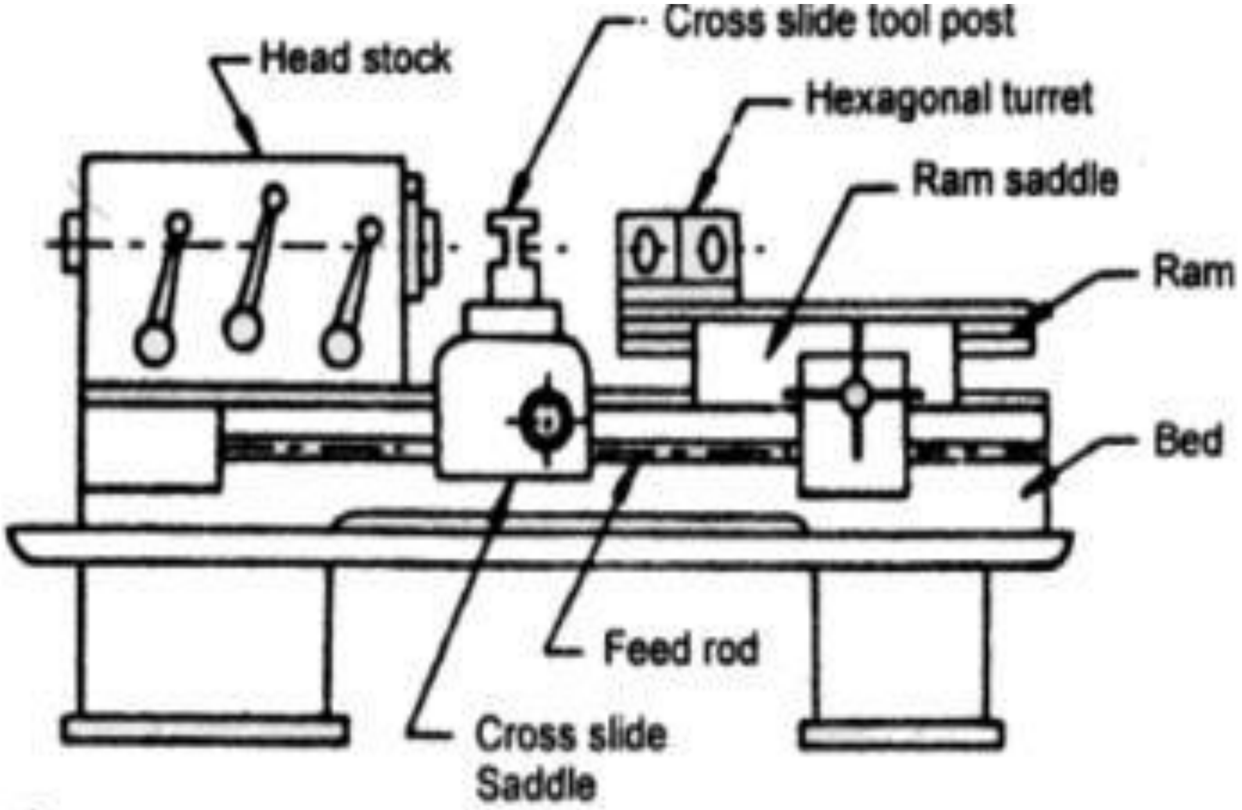
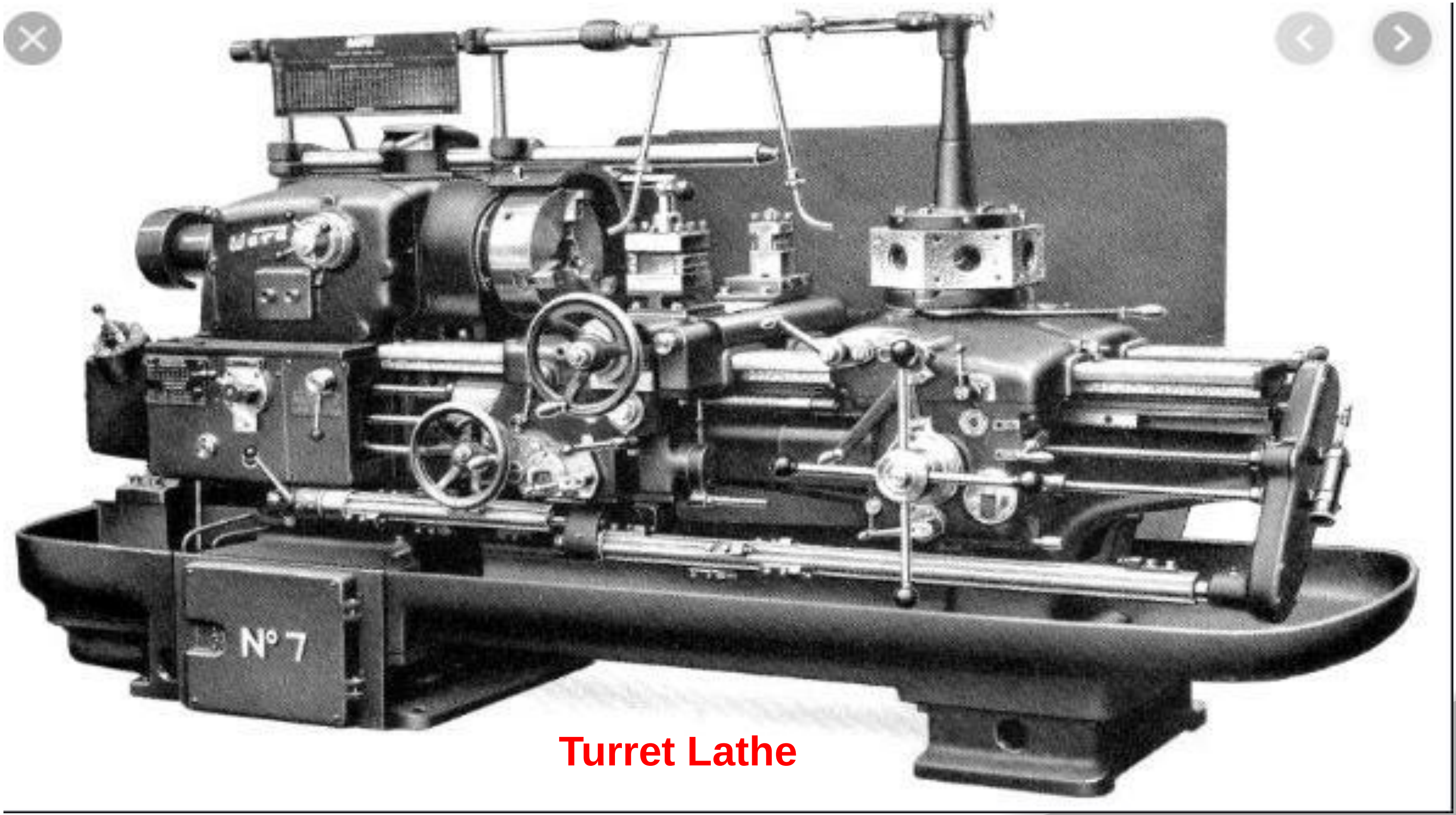


Figure 2.62. Capstan Lathe



Turret Lathe

Centre Lathe	Capston/Turret Lathe
It is a manually operated lathe	It is a semi automatic lathe
It has only one tool post tool changing time is more	Front and rear tool posts are available. Tool changing time is less
It has tail stock	It has turret head instead of tail stock
Only one tool can be fitted in the tail stock	Six different tools can be fitted in the turret head.
Number of speeds is less	Number of speeds is more
Tool changing time is more	Tool changing time is less
The machine should be stopped for changing tool	Tool can be changed without stopping the machine
It is not suitable for mass production	It is suitable for mass production
No feed stops to control the tool	The tools are controlled by feed stops
The tool is centered manually after changing the tool	The tool is centered automatically
Only one operation is done at a time	More than one operation can be done at a time

Capstan Lathe	Turret Lathe
It is a lightweight machine.	It is a heavyweight machine.
In capstan lathe, the turret tool head is mounted over the ram and that is mounted over the saddle.	In turret lathe, the turret tool head is mounted over the saddle like a single unit
For providing feed to the tool, ram is moved	For providing feed to the tool, the saddle is moved.
Because of no saddle displacement, Movement of turret tool head over the longitudinal direction of bed is small along with the ram.	Turret tool head moves along with the saddle over the entire bed in the longitudinal direction.
Used for shorter work piece because of limited ram movement	Used for longer work piece because of saddle movement along the bed.
Heavy cuts on the work piece cannot be given because of non-rigid construction	Heavy cuts on the work piece can be given because of the rigid construction of the machine.

Capstan Lathe	Turret Lathe
For indexing turret tool head, the hand wheel of the ram is reversed and turret tool index automatically.	For indexing turret tool head, the turret is rotated manually after releasing the clamping lever.
The turret head cannot be moved in the lateral direction of the bed.	The turret head can be moved crosswise i.e. in the lateral direction of bed in some turret lathe.
In capstan lathe, Collet is used to grip the Job.	In turret lathe, power Jaw chuck is used to grip the Job.
Used for machining workpiece up to 60 mm diameter.	Used for machining workpiece up to 120 mm diameter.
These are usually horizontal lathes.	Turret lathes are available in horizontal and vertical lathes.

Machining Calculations: Turning

- Spindle Speed - N
  - **v = cutting speed**
  - **D_o = outer diameter**

$$N = \frac{v}{\pi D_o}$$ (rpm)

- Feed Rate - f_r
  - **f = feed per rev**

$$f_r = N f$$ (mm/min -or- in/min)

- Depth of Cut - d
  - **D_o = outer diameter**
  - **D_f = final diameter**

$$d = \frac{D_o - D_f}{2L}$$ (mm/rev -or- in/rev)

- Machining Time - T_m
  - **L = length of cut**

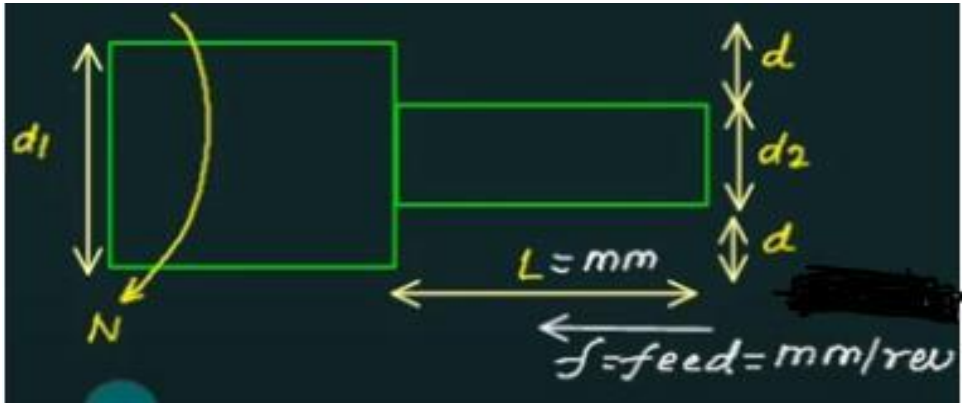
$$T_m = \frac{L}{f_r}$$ (min)

- Mat’l Removal Rate - MRR

$$MRR = v f d$$ (mm³/min -or- in³/min)

Turning:

Turning is a machining process to produce parts round in shape by a single point cutting tool on lathes. The tool is fed either linearly in the direction parallel or perpendicular to the axis of rotation of the work piece, or along a specified path to produce complex rotational shapes. The primary motion of cutting in turning is the rotation of the work piece, and the secondary motion of cutting is the feed motion.



[redacted]

$$T = \frac{\text{Length of the job}}{\text{Feed/rev.} \times \text{r.p.m}}$$

$$\text{Depth of cut (d)} = \frac{d_1 - d_2}{2}$$

$$MRR = \frac{\pi}{4}\frac{\left(d^2{}_1 - d^2{}_2\right).L}{T}\frac{mm^3}{min}$$

$$S = Vt \Rightarrow t = \frac{S}{V} \qquad T = \frac{L}{f\ N}$$

$$V_C = \text{Cutting velocity} = \frac{\pi dN}{1000}\text{m/mim}$$

$$U = \text{Specific energy} = \frac{W.Sec}{mm^3} = \frac{W}{mm^3/Sec} = \frac{Power}{MRR/60}$$

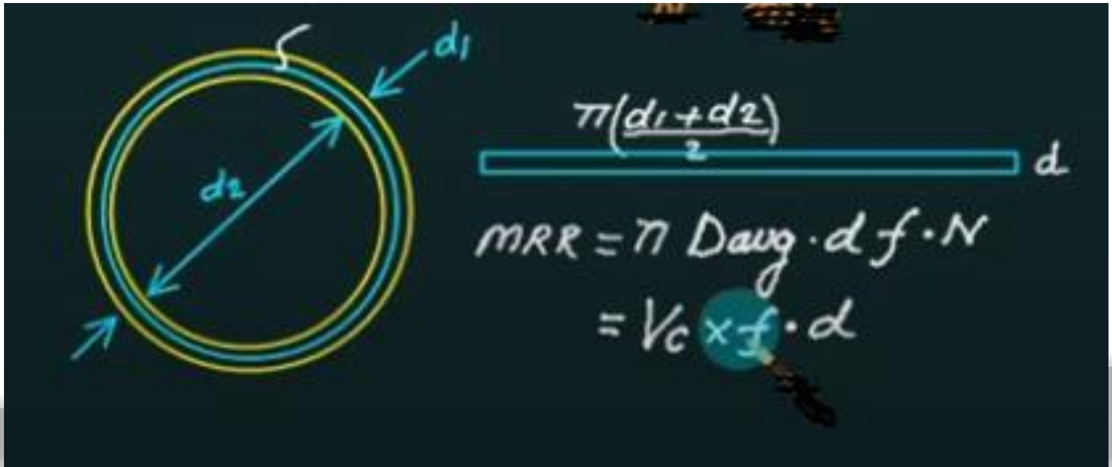
$$\text{U = Specific energy} = \frac{W.\text{Sec}}{\text{mm}^3} = \frac{W}{\text{mm}^3/\text{Sec}} = \frac{Power}{MRR/60}$$

$$\text{Power} = \frac{2\pi NT}{60}$$

$$T = Nm$$

F_C =Cutting force, N

$$\text{Power} = \text{F}_\text{C}.\frac{\text{V}_\text{C}}{60} = \text{N.m/s} = \text{Watt}$$



Knurling

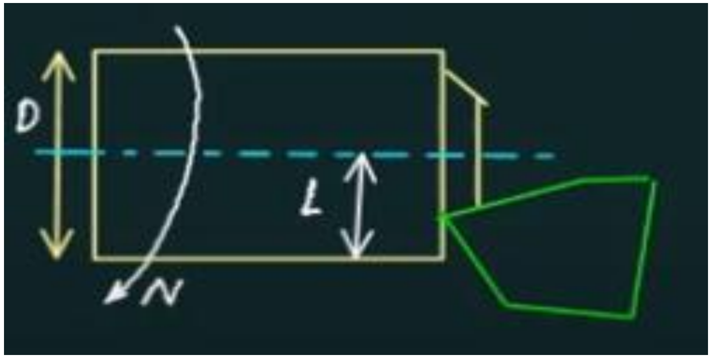
Knurling is the process used for making diamond shaped impression on the surface of a component to produce a rough surface to facilitate easy grip.

Time required for knurling operation (T)

$$T = \frac{\text{Length of the job}}{\text{Feed/rev.} \times \text{r.p.m}} = \frac{L}{f.N}$$

Facing

It is the process of the material removal from the surface at right angles to the axis of rotation of the job. Fig. shows how the facing is done. In this process tool is fed crosswise, while in turning, tool is fed longitudinally.



Time required for knurling operation (T)

$$T = \frac{\text{Length of the job}}{\text{Feed/rev.} \times \text{r.p.m}} = \frac{L}{f.N}$$

$$T = \frac{\text{Length of the job}}{\text{Feed/rev.} \times \text{r.p.m}} = \frac{D/2}{f.N}$$

Estimate the machining time in sec required in rough turning a 1.5-m-long, annealed aluminium-alloy round bar 75-mm in diameter, using a high-speed-steel tool, let feed = 2 mm/rev and maximum cutting speed of 4 m/s

$$V_C = \text{Cutting velocity} = \frac{\pi dN}{1000}\,\text{m/mim}$$

$$4\times60 = \frac{\pi\times75\times N}{1000}$$

$$N = 1018\text{rpm}$$

$$T = \frac{\text{Length of the job}}{\text{Feed/rev.} \times \text{r.p.m}} = \frac{L}{f.N}$$

$$T = \frac{L}{f.N} = \frac{1500}{2\times1018}$$

$$= 0.74\,\text{min}$$

Estimate the machining time to turn a MS bar of 3cm diameter down to 2.5cm for a length of 10cm in a single cut. Assume cutting speed = 30 m/min and feed = 0.4mm/rev.

$$V_C = \text{Cutting velocity} = \frac{\pi dN}{1000}\,\text{m/mim}$$

$$30 = \frac{\pi \times 30 \times N}{1000}$$

$$N = 318\ \text{rpm}$$

$$T = \frac{\text{Length of the job}}{\text{Feed/rev.} \times \text{r.p.m}} = \frac{L}{f.N}$$

$$T = \frac{L}{f.N} = \frac{100}{0.4 \times 318}$$

$$= 0.79\,\text{min}$$

A 150 mm long 12 mm diameter stainless steel rod is to be reduced in diameter to 10 mm by turning on a lathe in one pass. The spindle rotates at 500 rpm, and the tool is travelling at an axial speed of 200 mm/min. Calculate the time required for machining the steel rod

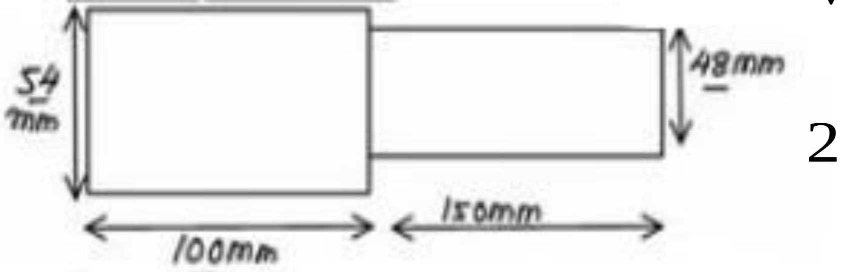
$$\mathrm{V_{actual}} = \mathrm{f.N} = 200\,mm/\min$$

$$\mathrm{T} = \frac{\text{Length of the job}}{\text{Feed/rev.} \times \text{r.p.m}} = \frac{\mathrm{L}}{\mathrm{f.N}}$$

$$T = \frac{\mathrm{L}}{\mathrm{f.N}} = \frac{150}{200}$$

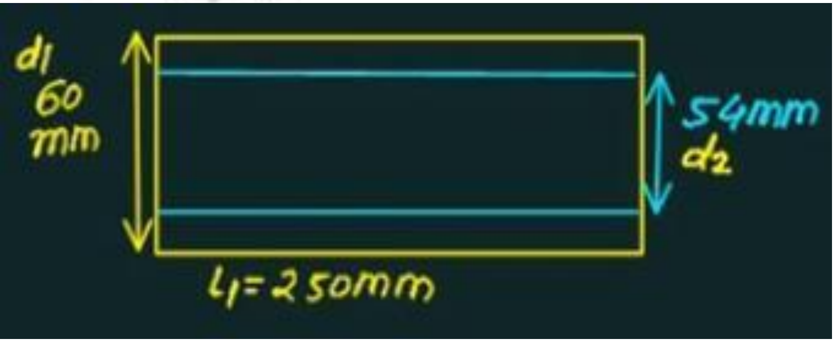
$$= 0.75\,\mathrm{min}$$

Find the time required to turn a 60 mm diameter rod to the dimensions shown in. Take cutting speed as 20 m/min, feed as 1.2 mm. All cuts are 3 mm deep.



$$V_C = \text{Cutting velocity} = \frac{\pi d_1 N_1}{1000}\ \text{m/mim}$$

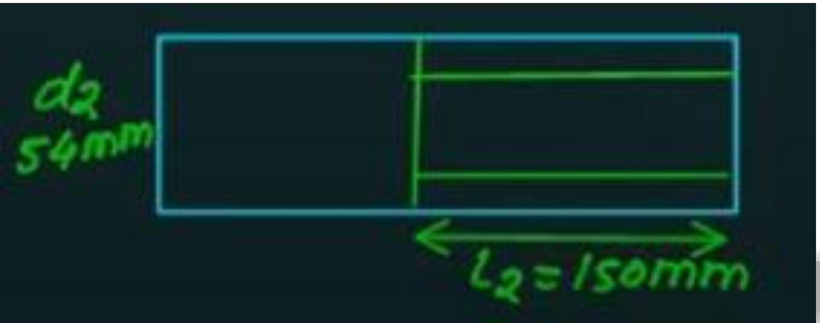
$$20 = \frac{\pi\times 60\times N_1}{1000} \Rightarrow N_1 = 106.1\ \text{rpm}$$



$$T_1 = \frac{L_1}{f.N_1} = \frac{250}{1.2\times 106.1} = 1.96\,\text{min}$$

$$V_C = \frac{\pi d_2 N_2}{1000}\ \text{m/mim}$$

$$20 = \frac{\pi\times 54\times N_2}{1000} \Rightarrow N_2 = 117.89\ \text{rpm}$$



$$T_2 = \frac{L_2}{f.N_2} = \frac{150}{1.2\times 117.89}$$

$$= 1.06\,\text{min}$$

$$T = T_1 + T_2 = 1.96 + 1.06 = 3.03\,\text{min}$$

A mild steel bar is turned on a lathe at a rotational speed of 200 rpm over its 120mm length using 0.5mm feed per revolution. If the cutting force is 1800N and diameter of the bar is 50mm, then the amount of heat generated during cutting

$$V_C = \text{Cutting velocity} = \frac{\pi dN}{1000}\,\text{m/mim} = \frac{\pi dN}{1000 \times 60}\,\text{m/sec}$$

$$V_C = \frac{\pi\times50\times200}{60000} = 0.523\text{m/sec}$$

$$\text{Power (P)} = \text{F.}V_C = 1800\times0.523 N - m/\sec$$

$$= 941.4W$$

A 150-mm-long, 75-mm-diameter titanium-alloy rod is being reduced in diameter to 65 mm by turning on a lathe in one pass. The spindle rotates at 400 rpm and the tool is travelling at an axial velocity of 200 mm/min

(a) Calculate the material removal rate in mm³/s

(b) Calculate the cutting force in N if the unit energy required is between 3.5 W-s/mm³

$$T = \frac{\text{L}}{\text{f.N}} = \frac{150}{200} = 0.75\,\text{min}$$

$$\text{MRR} = \frac{\pi}{4}\frac{(\text{d}^2{}_1 - \text{d}^2{}_2).L}{\text{T}} = \frac{\pi}{4}\frac{(75^2 - 65^2).150}{0.75} = 2.19\times10^5 mm^3/\min = 3665.2 mm^3/\sec$$

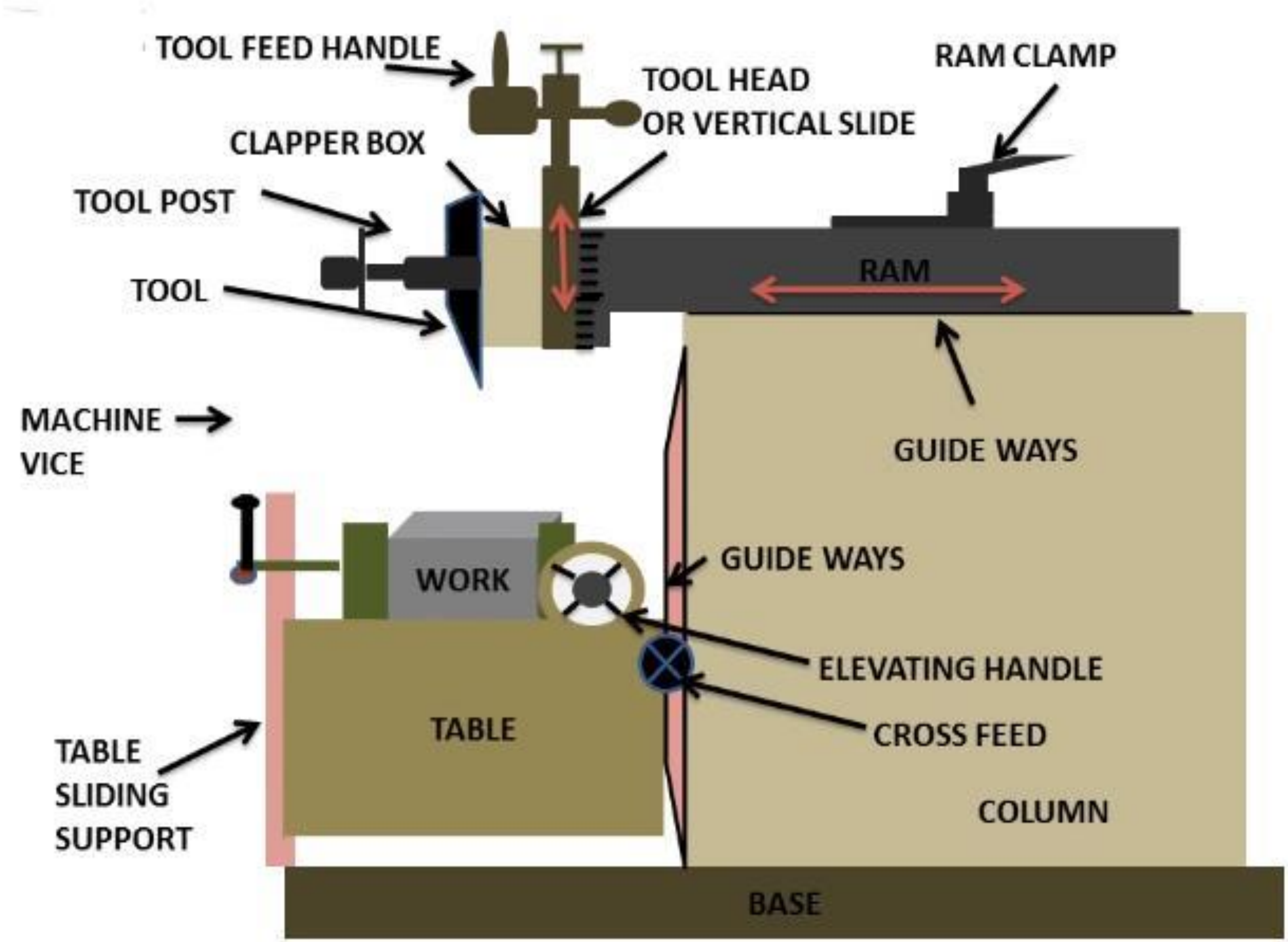
$$\text{V}_\text{C} = \text{Cutting velocity} = \frac{\pi \text{dN}}{60}\text{m/mim} = \frac{\pi\times0.075\times400}{60} = 1.57 m/s$$

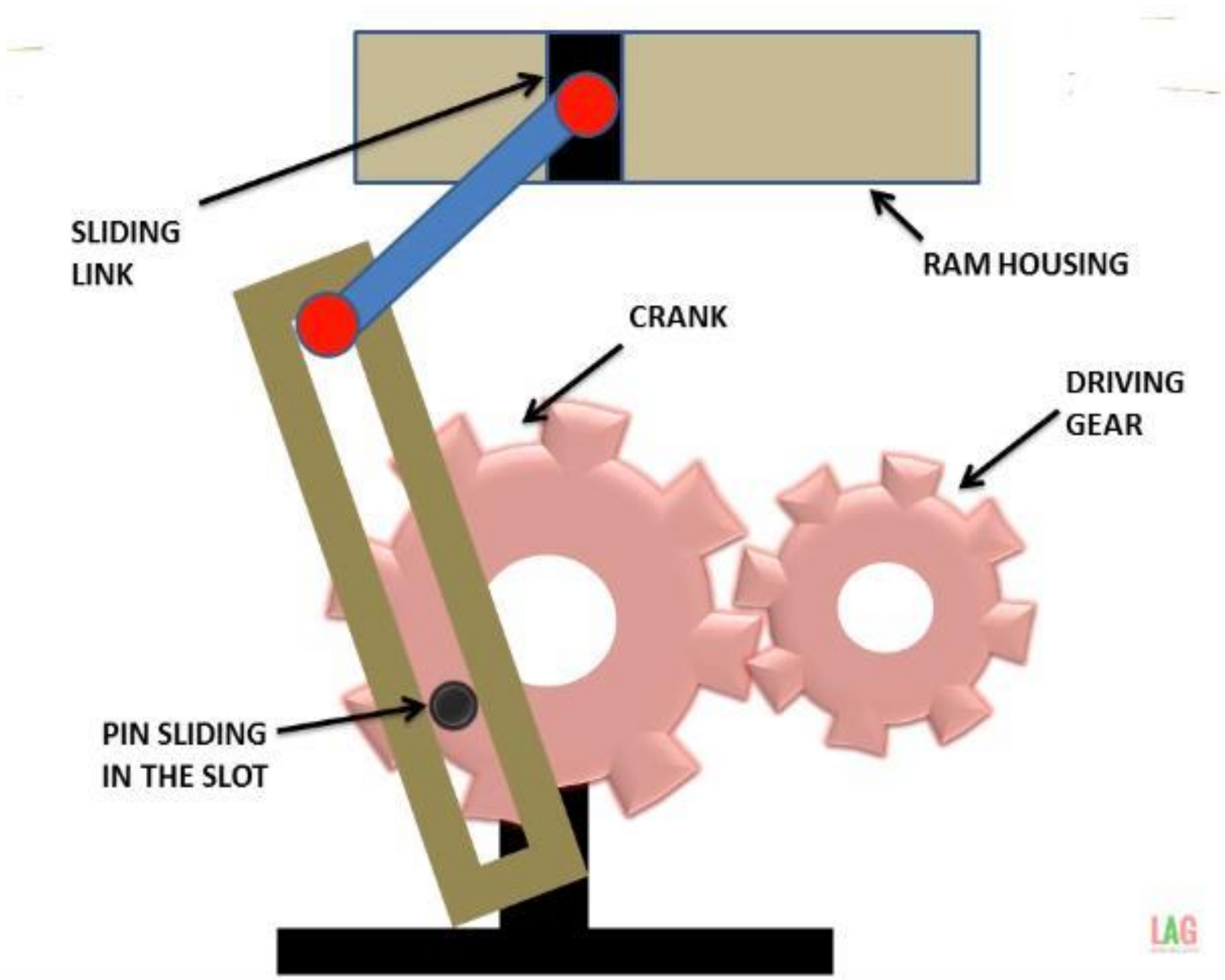
$$\frac{W}{mm^3/\sec} = \frac{Power}{MRR} = 3.5 \Rightarrow Power = 3.5\times3665.2 watt$$

$$F_C V_C = 12828 = F_C \times 1.57 = 12828 \Rightarrow F_C = 8166N$$

Shaping Machine

- The shaping machine is used to machine flat metal surfaces especially where a large amount of metal has to be removed.
- Other machines such as milling machines are much more expensive and are more suited to removing smaller amounts of metal, very accurately.
- The shaping machine is a simple and yet extremely effective machine
- It is used to remove material, usually metals such as steel or aluminium, to produce a flat surface.
- It can also be used to manufacture gears such as rack and pinion systems and other complex shapes


TOOL FEED HANDLE
TOOL HEAD
OR VERTICAL SLIDE
RAM CLAMP
CLAPPER BOX
TOOL POST
TOOL
RAM
MACHINE
VICE
GUIDE WAYS
WORK
GUIDE WAYS
ELEVATING HANDLE
CROSS FEED
TABLE
TABLE
SLIDING
SUPPORT
COLUMN
BASE


SLIDING LINK
RAM HOUSING
CRANK
DRIVING GEAR
PIN SLIDING IN THE SLOT
LAG

Types of Shaper Machine Mechanisms

- Crank and slotted link mechanism.
- Whitworth’s quick mechanism.
- Hydraulic shaper mechanism.
- Automatic table feed mechanism.

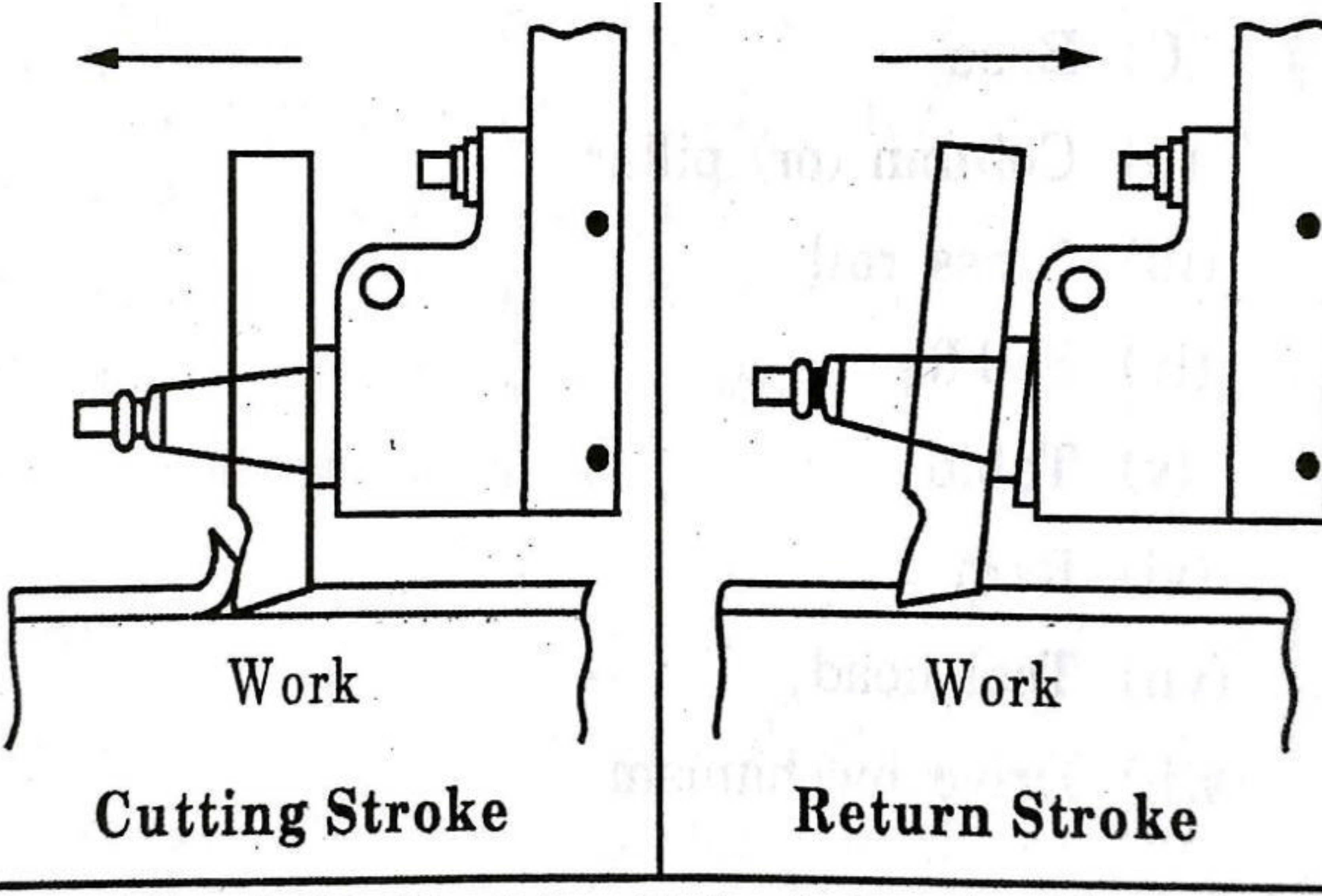
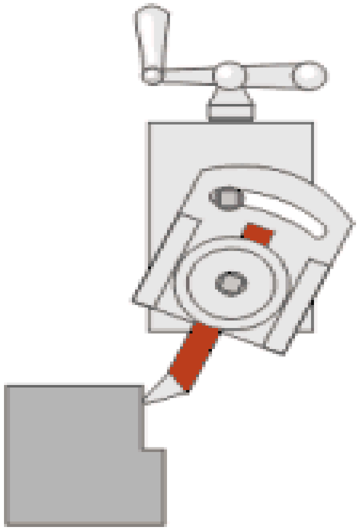


Fig. 6.53. Working Principle of a Shaper.

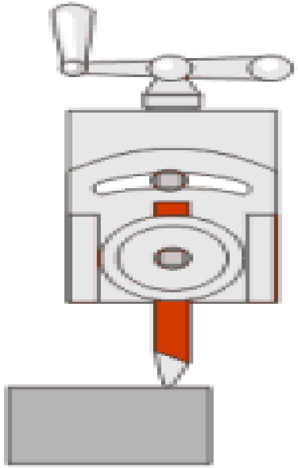
The tool post and the tool slide can be angled as seen below. This allows the shaper to be used for different types of work

DIA A: The tool post has been turned at an angle so that side of the material can be machined



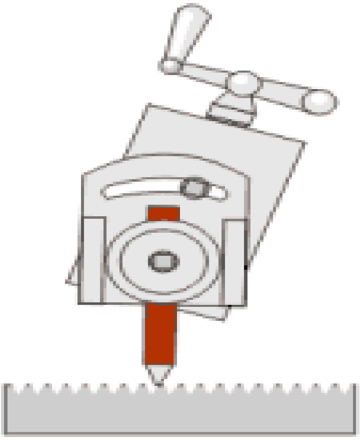
By V.Ryan

DIA B: The tool post is not angled so that the tool can be used to level a surface.



By V.Ryan

DIA C: The top slide is slowly feed into the material so that a 'rack' can be machined for a rack and pinion gear system.



By V.Ryan

Classification of shapers

Shapers are broadly classified as follows:

According to the type of mechanism used:

- ➢ Crank shaper.
- ➢ Geared shaper.
- ➢ Hydraulic shaper.

According to the position and travel of ram:

- ▪ Horizontal shaper.
- ▪ Vertical shaper.
- ▪ Traveling head shaper.

According to the type of design of the table:

- ✓ Standard or plain shaper.
- ✓ Universal shaper.

According to the type of cutting stroke:

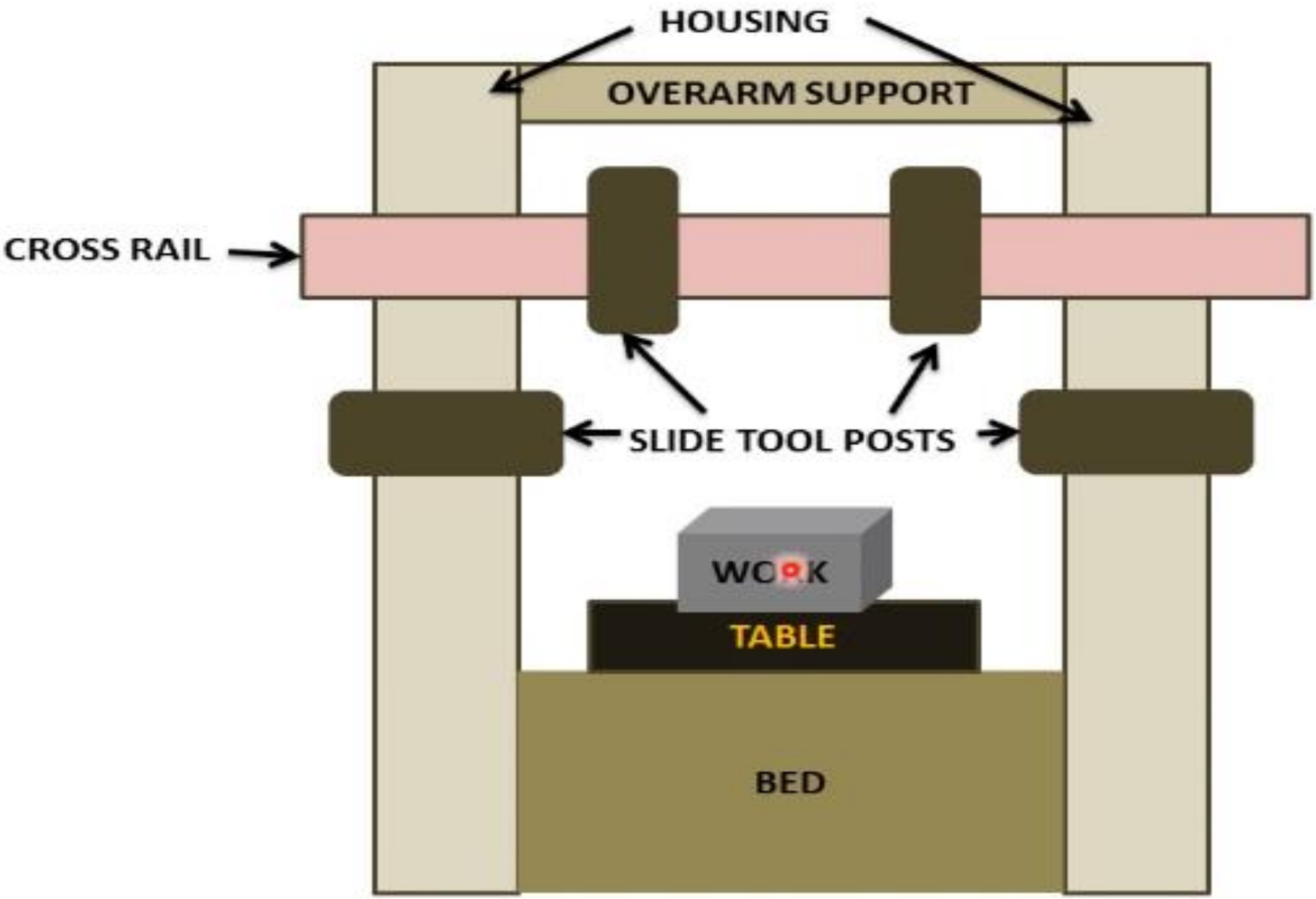
- ☐ Push type shaper.
- ☐ Draw type shaper.

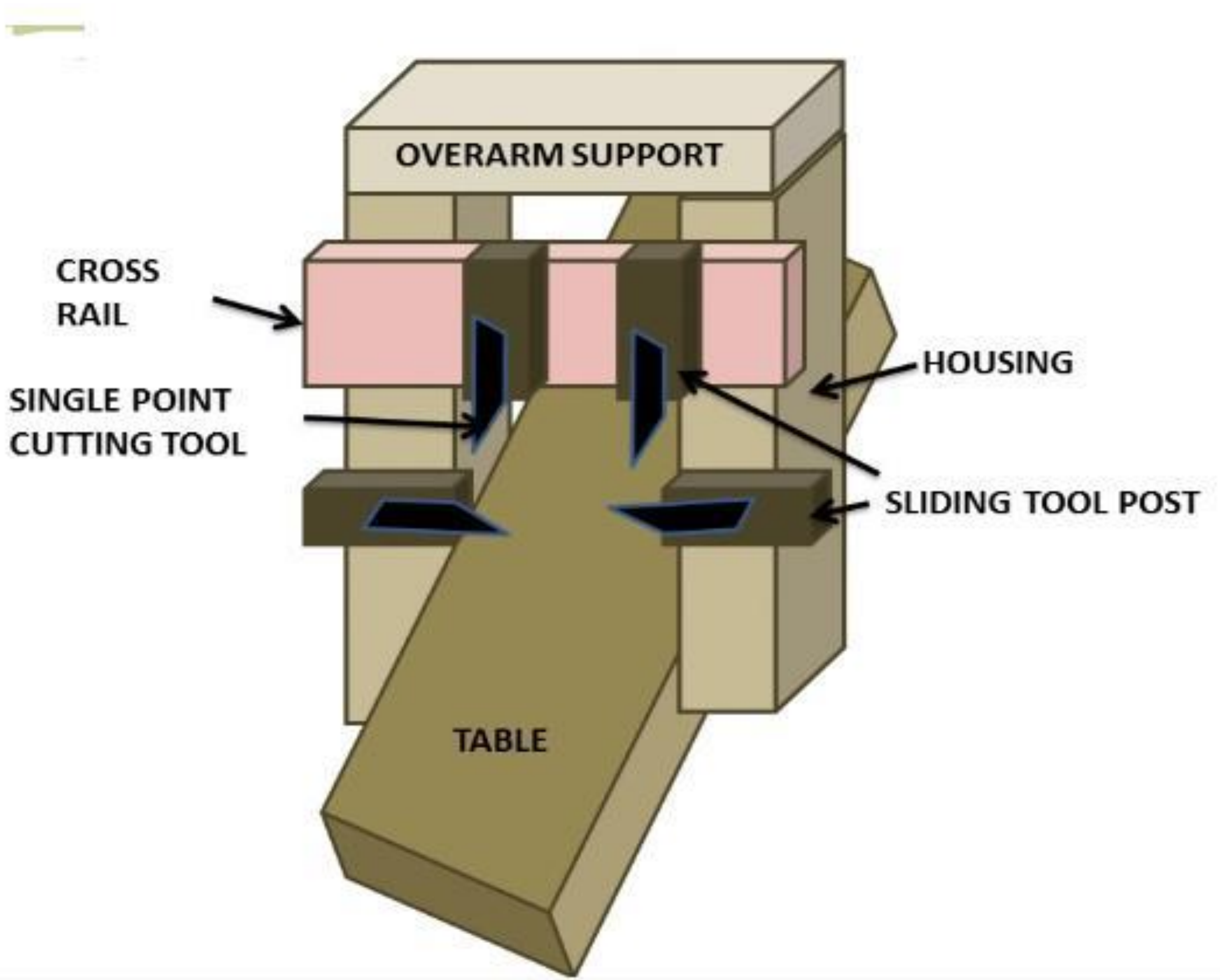
PLANER

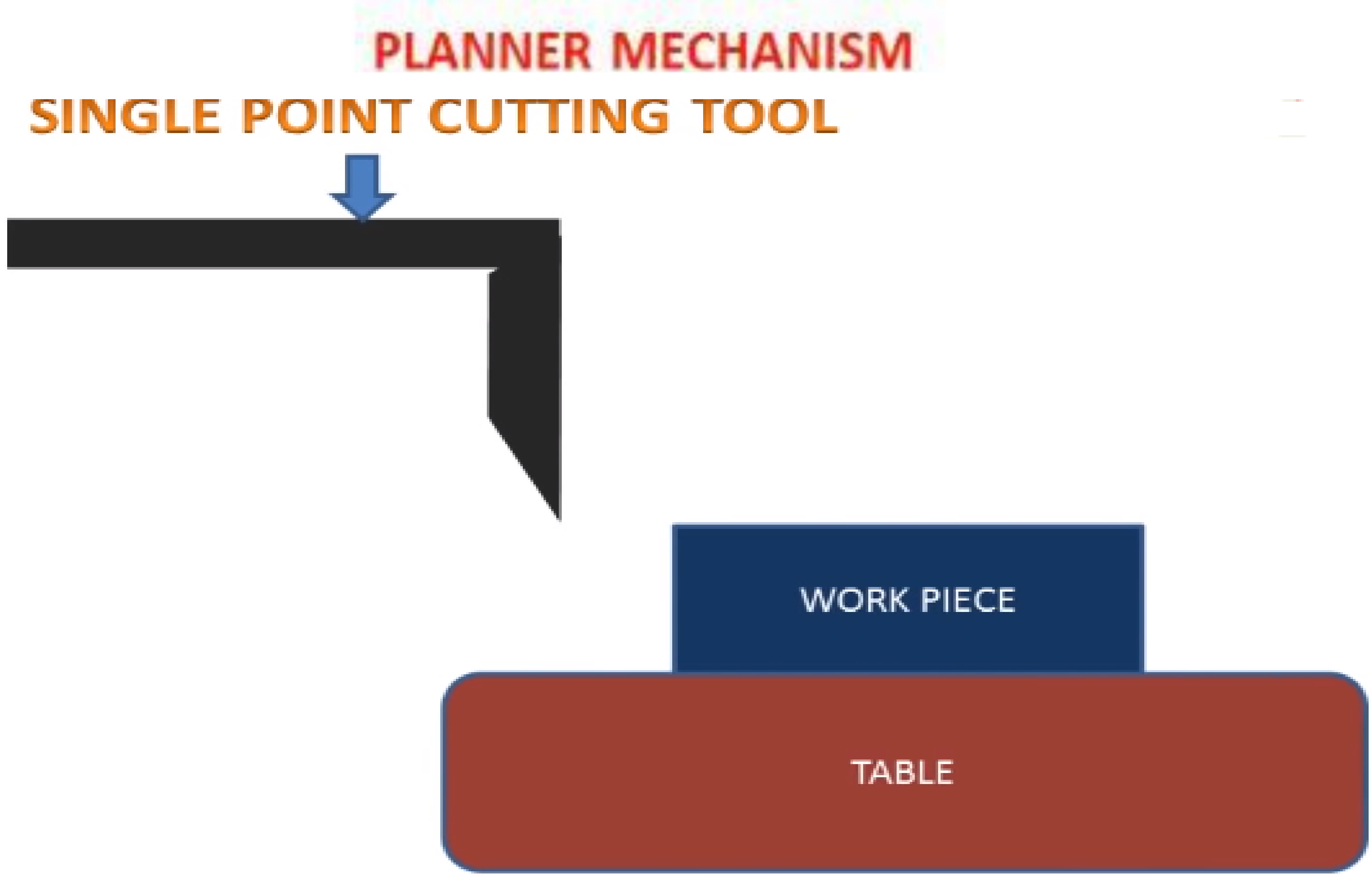
PLANER

- Like shapers, planers are also basically used for producing flat surfaces.
- But planers are very large and massive compared to the shapers.
- Planers are generally used for machining large work pieces which cannot be held in a shaper.
- The planers are capable of taking heavier cuts.
- The planer was first developed in the year 1817 by Richard Roberts, an Englishman

PLANER

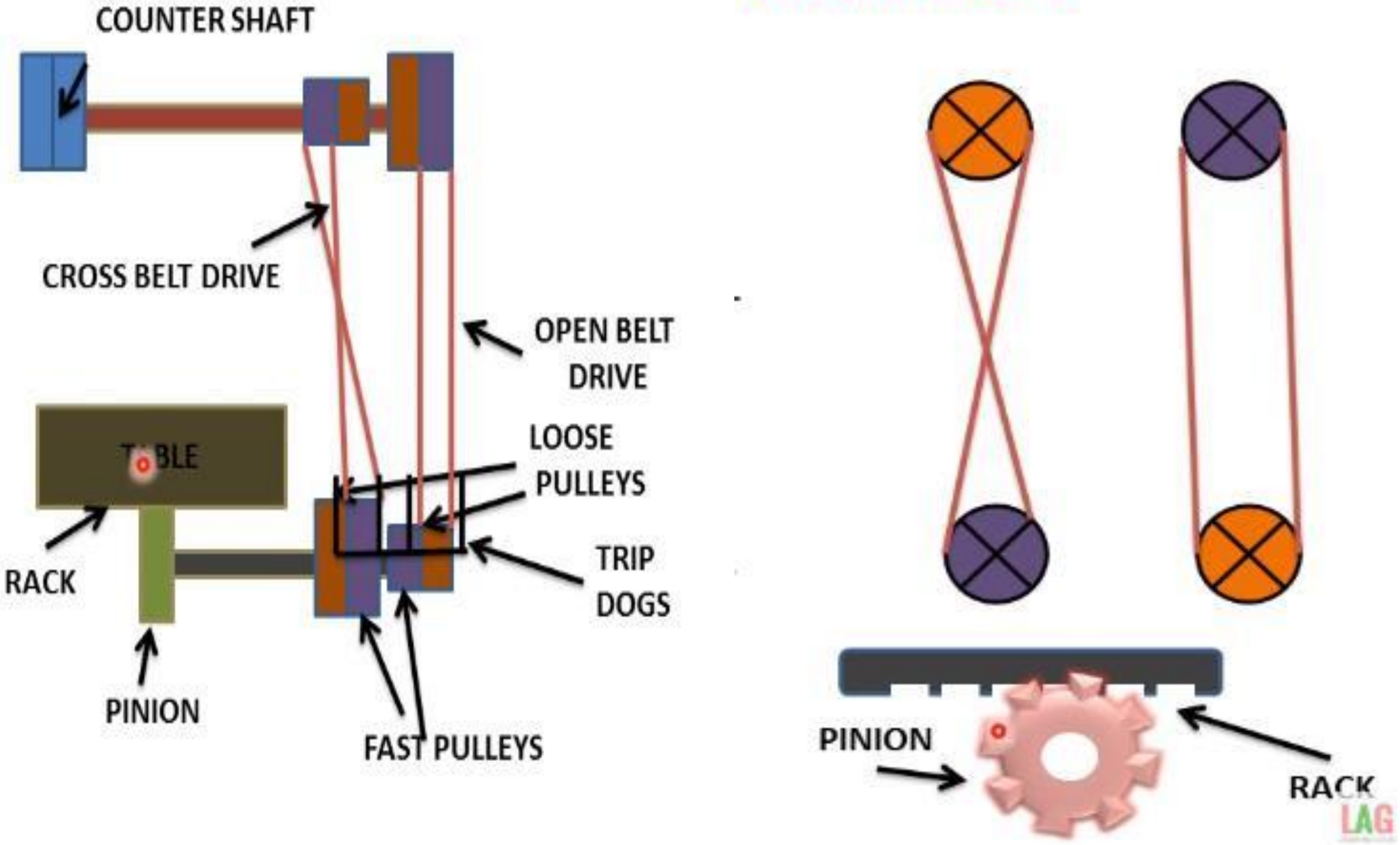

HOUSING
OVERARM SUPPORT
CROSS RAIL
SLIDE TOOL POSTS
WORK
TABLE
BED


OVERARM SUPPORT
CROSS RAIL
HOUSING
SINGLE POINT CUTTING TOOL
SLIDING TOOL POST
TABLE



PLANER MECHANISM

DRIVING MECHANISM OF PLANNER MACHINE



Types of planer

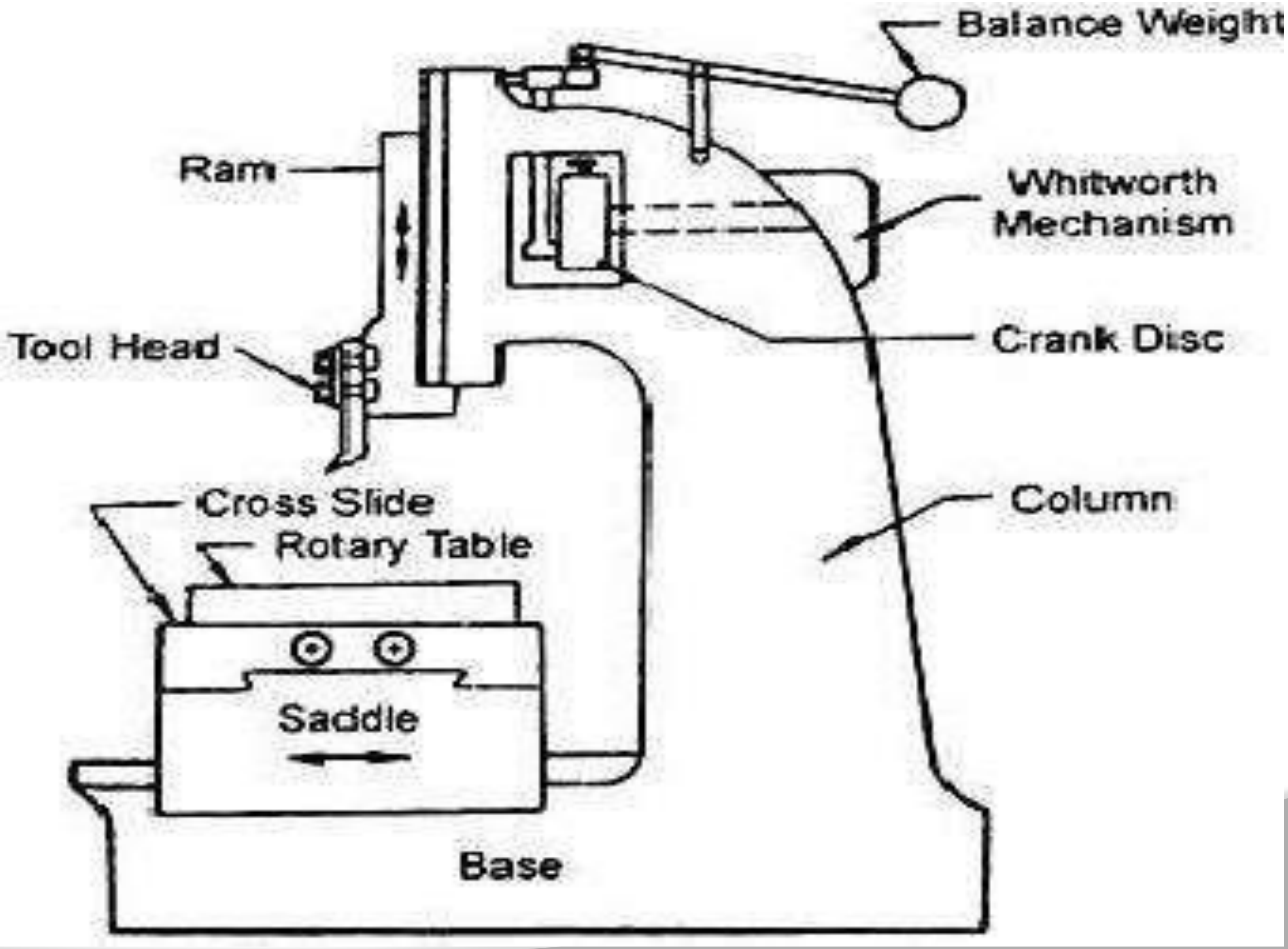
The different types of planer which are most commonly used are:

- Standard or double housing planer.
- Open side planer.
- Pit planer.
- Edge or plate planer.
- Divided or latching table planer.

Shaper	Planer
Tool – Reciprocates W/p - stationary	Work piece – Reciprocates Tool - stationary
Feed is given to the w/p	Feed is given to the tool
W/p is directly clamped on the table or in vice or chuck	W/p is directly clamped to the table
small size of jobs	Large size of jobs
It unable to take deep cuts and heavy feed	It able to take deep cuts and heavy feed
Generally one tool is used	Multiple tooling is used
Work setting is very easy and quick	Work setting requires much skill and takes a long time
It requires less floor area	It requires more floor area
Light, small and less cost machine	Heavier, larger and costlier machine

Slotting Machine

- Slotter can simply be considered as vertical shaper where the single point (straight or formed) cutting tool reciprocates vertically
- the work piece, being mounted on the table, is given slow longitudinal and / or rotary feed.
- The slotter is used for cutting grooves, keyways, internal and external gears and slots of various shapes.
- The slotter was first developed in the year 1800 by Brunel.


Balance Weight
Ram
Whitworth Mechanism
Crank Disc
Tool Head
Cross Slide
Rotary Table
Column
Saddle
Base

Slotting Machine

Construction: The slotter can be considered as a vertical shaper and its main parts are:

1. Base, column and table
2. Ram and tool head assembly
3. Saddle and cross slide
4. Ram drive mechanism and feed mechanism.

Types of slotter

The different types of slotter which are most commonly used are:

- Puncher slotter.
- Precision slotter.

Puncher slotter

- It is a heavy, rigid machine designed for removal of a large amount of metal from large forging or castings.
- The length of a puncher slotter is sufficiently large.
- It may be as long as 1800 to 2000 mm.
- The ram is usually driven by a spiral pinion meshing with the rack teeth cut on the underside of the ram.
- The pinion is driven by a variable speed reversible electric motor similar to that of a planer.
- The feed is also controlled by electrical gears.

Precision slotter

- It is a lighter machine and is operated at high speeds.
- The machine is designed to take light cuts giving accurate finish.
- Using special jigs, the machine can handle a number of identical works on a production basis.
- The precision machines are also used for general purpose work and are usually fitted with Whit worth quick return mechanism

Shaper	slotter
Shaper is commonly used to make flat surfaces	Slotter is used for cutting groove, keyways and slots on inside and outside surface.
Cutting stroke is horizontal with slower than unused stroke	Cutting stroke is vertical with slower than the unused stroke
cutting tool is move up or down to regulate deepness of the cut	Cutting tool is move horizontally to regulate deepness of cut
Cutting tool move horizontally, up and down through cutting process	Cutting tool move vertically to perform cutting process
Distance of tool move is familiar through stroke adjusting screw	Distance of tool move is familiar through stroke adjusting screw
Work piece is held on a fixed bed to be usually rectangular in shape	Work piece is held on a fixed bed to be usually circular in shape

SHAPER	PLANER	SLOTTER
This is lighter, smaller and cheaper	These are heavier, larger and costlier	lighter, Smaller and Cheaper same like shaper machines
Low machining accuracy	High machining accuracy	Low machining accuracy
The rate of power consumption is low	Power consumption is High	Same as a shaper, The rate of power consumption is low
Not possible to make deep cuts and heavy feeds	Possible to make deep cuts and heavy feeds	In Slotter, Not Possible to take deep cuts and heavy feeds
Intended for small Jobs	This is intended for large Jobs	This is intended for small Jobs
It Requires Less Floor Space	It Requires Large Floor Space	Whereas It Requires Less Floor Space
In Shaper, The tool is moving and work is Stationary	The tool is Stationary and work is moving	Same as shaper, The tool is moving and work is Stationary

SHAPER	PLANER	SLOTTER
Usually, only one tool is used on a shaper	Multiple tooling permits machining of more than one surface at a time.	Only one tool is used for machining
Tools used are Lighter and Smaller	Heavier, Stronger and Larger	Tools used are Lighter and Smaller
Work Setting requires less Skill and less time	Requires more skill and more time	Work Setting requires less Skill and less time

UNIT - III

MACHINE TOOL-II

UNIT-III SYLLABUS

- Milling machines – Types – Principal parts – Milling mechanism
- Work holding devices – Milling machine attachments
- Types of milling cutters – Elements of plain milling cutters
- Nomenclature - Cutting forces in milling – Milling cutter materials
- Up milling, down milling and face milling operations
- Drilling Machines – Types – Work holding devices
- Tool holding devices – Drill machine operations
- Drilling machine tools – Twist drill nomenclature-cutting forces in drilling
- Calculation of machining time

UNIT-III

At the end of the course students are able to :

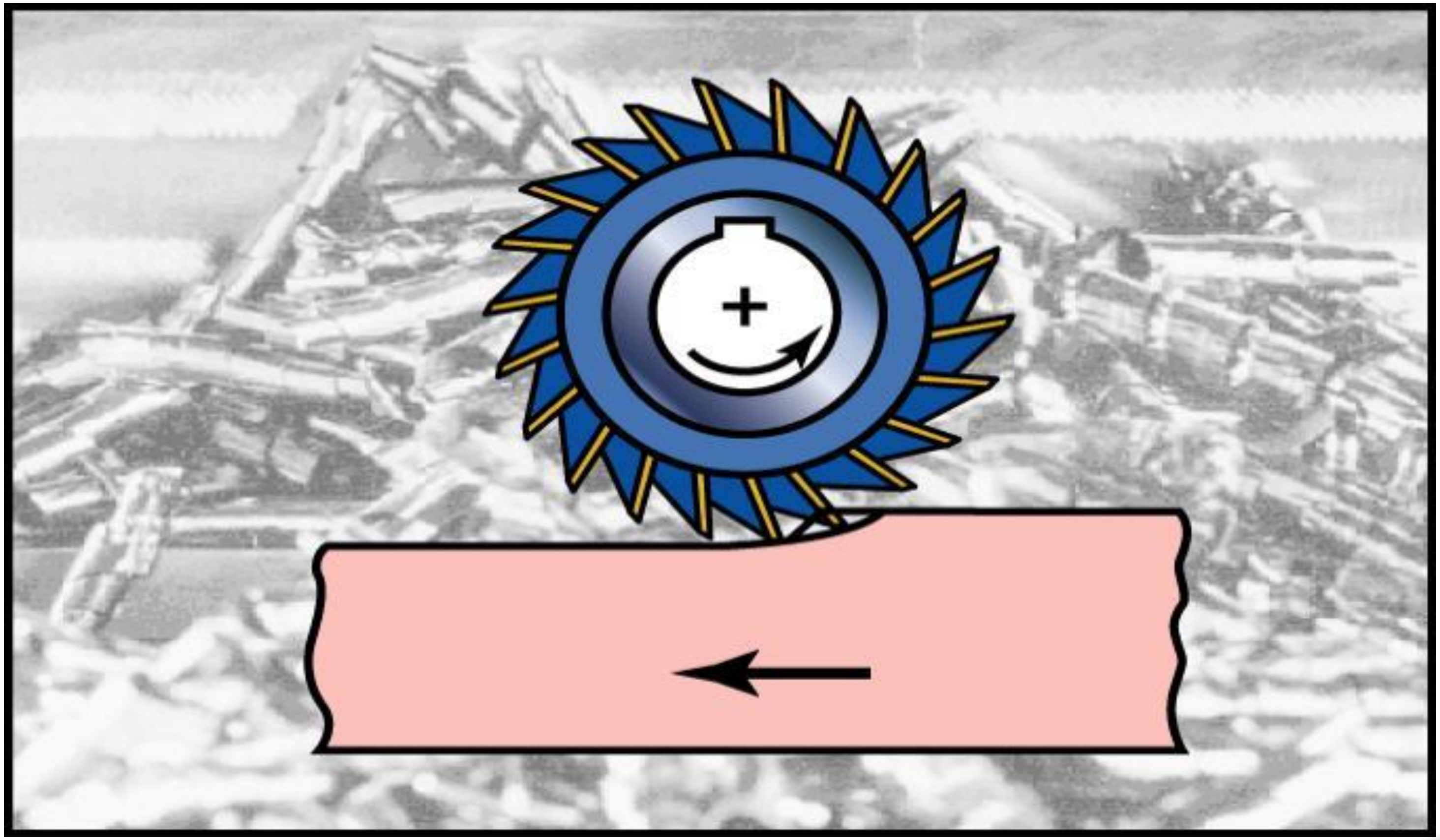
Course Outcomes		Knowledge Level (Bloom's Taxonomy)
CO 6	**Identify** most significant process parameters in machine tool for optimal machining	**Remember (L1)**
CO 7	**Explain** the working principles of Milling, drilling and surface grinding machines for manufacturing the components of their requirement	**Understand (L2)**
CO 8	**Estimate** machining times for machining operations at specified levels of cutting parameters of machine tools	**Apply (L3)**

UNIT-III

Program Outcomes (POs)		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE / Quiz / AAT
PO 2	**Problem Analysis:** An ability to analyze complex engineering problems to arrive at a relevant conclusion using knowledge of mathematics, science and engineering.	1	CIE / Quiz / AAT

Milling

Machining Processes Used to Produce Various Shapes: Milling



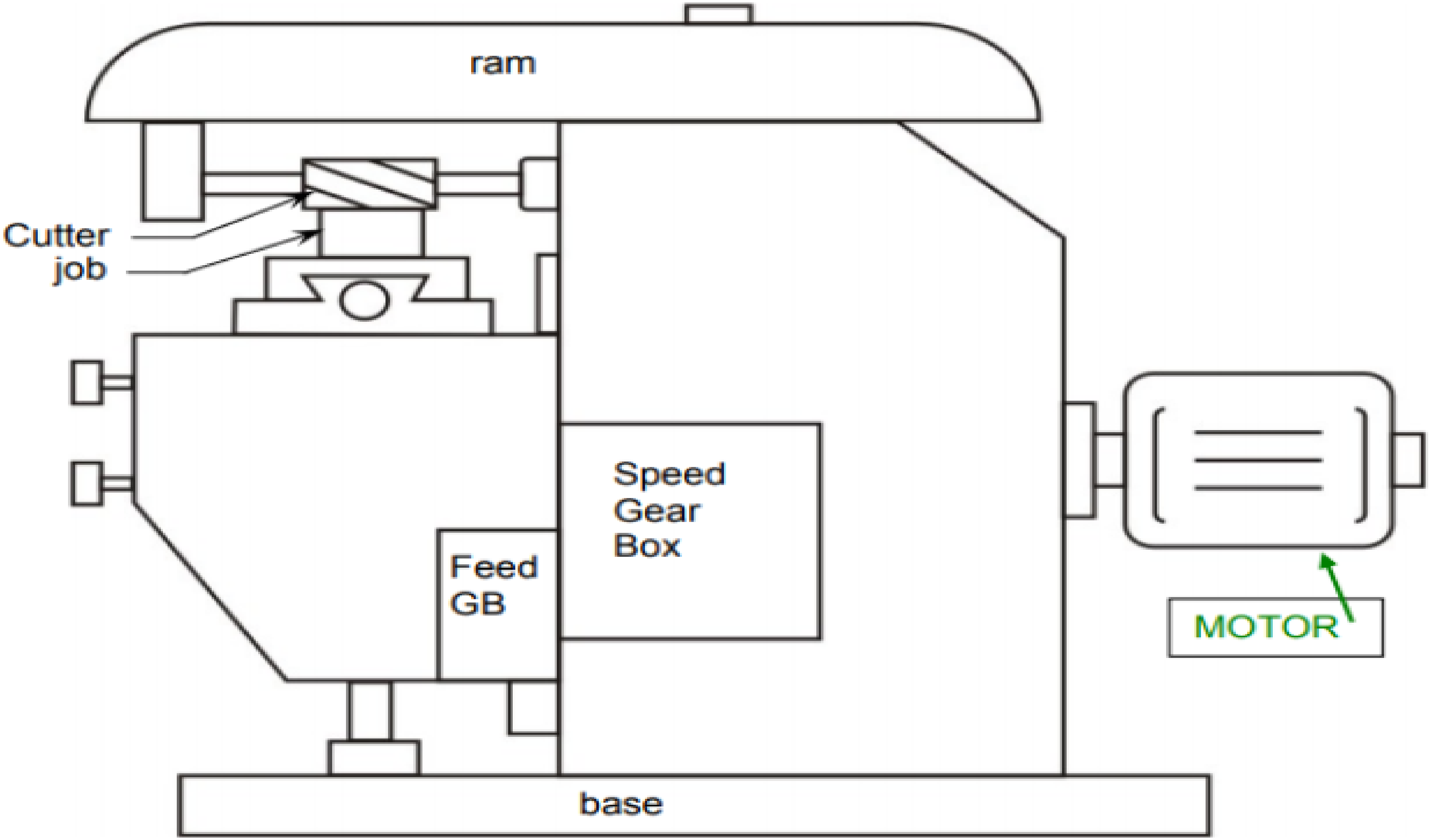
Milling and Milling Machines, Milling operations

Milling:

- a process in which a rotating multi-tooth cutter removes material while traveling along various axes with respect to the work-piece.
- Figure shows basic types of milling cutters & milling operations
- In peripheral milling (also called plain milling), the axis of cutter rotation is parallel to the work-piece surface.
- When the cutter is longer than the width of the cut, the process is called slab milling

Milling Machine

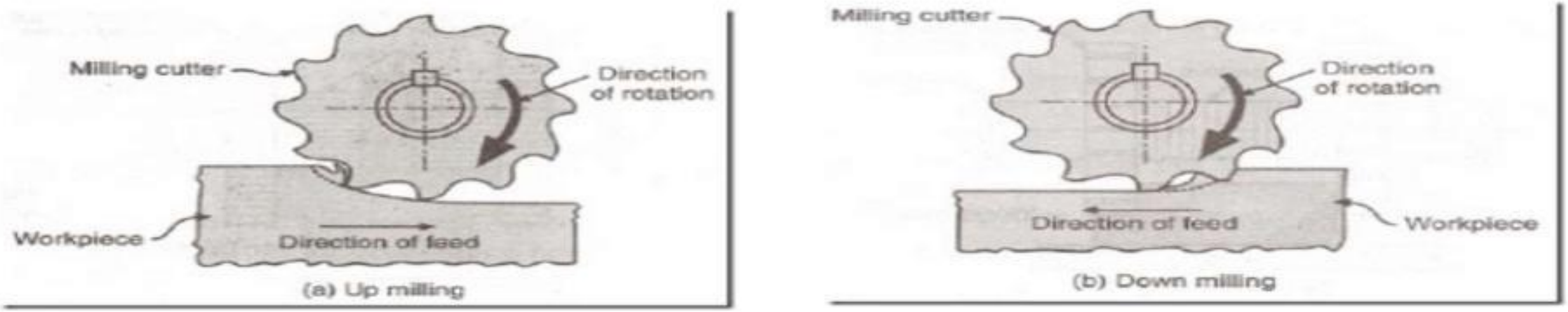
Schematic view of a milling machine



Milling Machine

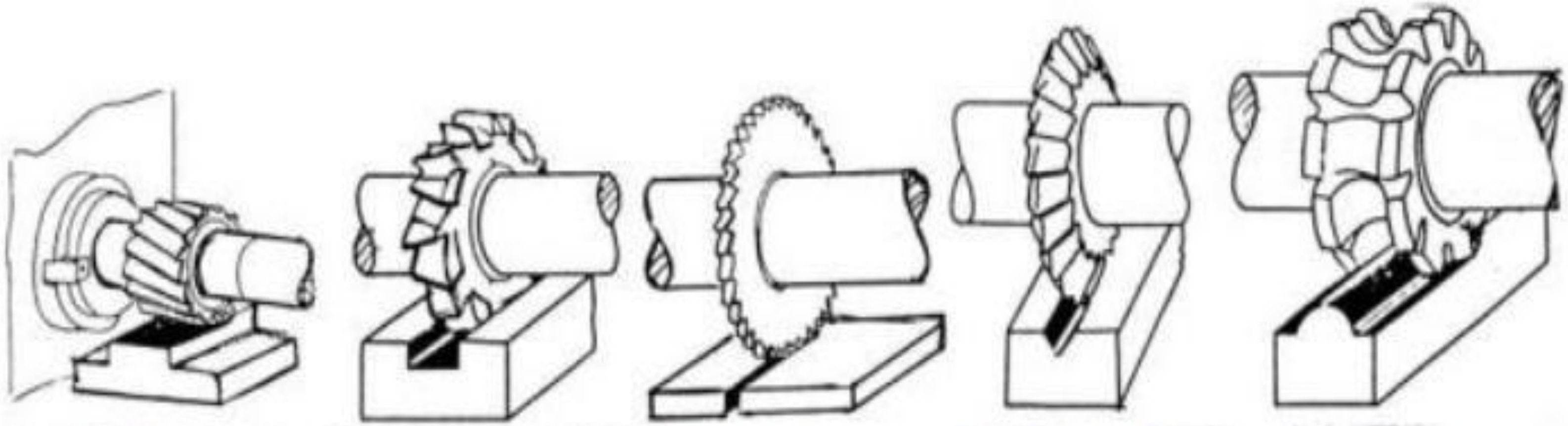
- **Milling arbour** : to hold and rotate the cutter
- **Ram**: to support the arbour
- **Machine table** : on which job and job holding devices are mounted to provide the feed motions to the job.
- **Power drive with Speed and gear boxes** : to provide power and motions to the tool work
- **Bed** : which moves vertically upward and downward and accommodates the various drive mechanisms
- **Column with base** : main structural body to support other parts.

PRINCIPLE OF MILLING



Milling machines can do several operations like
o making flat surfaces
o grooving, slitting and parting
o helical grooving
o forming 2D and 3 D contoured surfaces

Some common milling operation



surfacing slotting slitting grooving forming

Classifications of Milling Machines

TYPES OF MILLING MACHINE

Milling machines are broadly classified as follows:

Column and knee type

- Hand milling machine.
- Universal milling machine.
- Omniversal milling machine.
- Vertical milling machine.

Manufacturing or bed type

- Simplex milling machine.
- Duplex milling machine.
- Triplex milling machine.
- Plain or horizontal milling machine.

Planer type Special type

- Drum milling machine.
- Rotary table milling machine.
- Profile milling machine.
- Pantograph milling machine.
- Planetary milling machine.

Horizontal Milling Machines

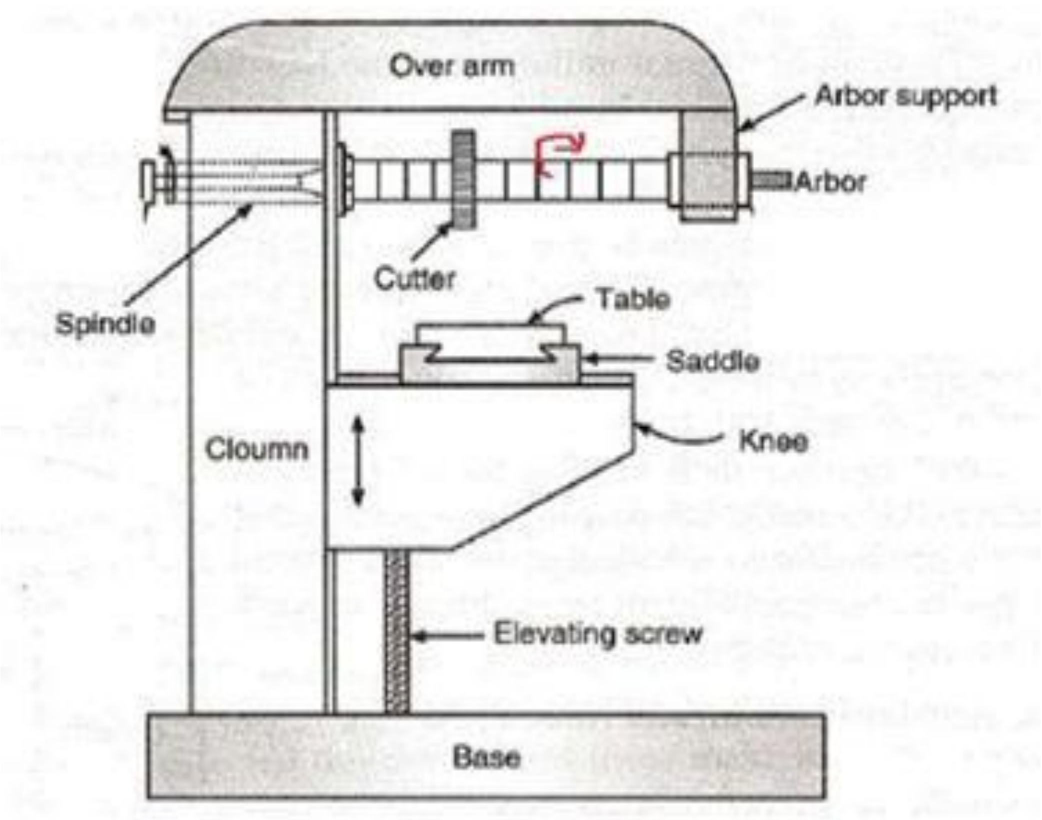
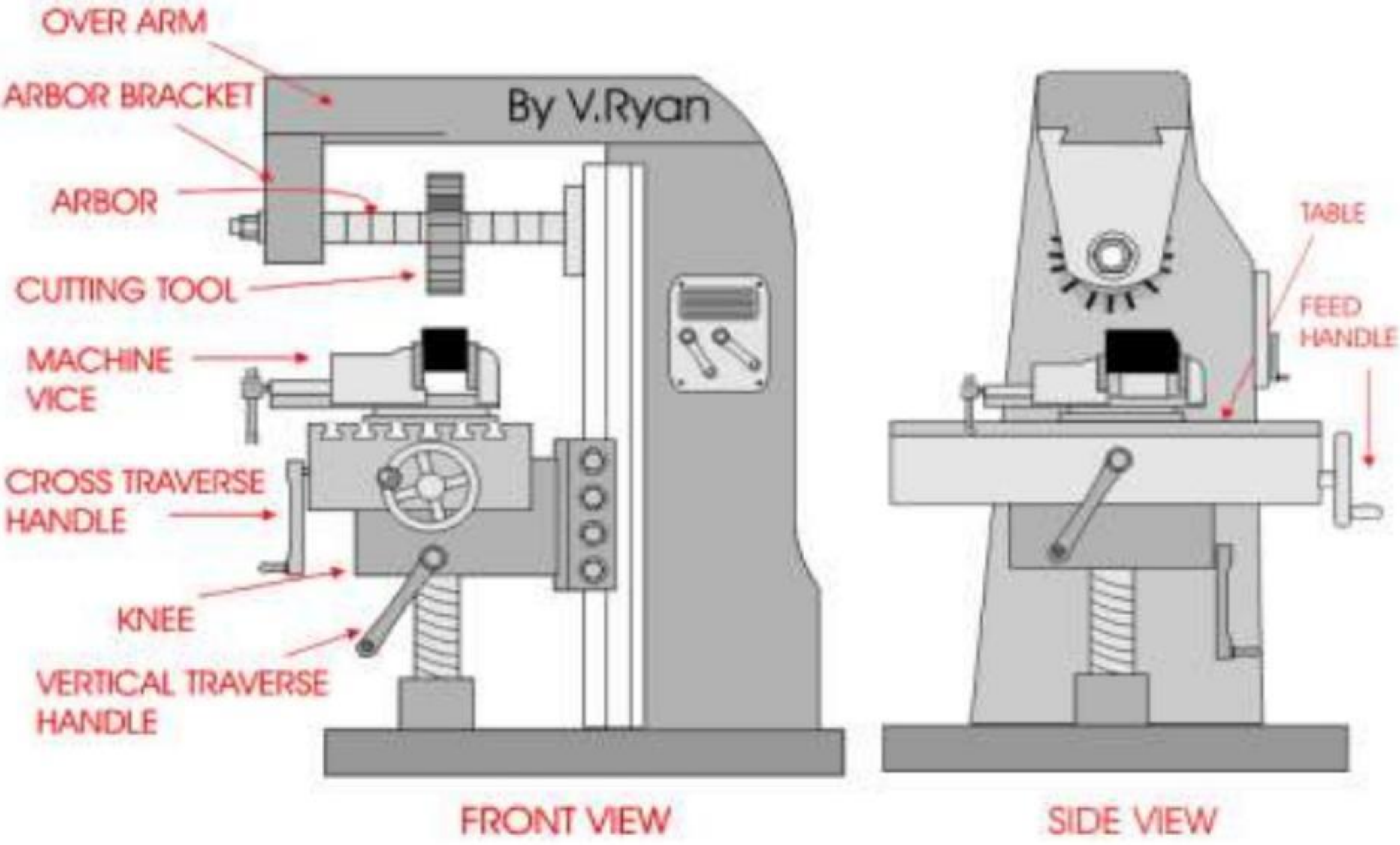


FIG. HORIZONTAL MILLING MACHINE

Major Parts:

1. Base
2. Column
3.Spindle
4. Over arm
5. Knee
6. Saddle
7.Work Table


OVER ARM
ARBOR BRACKET
ARBOR
CUTTING TOOL
MACHINE VICE
CROSS TRAVERSE HANDLE
KNEE
VERTICAL TRAVERSE HANDLE
By V.Ryan
TABLE
FEED HANDLE
FRONT VIEW
SIDE VIEW

VERTICAL MILLING MACHINE

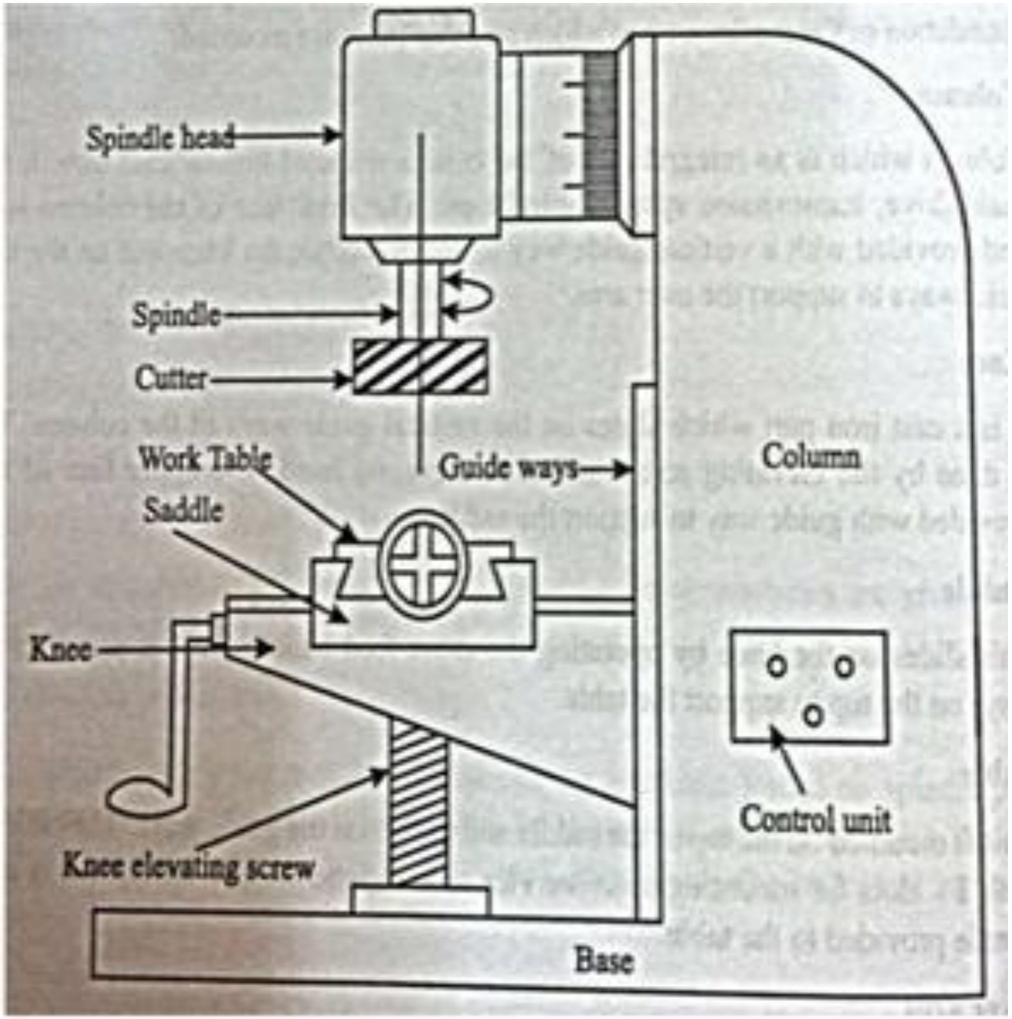


FIG. VERTICAL MILLING MACHINE

Major Parts:

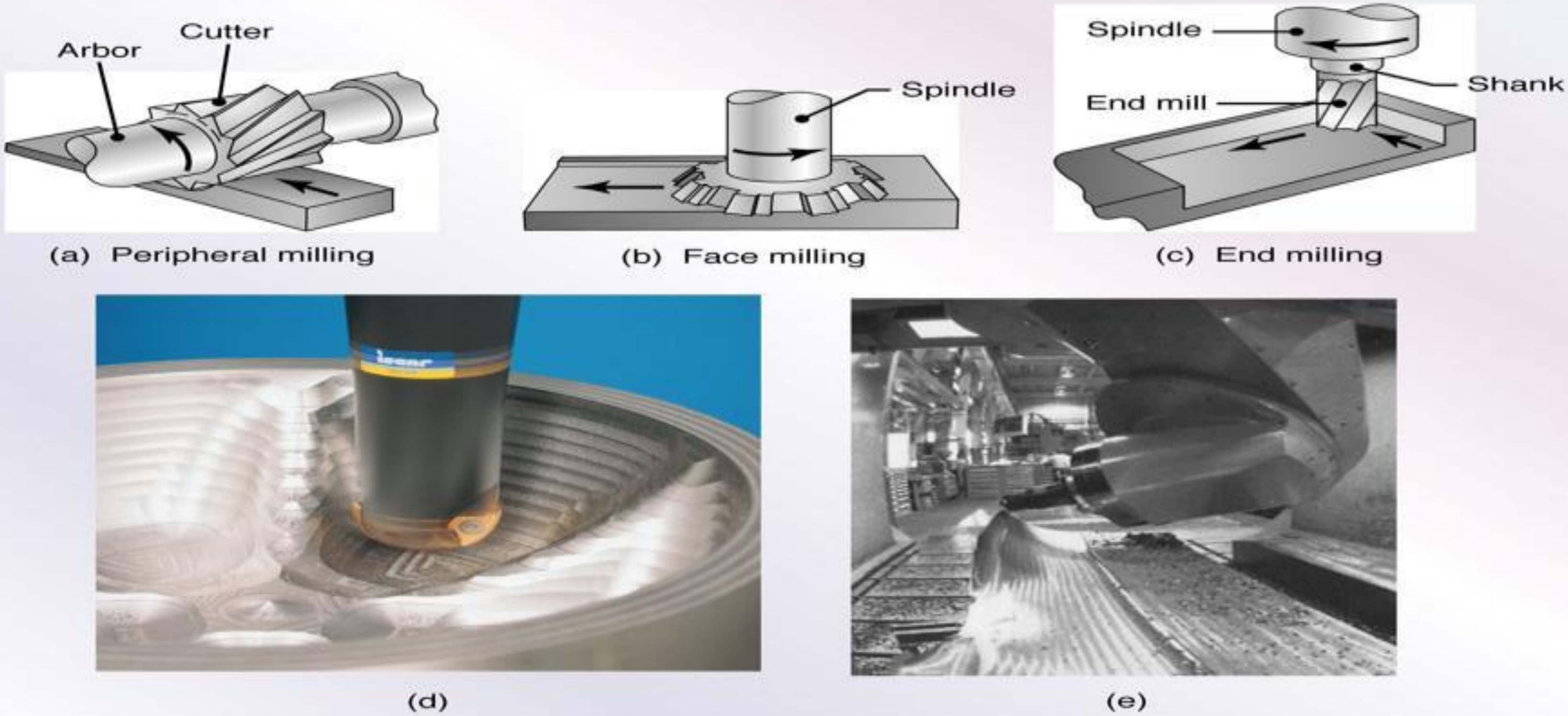
1. Base
2. Column
3. Spindle
4. Spindle Head
5. Knee
6. Saddle
7. Work Table

Horizontal Milling Machine	Vertical Milling Machine
A Cutter is mounted on the arbor.	Here instead of an arbor, the cutter is mounted directly on the spindle.
In the Horizontal Milling machine, a cutter is fixed not move up and down.	But here the cutter moves up and down.
The spindle is horizontal and parallel to the work table.	The spindle is vertical and it is perpendicular to the worktable.
The spindle can not be tilted in this machine so angular cutting operation not possible	Here spindle can be tilted so angular cutting operation is possible.
The operation like Plain, Gear, Straddle, Gang Milling operation are performed.	The operation like T slot, angular, Flat, Slot Milling operation are performed.
The price of the machine is high.	The price of this machine is low
Chances of getting a poor surface finish are not possible.	we can get a poor surface finish here.
The working capacity is high	The working capacity of this machine is low
Machines require a larger area	Machines require a Smaller area

Milling Operations:

1. Plain or slab milling
2. Face milling
3. End milling
4. Slot milling
5. Angular milling
6. Form milling
7. Straddle milling
8. Gang milling
9. Slitting or saw milling
10. Gear cutting

Milling Cutters and Milling Operations



(a) Peripheral milling (b) Face milling (c) End milling

(d) (e)

Figure 24.2 Some basic types of milling cutters and milling operations. (a) Peripheral milling. (b) Face milling. (c) End milling. (d) Ball-end mill with indexable coated-carbide inserts machining a cavity in a die block. (e) Milling a sculptured surface with an end mill,

Milling Operations

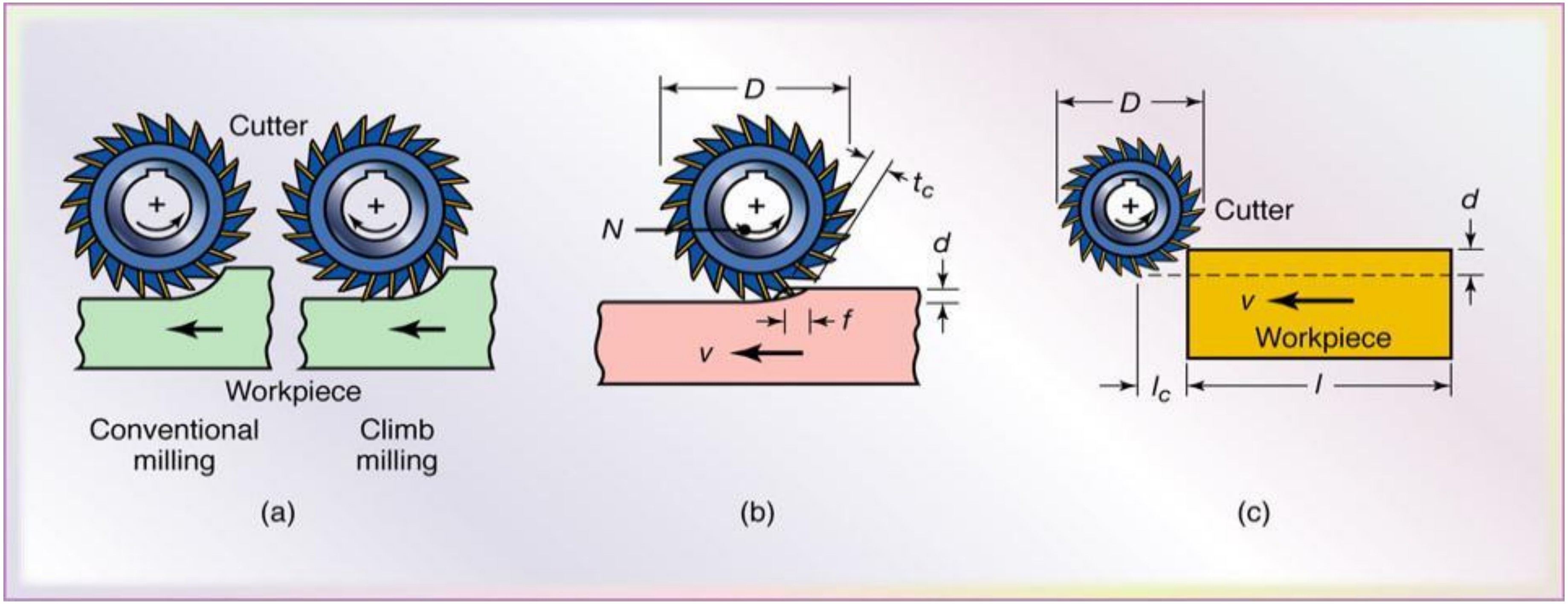


Figure 24.3 (a) Schematic illustration of conventional milling and climb milling. (b) lab-milling operation showing depth-of-cut, *d*; feed per tooth, *f*; chip depth-of-cut, t_c; and workpiece speed, *v*. (c) Schematic illustration of cutter travel distance, l_c, to reach full depth-of-cut.

Milling operations: up milling

Conventional Milling (Up Milling)

- Max chip thickness is at the end of the cut
- Advantage: tooth engagement is not a function of work piece surface characteristics, and contamination or scale on the surface does not affect tool life.
- Cutting process is smooth
- Tendency for the tool to chatter
- The work piece has a tendency to be pulled upward, necessitating proper clamping.

Milling and Milling Machines
Milling operations: Down milling

Climb Milling (Down Milling)

- Cutting starts at the surface of the work piece.
- Downward compression of cutting forces hold work piece in place
- Because of the resulting high impact forces when the teeth engage the work piece, this operation must have a rigid setup, and backlash must be eliminated in the table feed mechanism
- Not suitable for machining work piece having surface scale.

Face-Milling Operation

The cutter is mounted on a spindle whose axis of rotation is perpendicular to work piece surface.

Lc= D/2

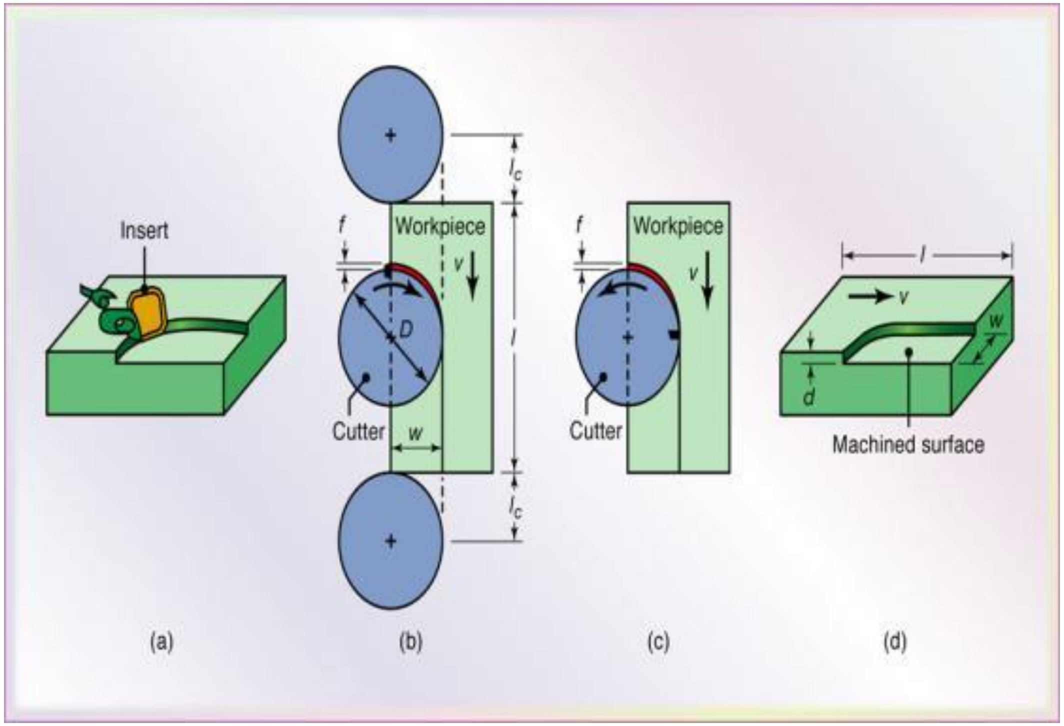


Figure 24.4 Face-milling operation showing (a) action of an insert in face milling; (b) climb milling; (c) conventional milling; (d) dimensions in face milling. The width of cut, *w,* is not necessarily the same as the cutter radius.

Face-Milling Cutter with Indexable Inserts

Figure 24.5 A face-milling cutter with index able inserts.
Source: Courtesy of Ingersoll Cutting Tool Company.

Effect of Insert Shape on Feed Marks on a Face-Milled Surface

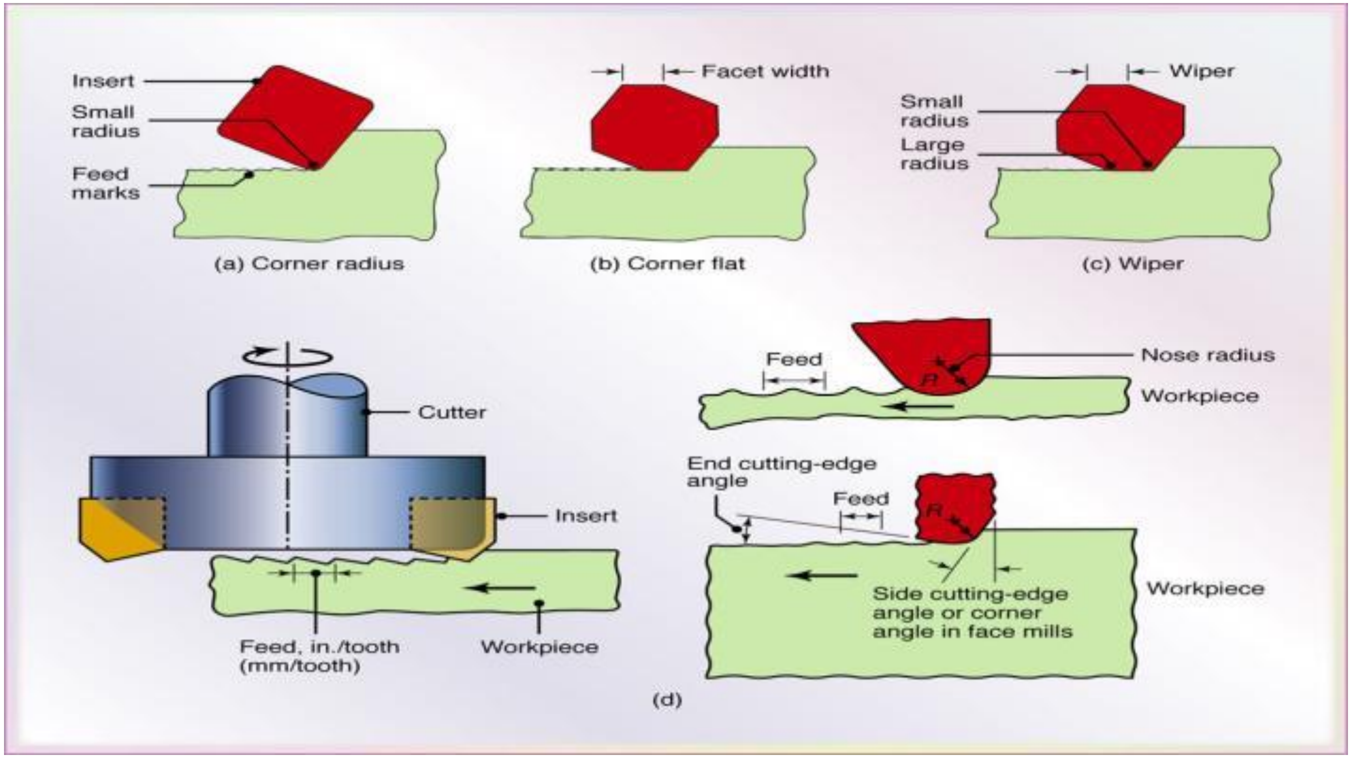


Figure 24.6 Schematic illustration of the effect of insert shape on feed marks on a face-milled surface: (a) small corner radius, (b) corner flat on insert, and (c) wiper, consisting of small radius followed by a large radius which leaves smoother feed marks. (d) Feed marks due to various insert shapes.

Face-Milling Cutter

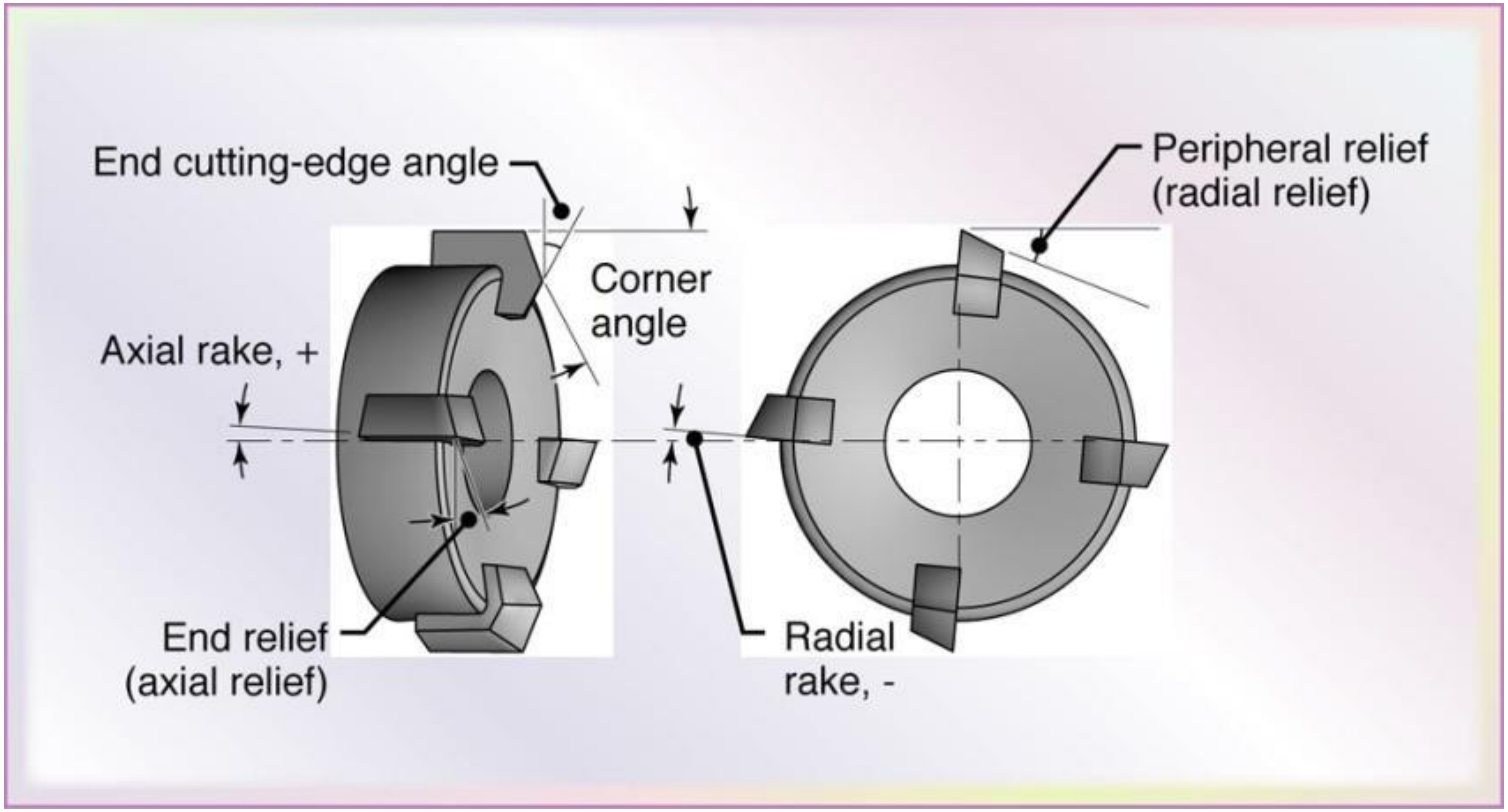


Figure 24.7 Terminology for a face-milling cutter.

Effect of Lead Angle on Un deformed Chip Thickness in Face Milling

- Lead angle of insert has a direct influence on un deformed chip thickness
- As the lead angle increases, un deformed chip thickness decreases, length of contact increases
- Range of lead angles = 0-45
- X-sectional area of un deformed chip remains constant
- As lead angle decreases, there is a smaller vertical force comp (axial force)
- Ratio of cutter diameter, D, to width of cut should be no less than 3:2

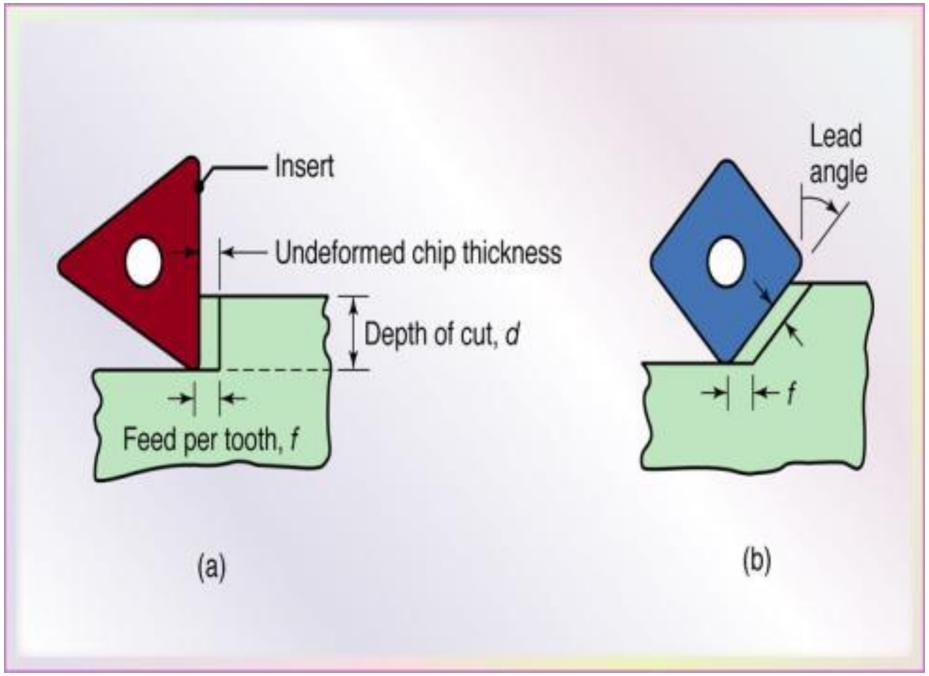


Figure 24.8 The effect of the lead angle on the un deformed chip thickness in face milling. Note that as the lead angle increases, the chip thickness decreases, but the length of contact (i.e., chip width) increases. The edges of the insert must be sufficiently large to accommodate the contact length increase.

Position of Cutter and Insert in Face Milling

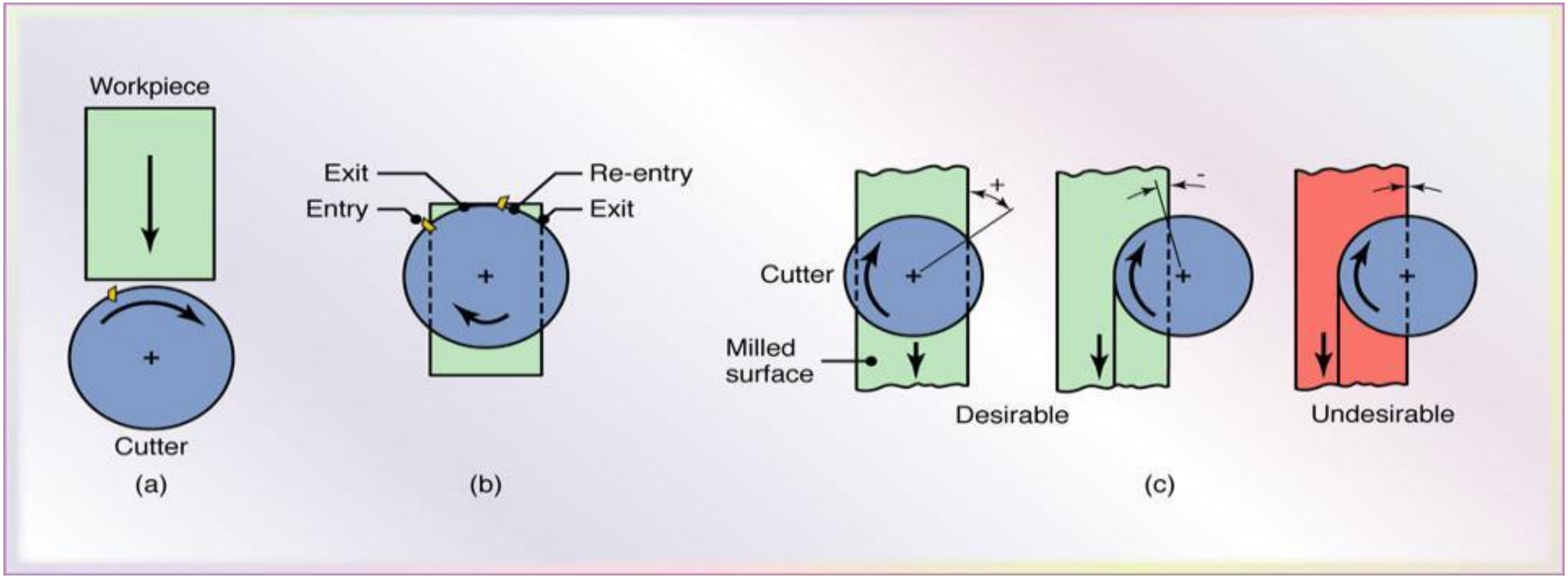


Figure 24.9 (a) Relative position of the cutter and insert as it first engages the work piece in face milling. (b) Insert positions towards the end of cut. (c) Examples of exit angles of insert, showing desirable (positive or negative angle) and undesirable (zero angle) positions. In all figures, the cutter spindle is perpendicular to the page and rotates clockwise.

EXAMPLE 24.2 Material-removal Rate, Power Required, and Cutting Time in Face Milling

T-Slot Cutting and Shell Mill

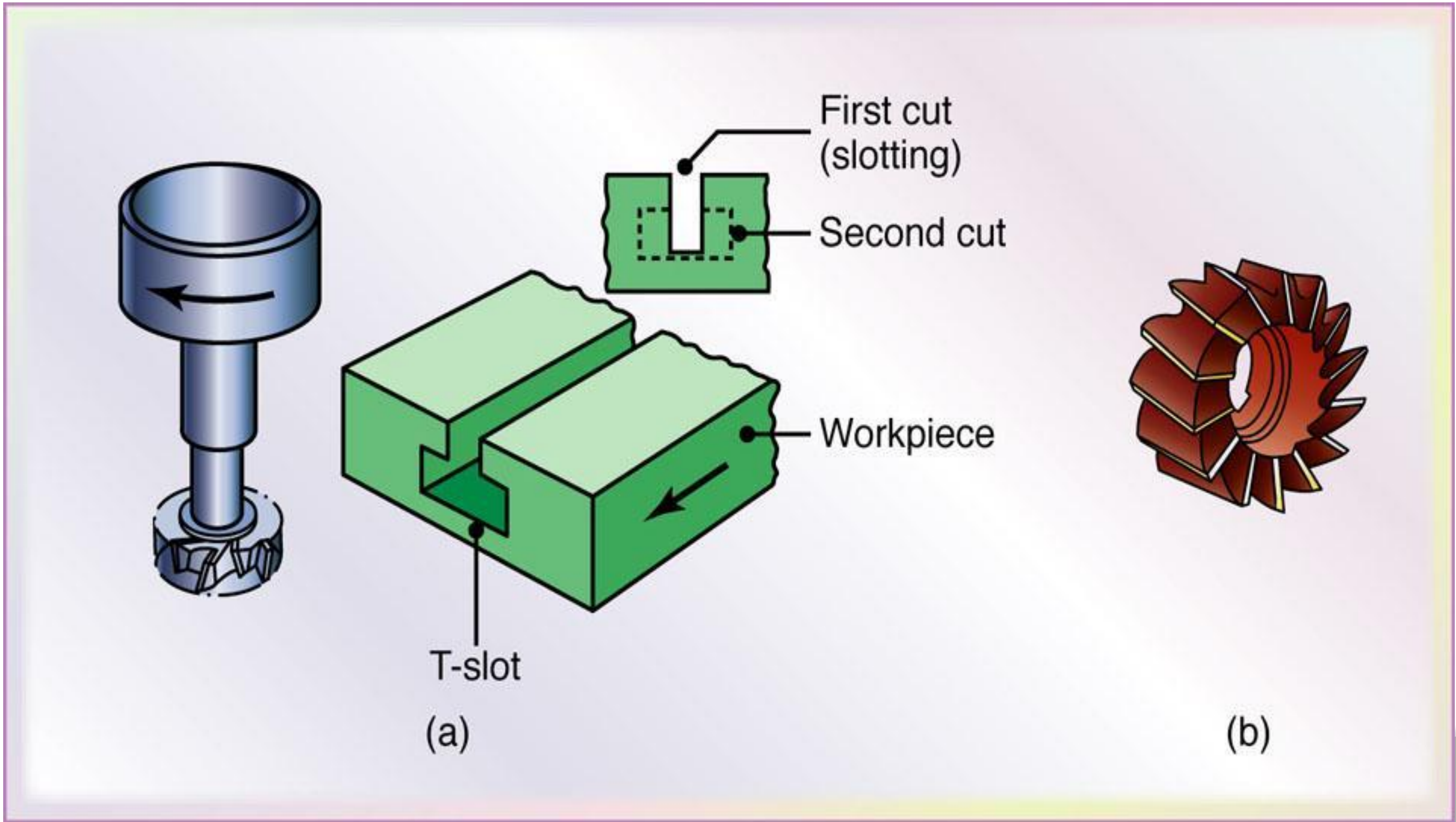
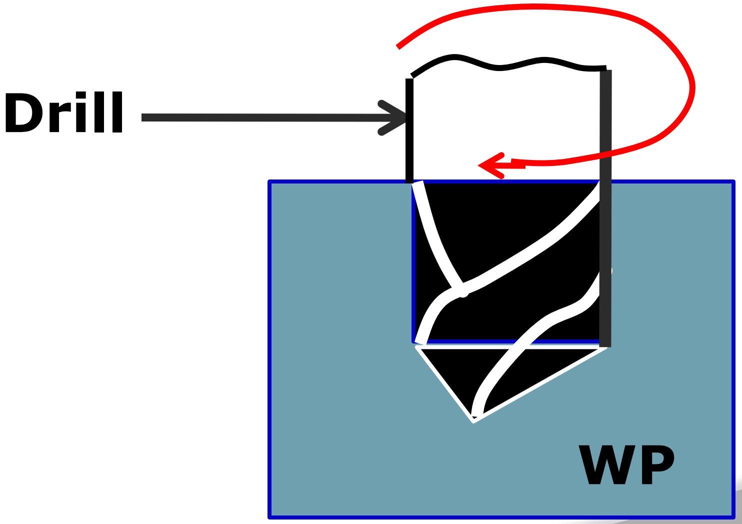


Figure 24.12 (a) T-slot cutting with a milling cutter. (b) A shell mill.

Drilling

- Drilling is the operation of originating a cylindrical hole

- Hole is generated by rotating cutting edges of drill, which exerts large force on the WP to originate a hole.

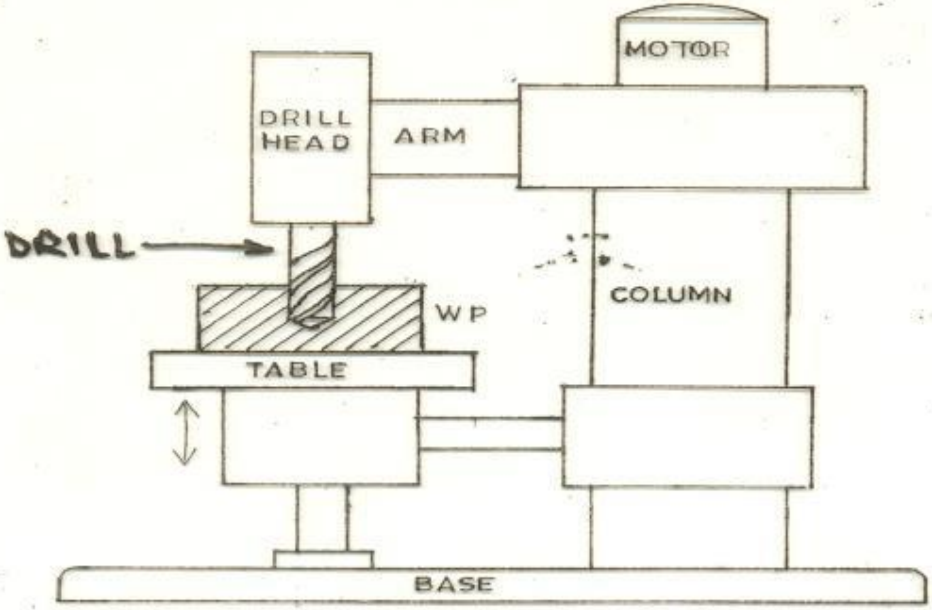


Principle of Drilling Machine

- Drilling is an operation of generating a hole of different diameters by means of rotating cutting tools of different diameters. The tool used for drilling hole is called as drill.
- Similar operations like boring, reaming, counter boring, counter sinking, tapping etc. are also performed with the drilling machine.
- This is done by holding the tools rigidly in the tool holding device know as Chuck. Thus in this machining operation the tool is rotating one while the work piece is stationary one, which rests on the working table.

Types of Drilling Machines

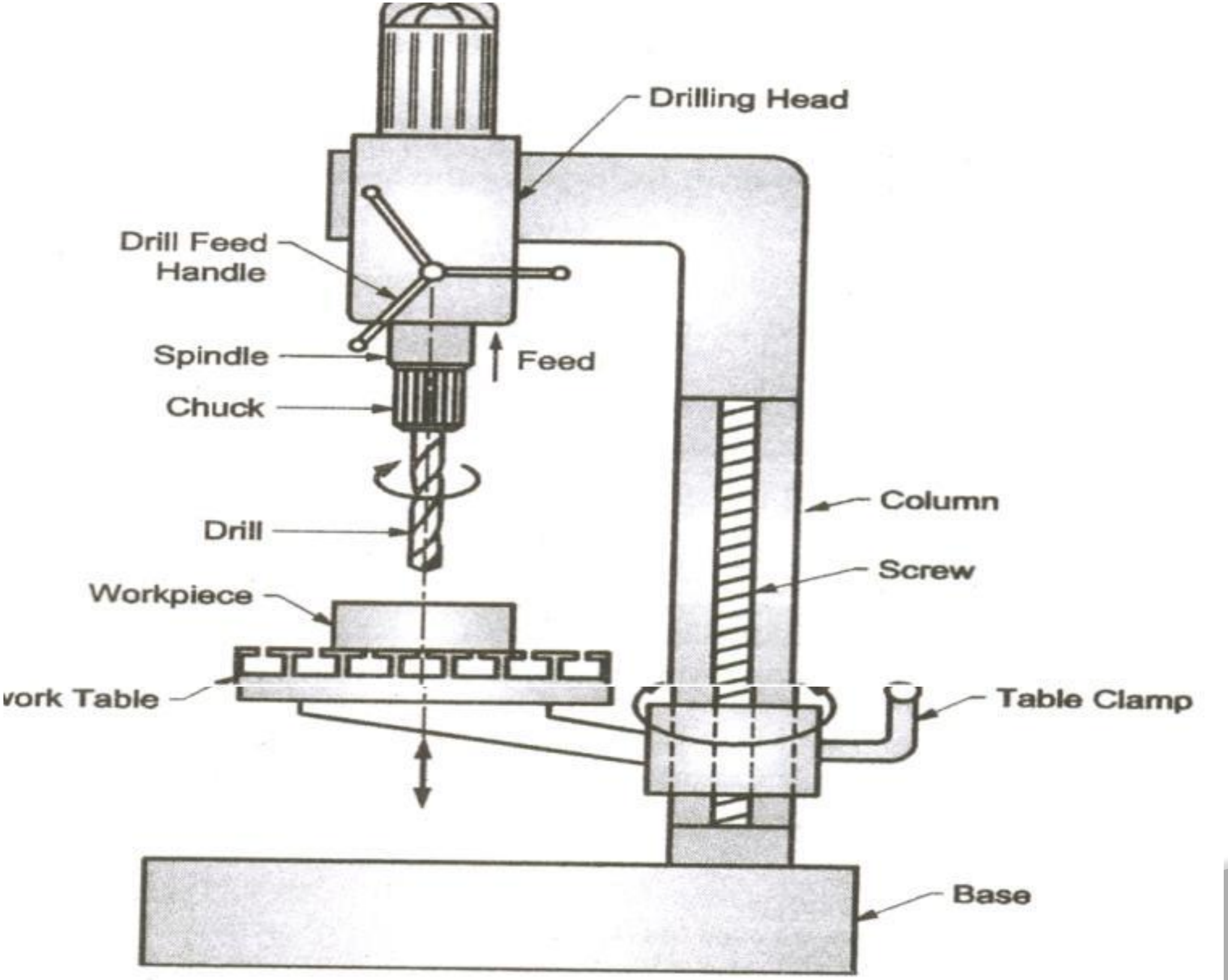
- Portable Drilling Machine
- Sensitive Drilling Machine
- Pillar/Upright Drilling Machine
- Radial Drilling Machine
- Gang Drilling Machine
- Multiple Spindle Drilling Machine
- Automatic Drilling Machine
- Deep Hole Drilling Machine



Drill Machine

Twist Drill

Block Diagram of Drilling Machine



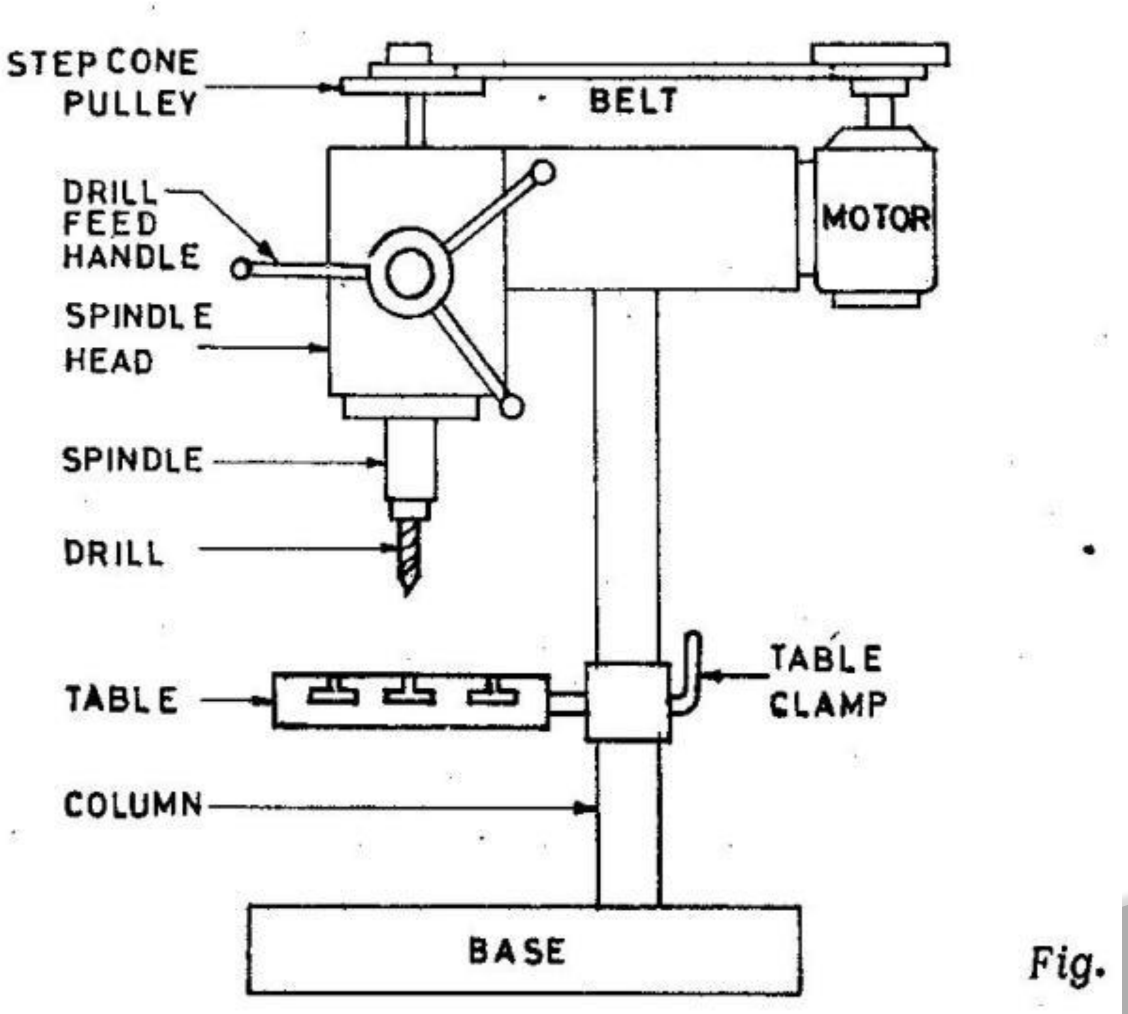
Major Components of Drill Machine

1. **Base –** It is a part of the machine on which the vertical column is mounted.
2. **Column –** It is the vertical member of the drilling machine. It supports table and the head including driving mechanism.
3. **Table –** It is mounted on the column. ‘T’ slots are provided on it to clamp the work piece on it.
4. **Head –** It is mounted on the top of the column. It consists of driving and feeding mechanism for the spindle.
5. **Spindle –**vertical shaft which holds the chuck and drill. Rotary motion of the spindle is given directly to the tool to cut the material from the work piece.
6. **Spindle drive and feed mechanism –** Multiple speeds may be obtained by a step cone pulley drive or by gear. Feed mechanism provided in drilling machine is either by quick reverse hand feed or by sensitive hand feed. The feed movement may be controlled by hand or power.

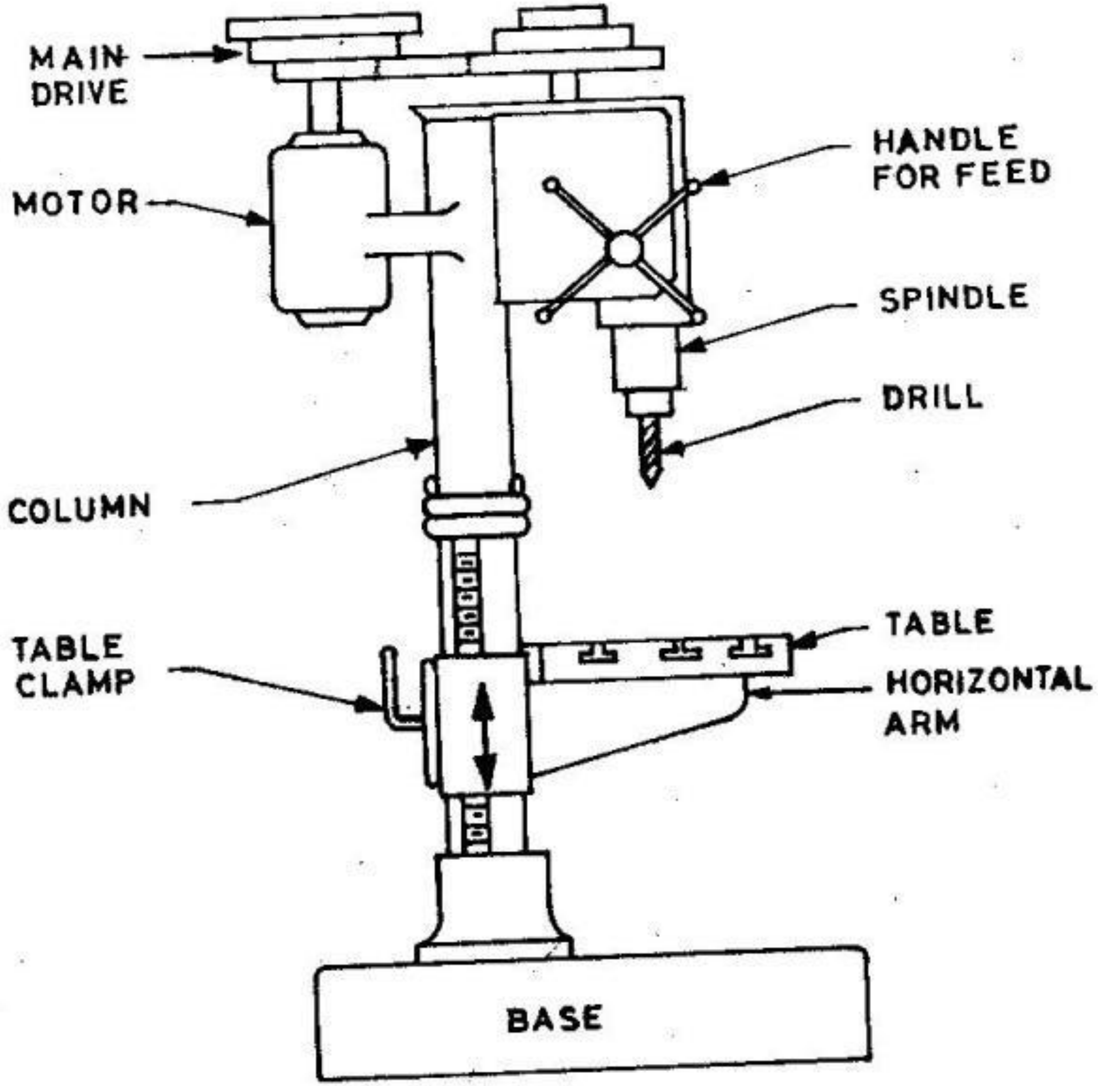
Sensitive Drilling Machine

- Drill holes from 1.5 to 15mm

- Operator senses the cutting action so sensitive drilling machine



Up-Right Drilling Machine

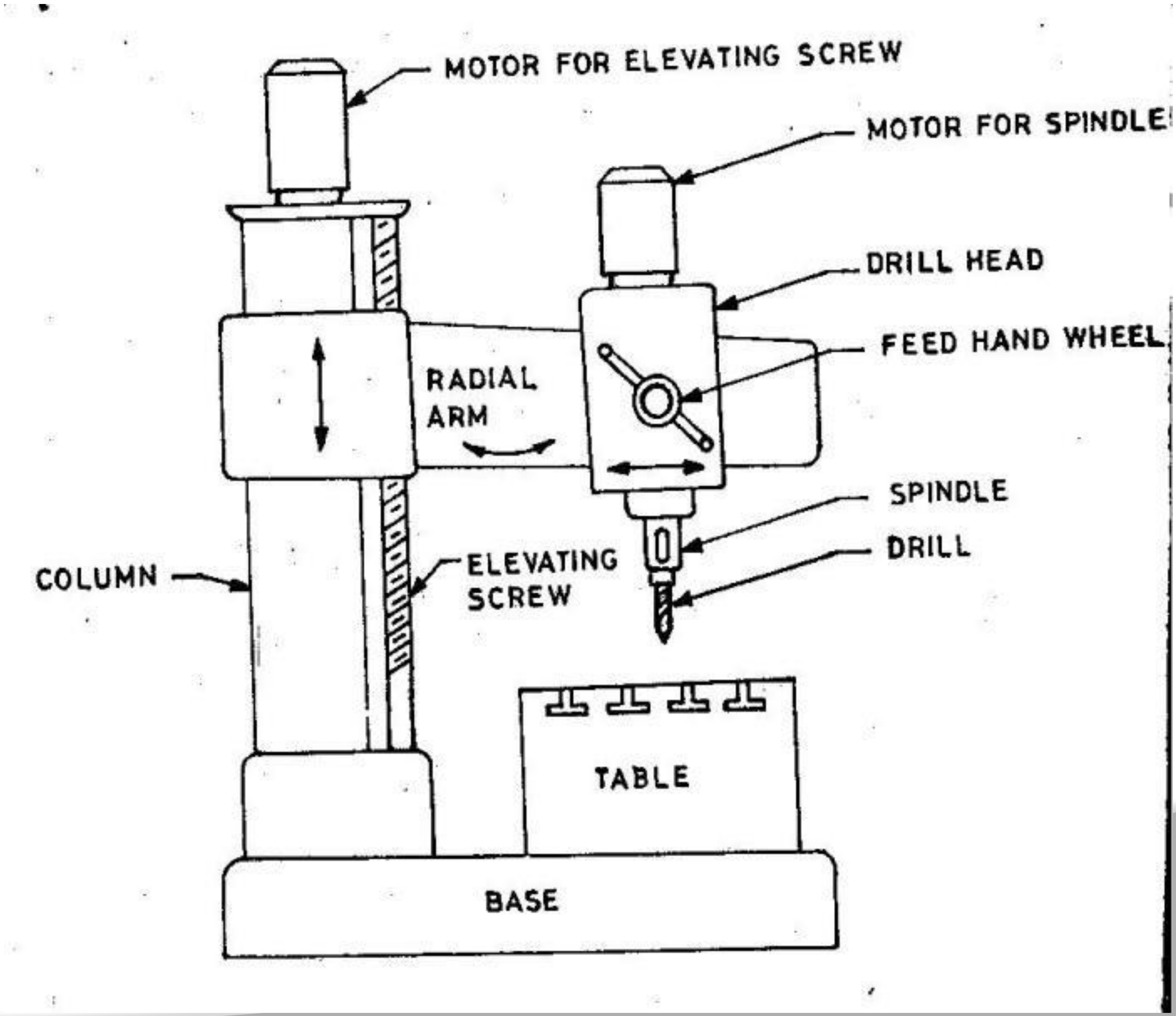


- Drill holes up to 50mm

- Table can move vertically and radially

Radial Drilling Machine

- **It the largest and most versatile used fro drilling medium to large and heavy work pieces.**



UNIT-IV

GEOMETRICAL DIMENSIONING AND TOLERANCES

UNIT-IV SYLLABUS

- Systems of Limits and Fits: Introduction, normal size, tolerance limits, deviations, allowance, fits and their types
- Unilateral and bilateral tolerance system, hole and shaft basis systems, Interchangeability and selective assembly.
- Linear Measurement: Slip gauges, dial indicator, micrometers;
- Measurement of angles and tapers: Bevel protractor, angle slip gauges, spirit levels, sine bar.

UNIT-IV

At the end of the course students are able to :		
	Course Outcomes	Knowledge Level (Bloom's Taxonomy)
C O 9	**Apply** the principles of limits, fits and tolerance while designing and manufacturing the components of their requirement	**Apply (L3)**
CO 10	**Choose** an appropriate measuring instrument for accurate inspection of the dimensional and geometric features of a given component	**Apply (L3)**

UNIT-IV

Program Outcomes (POs)		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE / Quiz / AAT
PO 2	**Problem Analysis:** An ability to analyze complex engineering problems to arrive at a relevant conclusion using knowledge of mathematics, science and engineering.	1	CIE / Quiz / AAT
PO 3	**Design/ development of solutions:** Competence to design a system, component or process to meet societal needs within realistic constraints.	1	Discussion /AAT

Metrology

- Metrology is the science of measurement

- Dimensional metrology is that branch of Metrology which deals with measurement of “dimensions” of a part or workpiece (lengths, angles, etc.)

- Dimensional measurements at the required level of accuracy are the essential link between the designers intent and a delivered product.

LIMITS, FITS & TOLERANCES

Definitions

- **Normal size:** Normal size of part by which it is referred to as a matter of convenience

- **Basic size:** The size with reference to which the limits of size are fixed.

- **Zero line:** It is a straight line corresponding to the basic size.

- **Actual size:** Actual measured dimension of the part

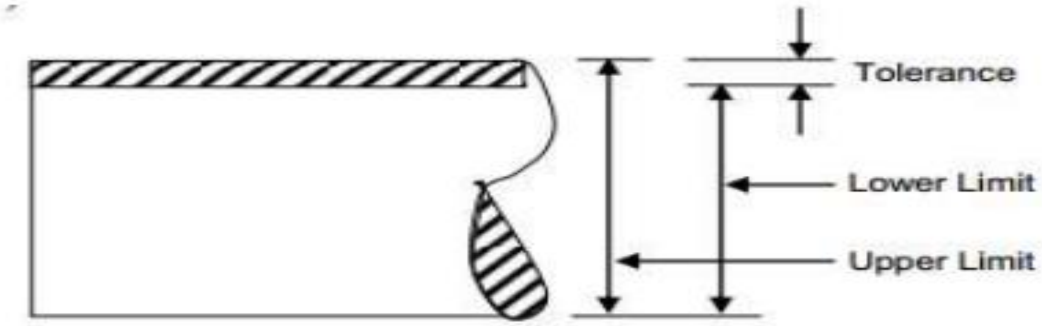
LIMITS

- **The two extreme permissible sizes of a part between which the actual size should lie.**

  (upper limit and lower limit)

  Upper limit: **The greater of the two limits of size.**

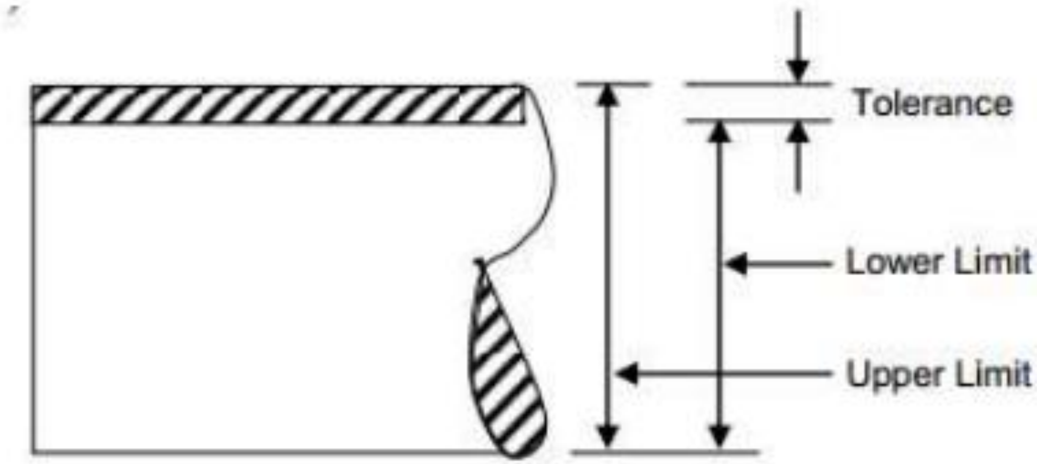
  Lower limit: **The smaller of the two limits of size.**



TOLERANCES

- **It is the difference between the upper and lower limits**

  tolerance = upper limit – lower limit



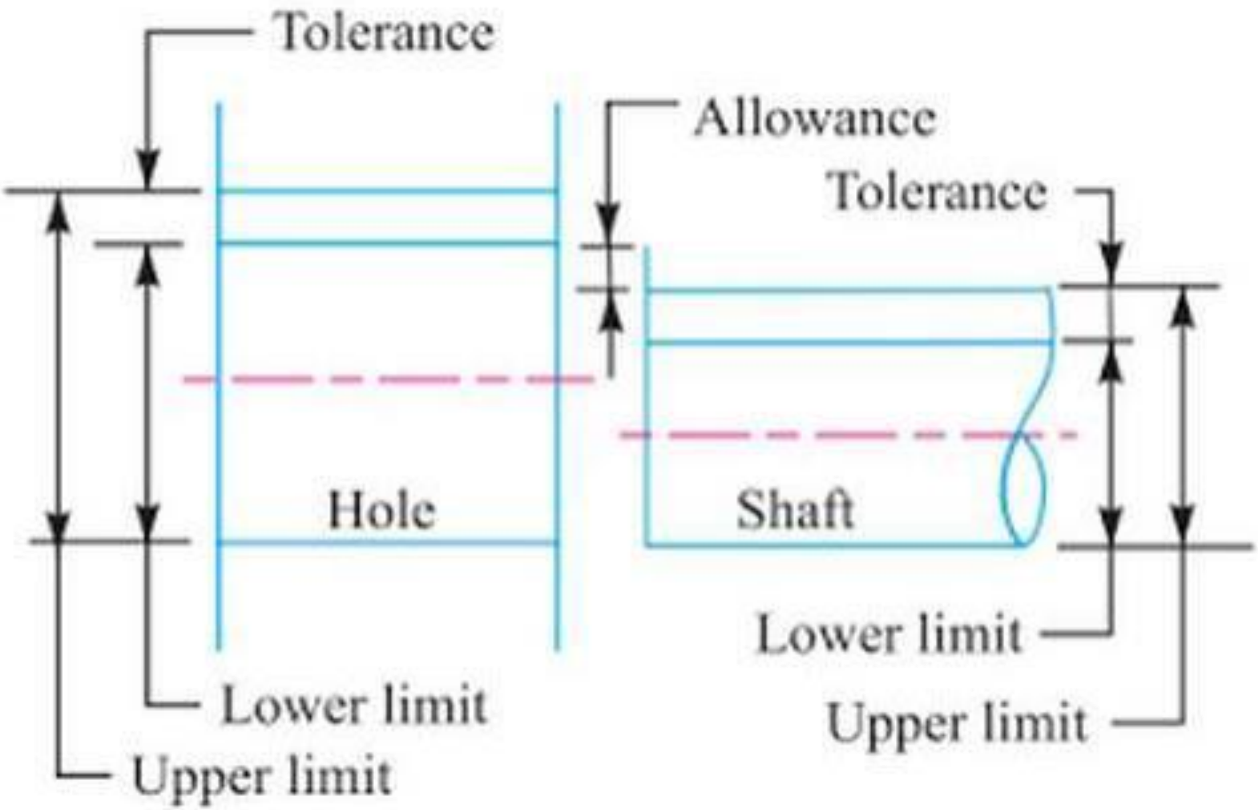
Why it is necessary?

- **It is impossible to manufacture a part or component to an exact size or geometry.**
- **Since variation from the drawing is inevitable, acceptable degree of variation must be applied.**
- **Large variation may affect the functionality of the part.**
- **Small variation may effect the economy of the part.**

ALLOWANCES

- **It is the difference between the basic dimensions of the mating parts**

- **When the shaft size is less than the hole size, then the allowance is positive and when the shaft size is greater than the hole size, then the allowance is negative.**

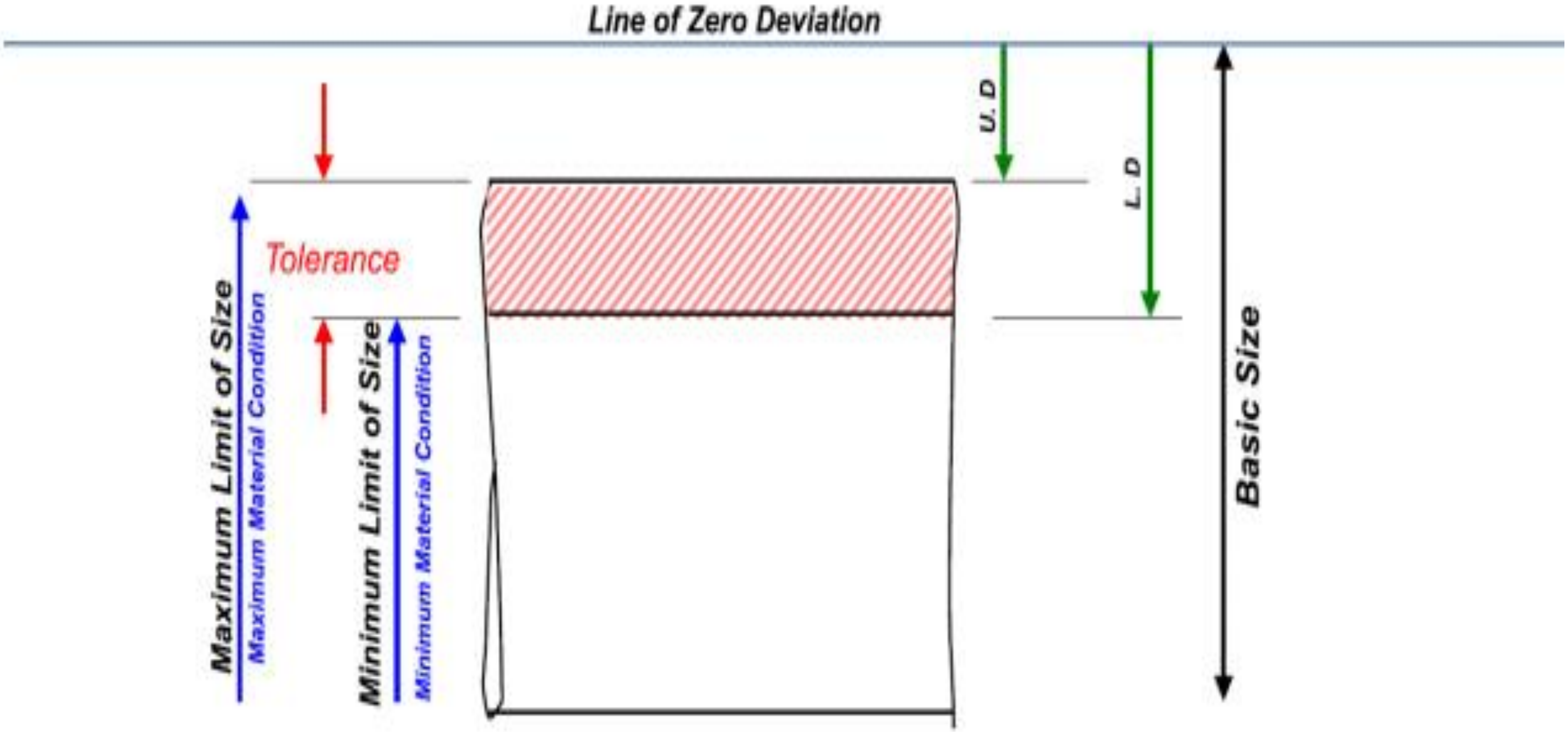

Tolerance
Allowance
Tolerance
Hole
Shaft
Lower limit
Lower limit
Upper limit
Upper limit

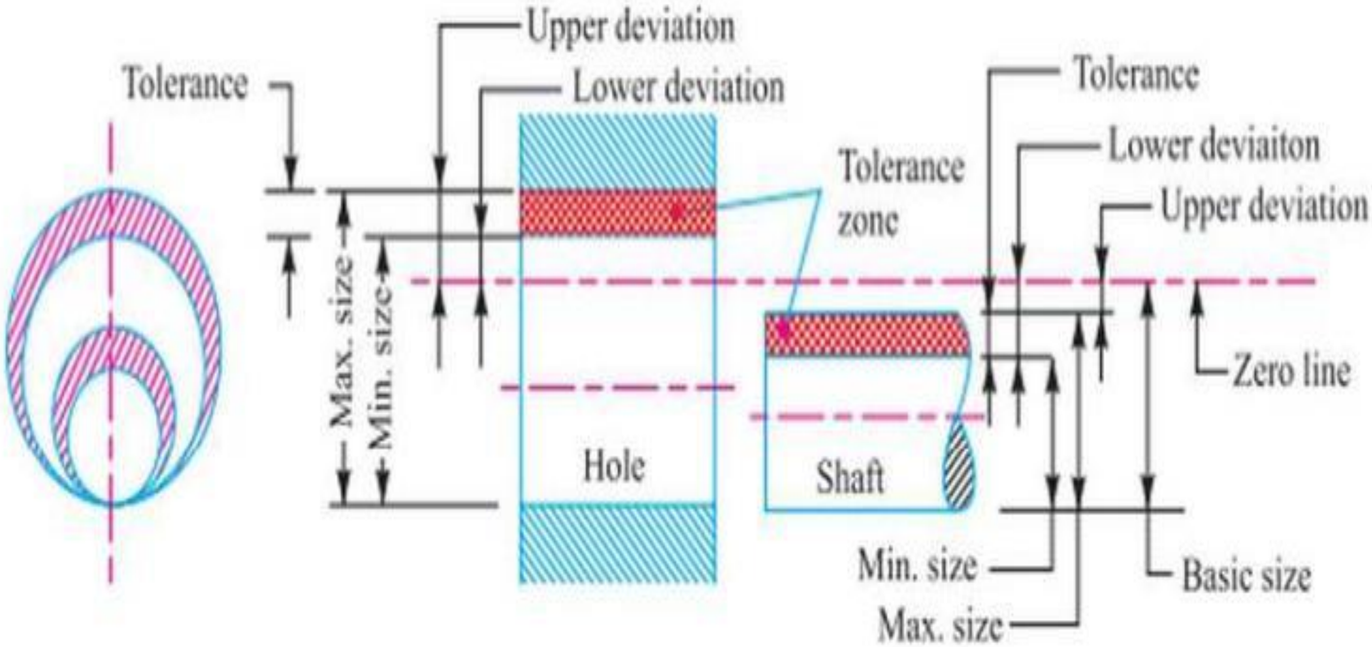
Definitions

- **Tolerance Zone:** **It is the zone between the maximum and minimum limit size.**

- **Upper Deviation:** **It is the algebraic difference between the maximum size and the basic size.**

- **Lower Deviation:** **It is the algebraic difference between the minimum size and the basic size.**


Line of Zero Deviation
Tolerance
Maximum Limit of Size
Maximum Material Condition
Minimum Limit of Size
Minimum Material Condition
U. D
L. D
Basic Size

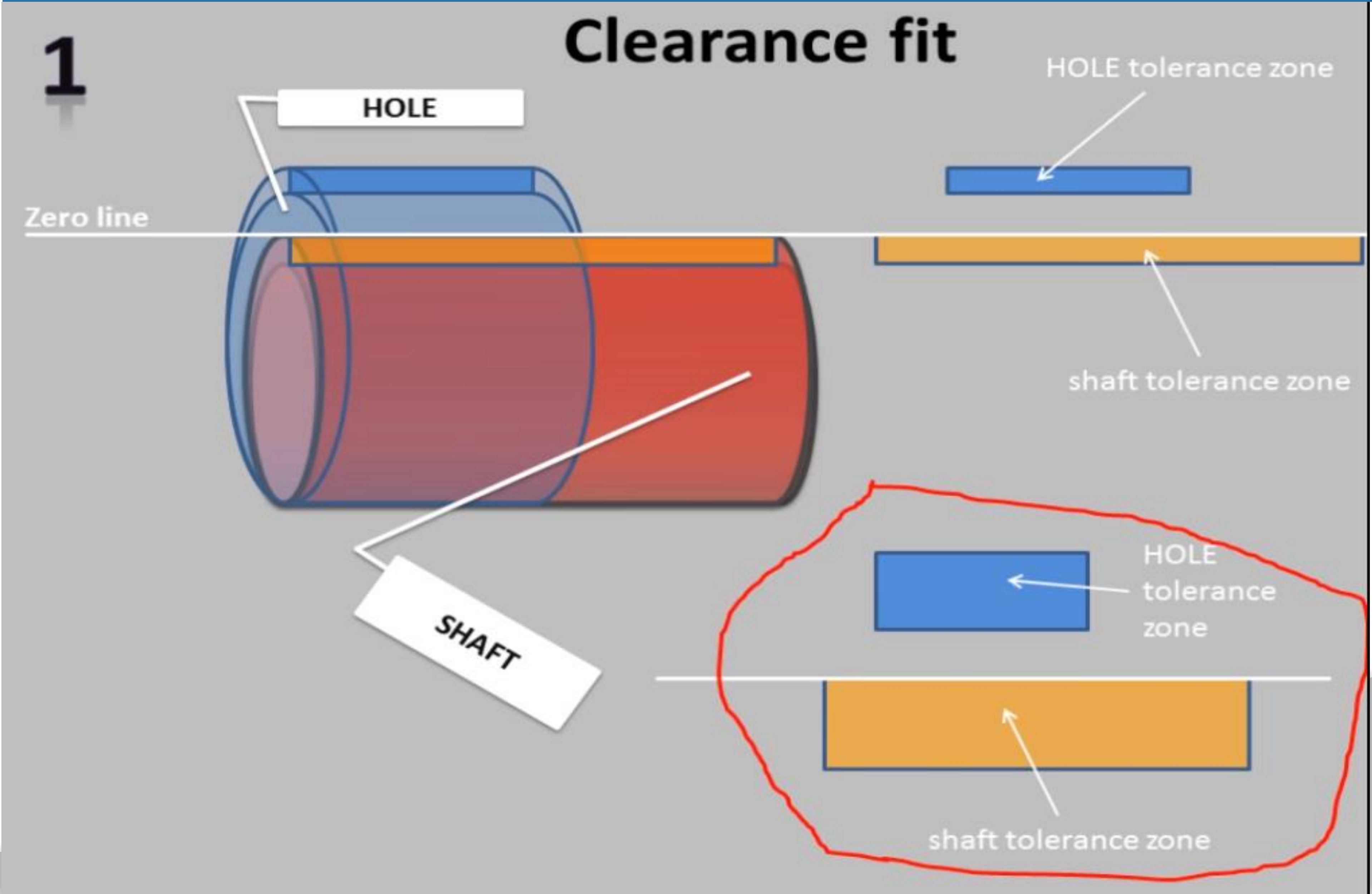

Upper deviation
Lower deviation
Tolerance
Tolerance zone
Tolerance
Lower deviaiton
Upper deviation
Max. size
Min. size
Zero line
Hole
Shaft
Min. size
Max. size
Basic size

FIT

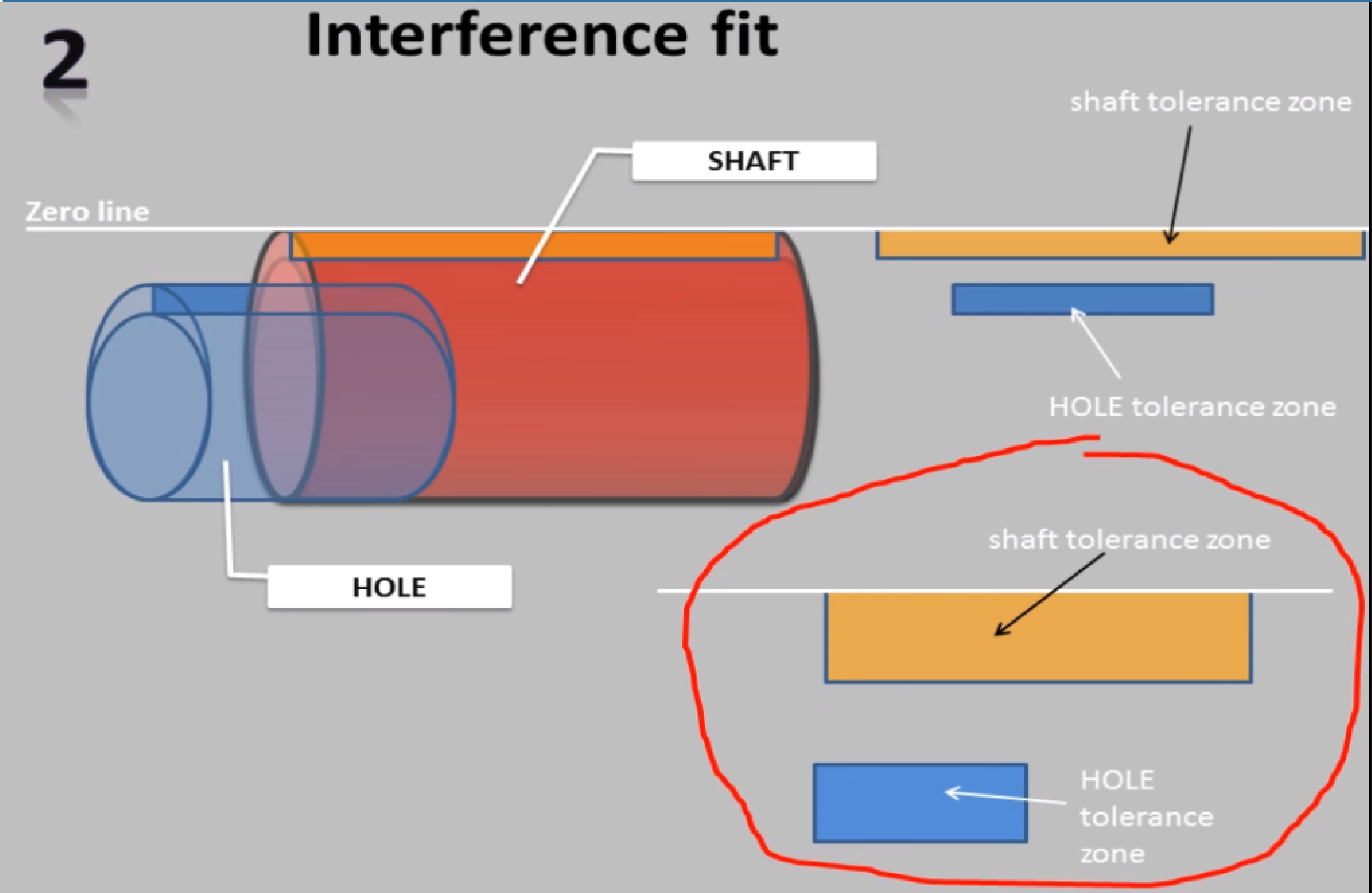
If it is the degree of looseness or tightness between two mating parts to perform a definite function.

1. **Clearance fit**
2. **Transition fit**
3. **Interference fit**

Clearance fit



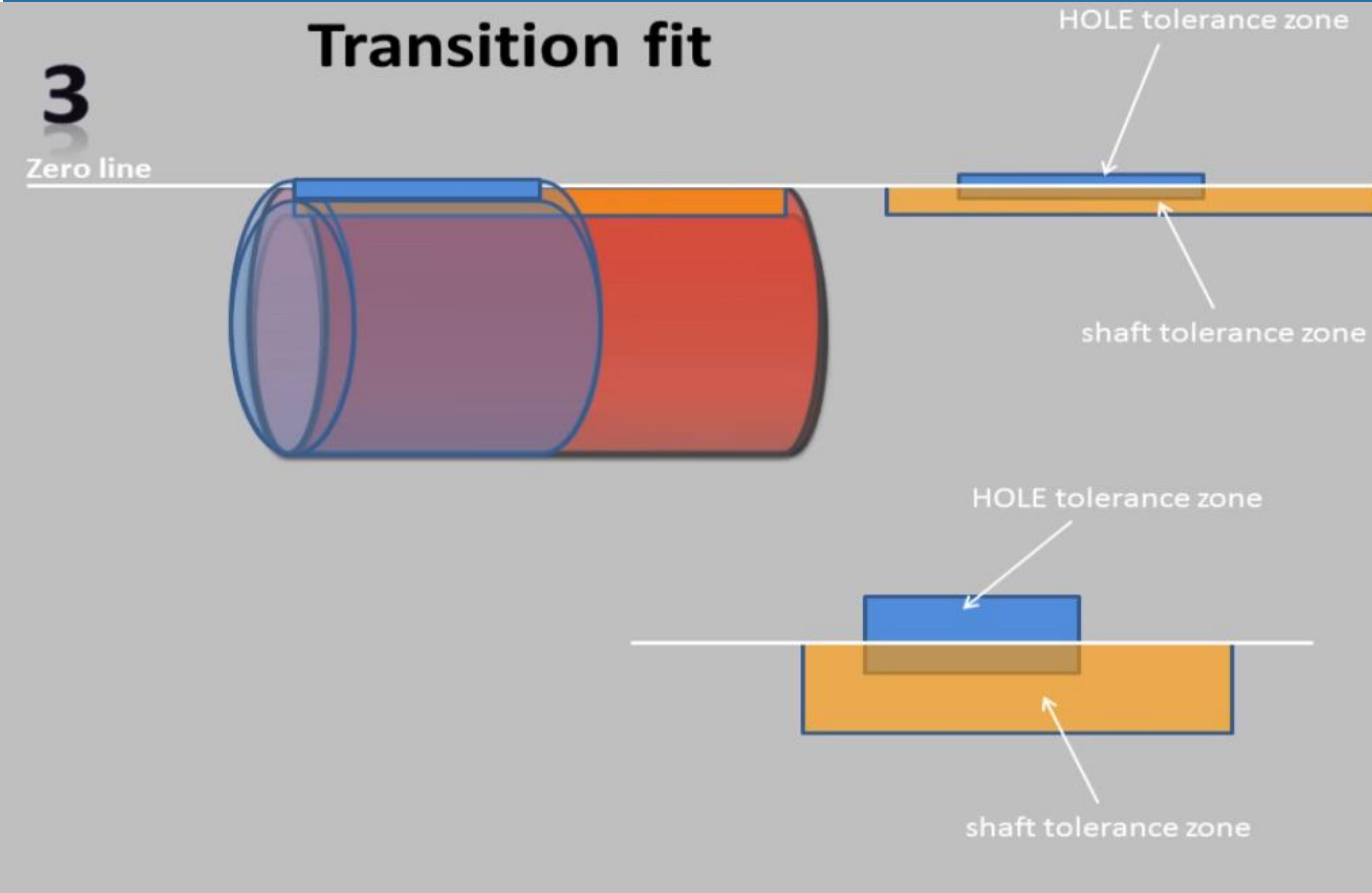
Interference fit



2

Interference fit

Transition fit



SHAFT BASIS SYSTEM

1

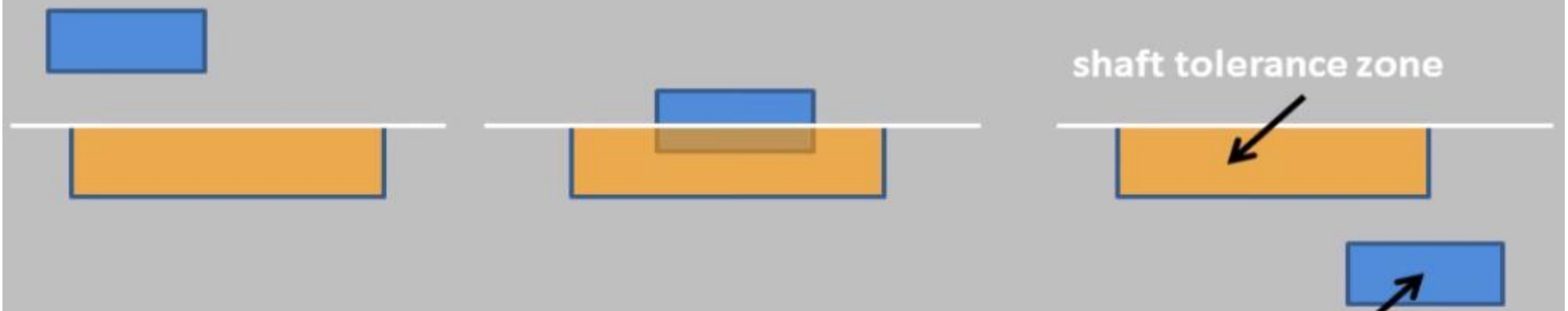
Clearance Fit

3

Transition Fit

2

Interference Fit



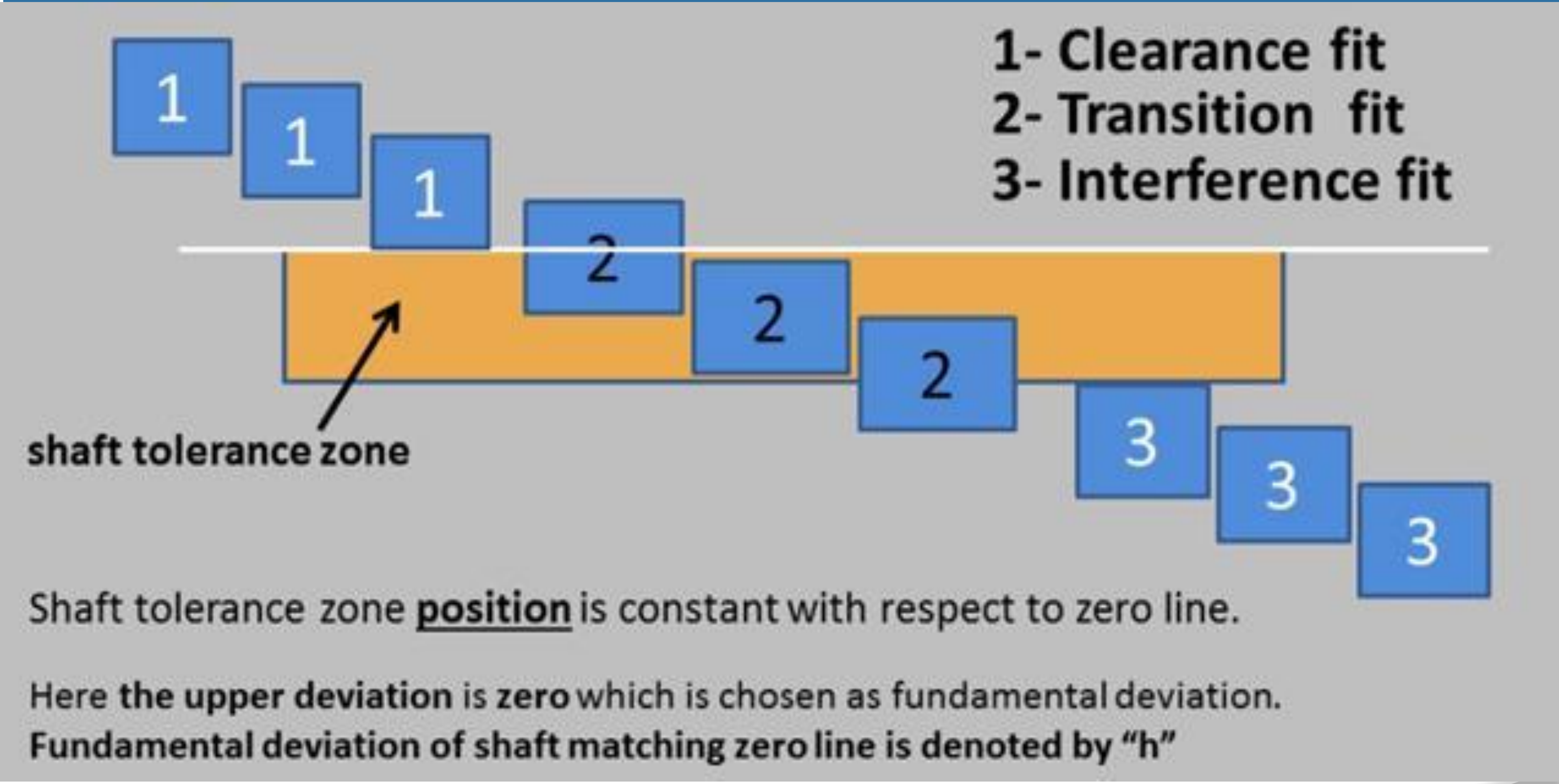
shaft tolerance zone

HOLE tolerance zone

If you observe, HOLE tolerance zone changing its position to get required fit.

But **shaft tolerance zone is not moving its position with respect to zero line.**

It is **shaft basis system** of limits and fits.



1- Clearance fit
2- Transition fit
3- Interference fit

Shaft tolerance zone **position** is constant with respect to zero line.

Here **the upper deviation** is **zero** which is chosen as fundamental deviation.
Fundamental deviation of shaft matching zero line is denoted by “h”

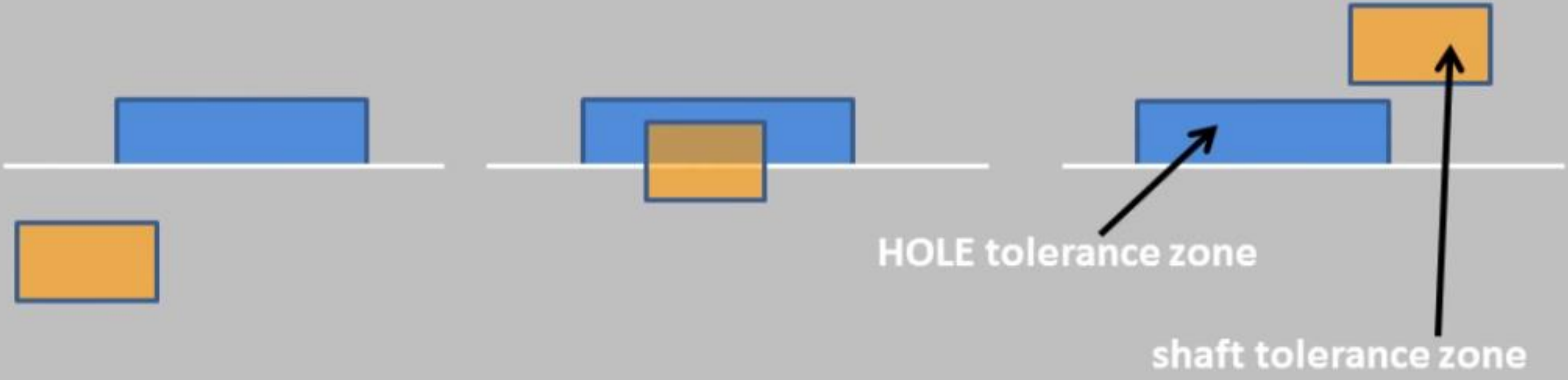
In shaft basis system of limits and fits, Fundamental deviation of shaft always will be “h”

HOLE BASIS SYSTEM

1 Clearance Fit

2 Transition Fit

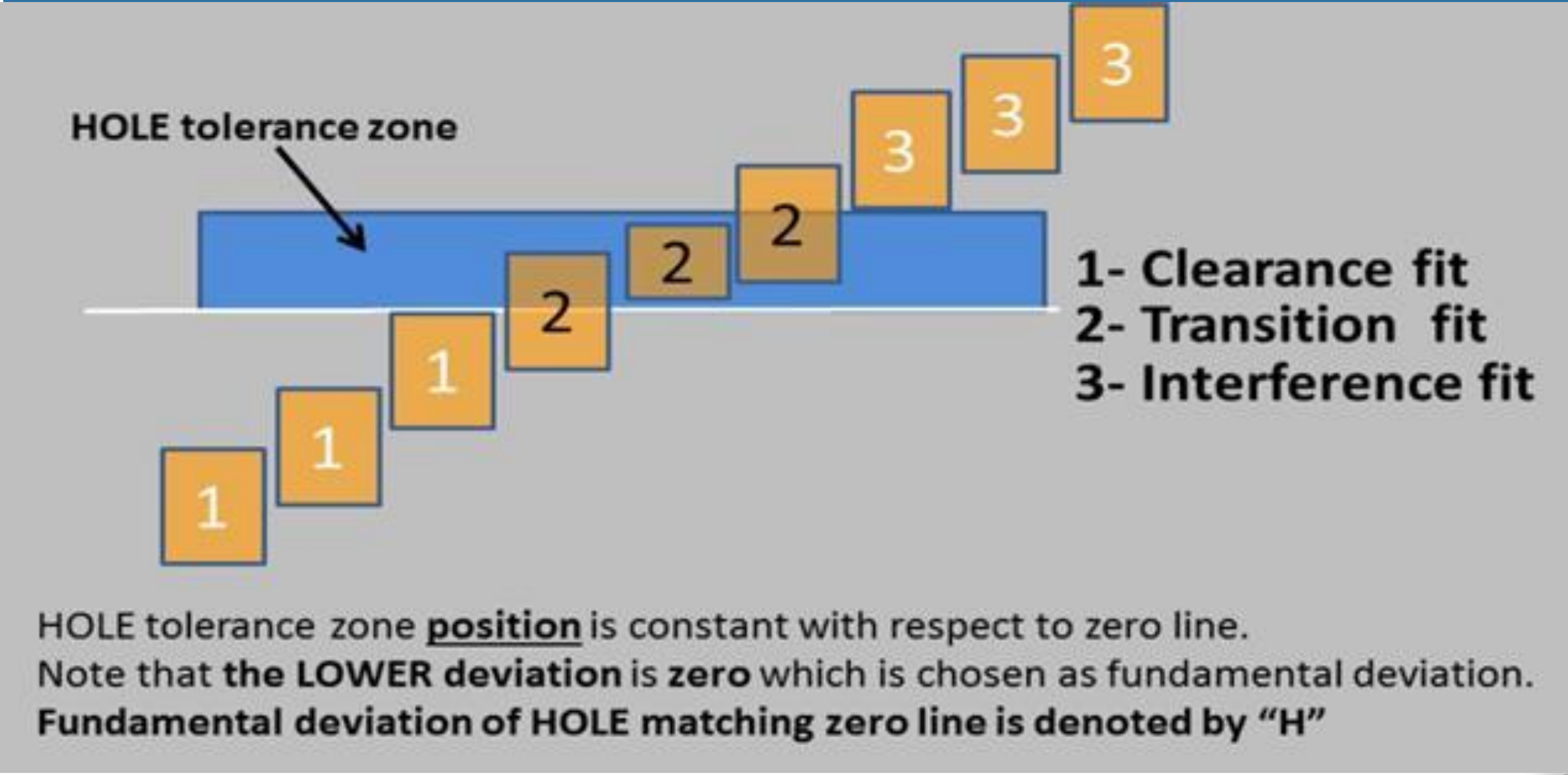
3 Interference Fit



If you observe, shaft tolerance zone changing its position to get required fit.

But **HOLE tolerance zone is not moving its position with respect to zero line.**

It is **HOLE basis system** of limits and fits.

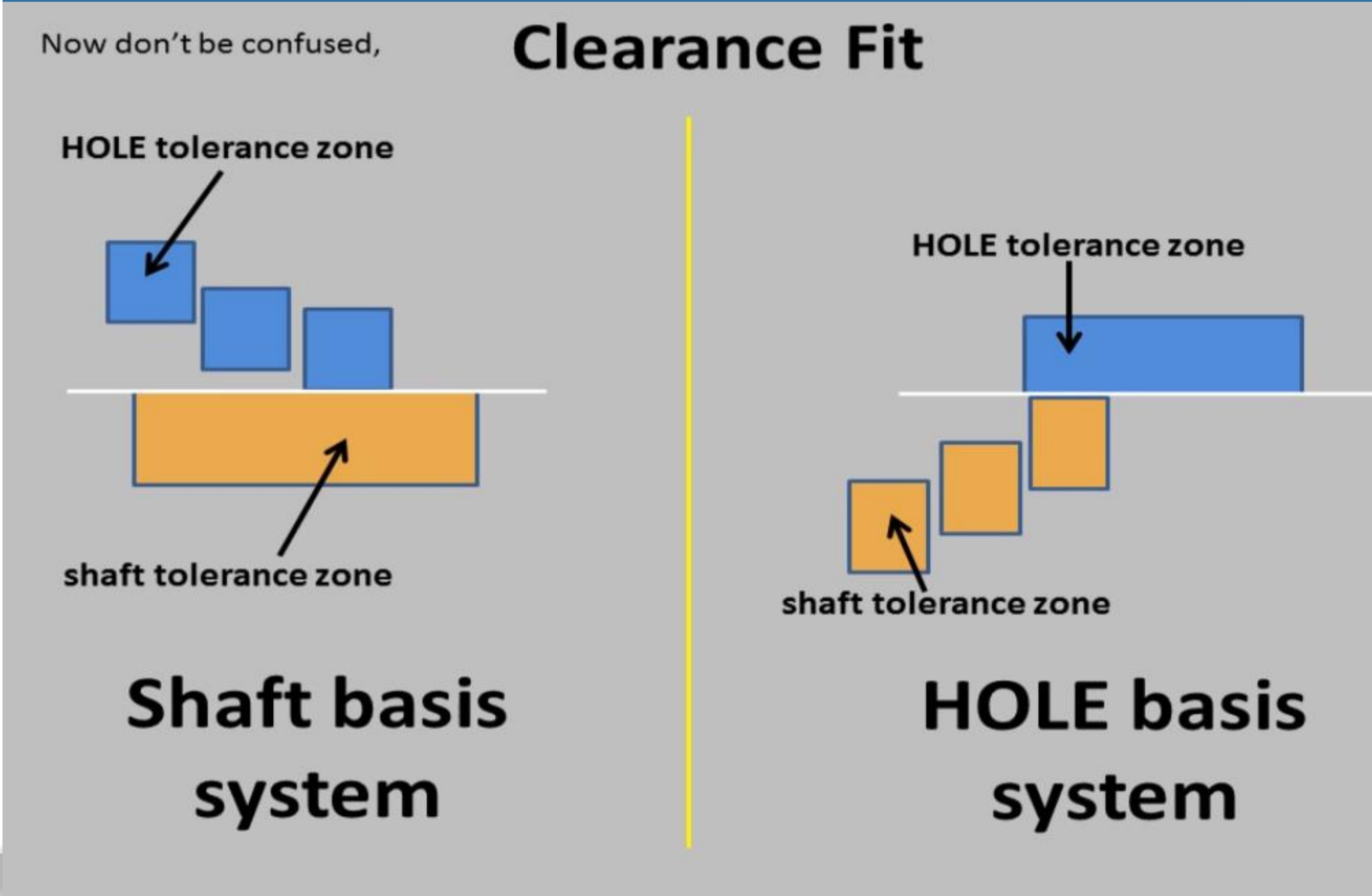


1- Clearance fit
2- Transition fit
3- Interference fit

HOLE tolerance zone **position** is constant with respect to zero line.
Note that **the LOWER deviation** is **zero** which is chosen as fundamental deviation.
Fundamental deviation of HOLE matching zero line is denoted by “H”

In HOLE basis system of limits and fits, Fundamental deviation of HOLE always will be “H”

Clearance fit



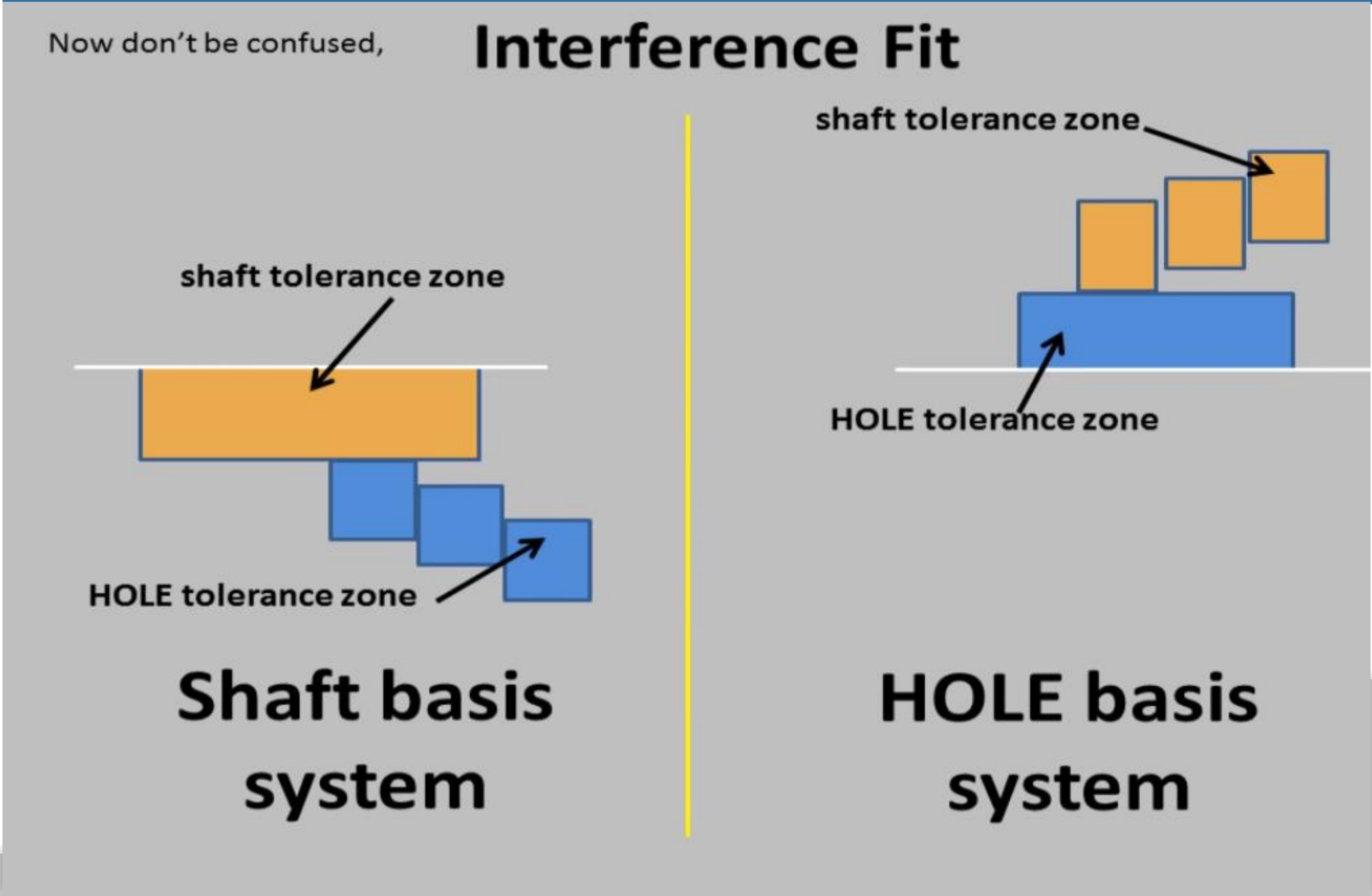
Now don't be confused,

Clearance Fit

Shaft basis system

HOLE basis system

Interference fit



Now don't be confused,

Interference Fit

Shaft basis system

HOLE basis system

Tolerances

- **Bilateral Tolerance**

Variation is permitted in both positive and negative directions from the nominal dimension

- possible for a bilateral tolerance to be unbalance: for Example, 2,500 +0.010, -0.005

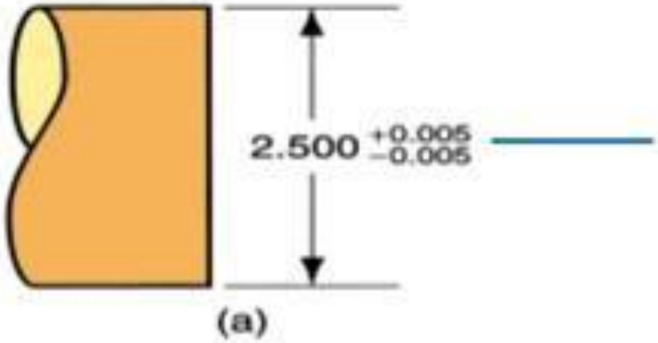


Fig: Ways to specify tolerance limits for a nominal dimension of 2.500

Unilateral Tolerance

Variation from the specified dimension is permitted in only one direction

- Either positive or negative, but not both

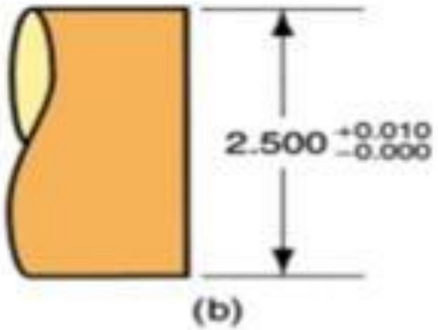


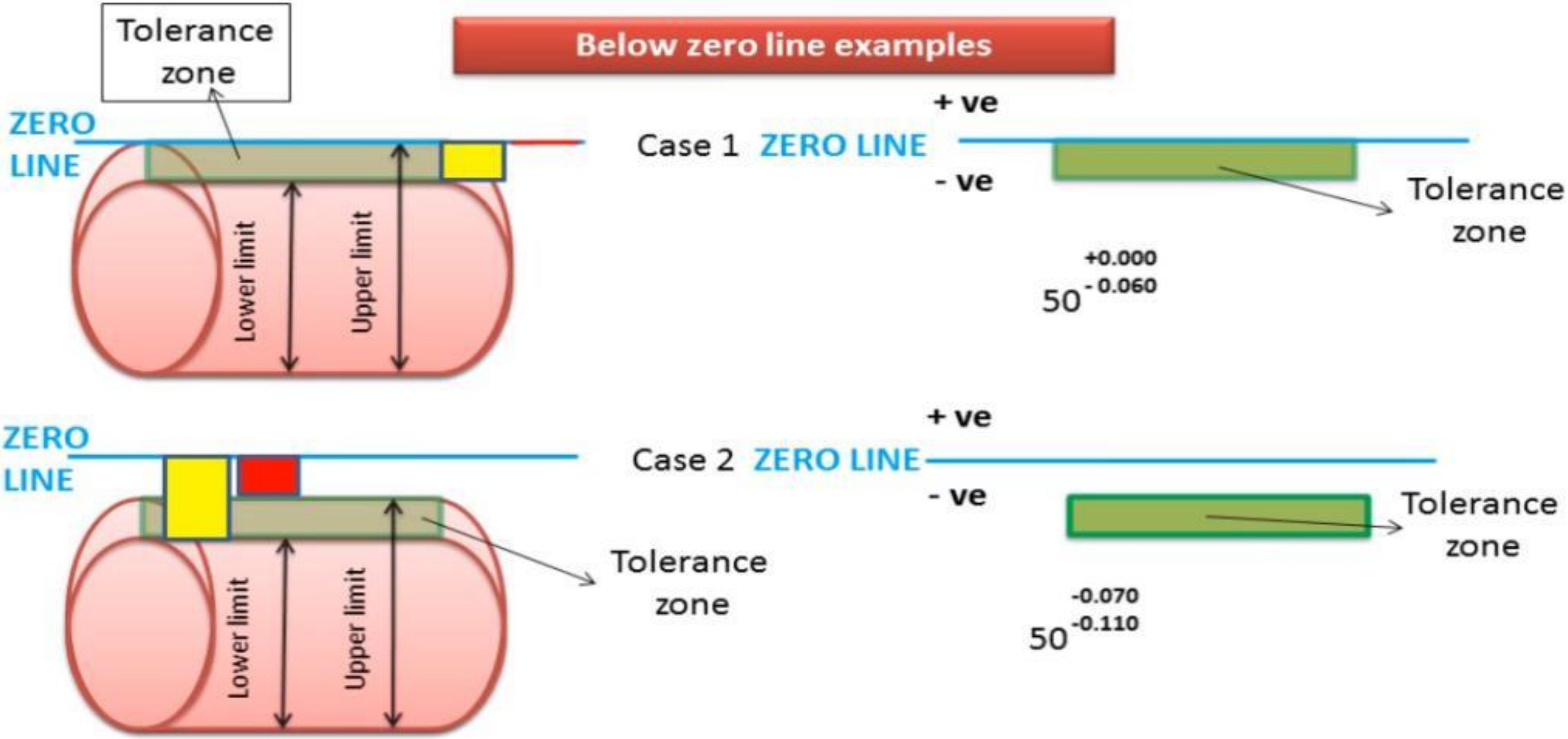
Fig: Ways to specify tolerance limits for a nominal dimension of 2.500

Unilateral Tolerances

UNILATERAL tolerance **(Uni – one, lateral – side)**

The tolerance zone always lie above zero line **or** below zero line in case of **Unilateral Tolerance. i.e. one side tolerance.**

Below zero line examples



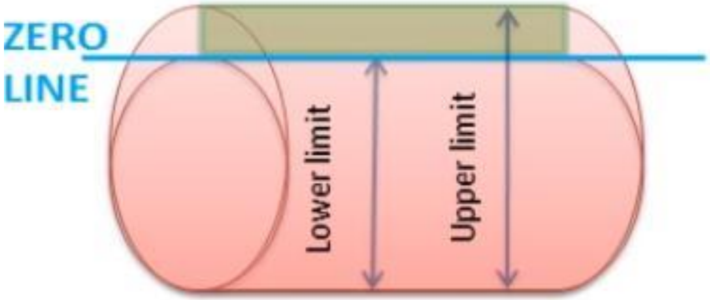
Case 1: $50^{+0.000}_{-0.060}$

Case 2: $50^{-0.070}_{-0.110}$

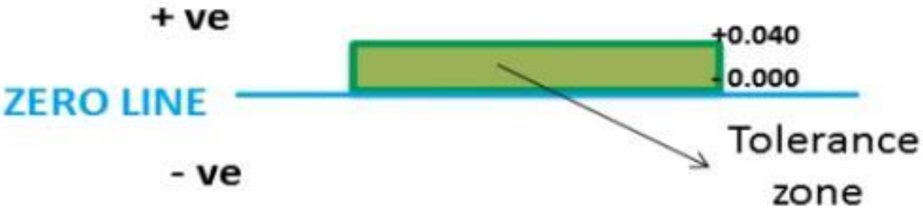
In both the cases tolerance zone lies **below zero line.** It means –ve deviation only.

UNILATERAL tolerance

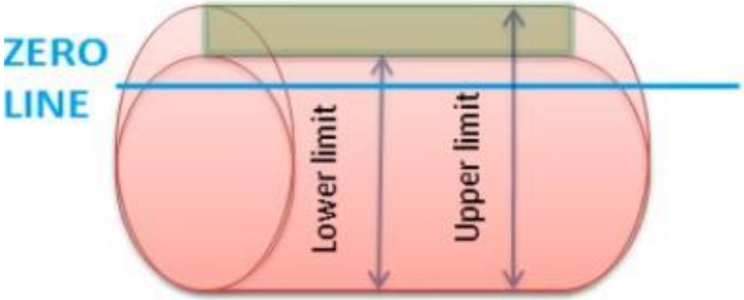
Above zero line examples



Case 1



eg. $50^{+0.040}_{-0.000}$



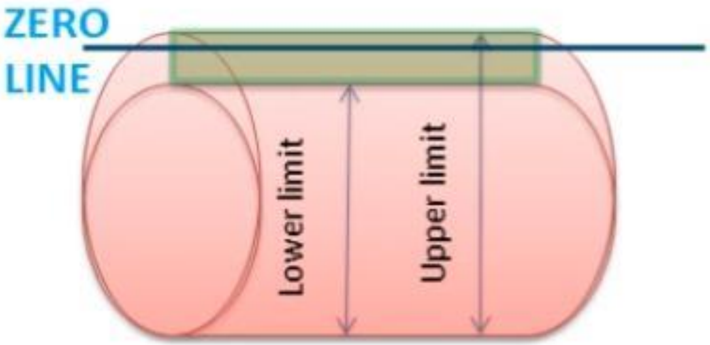
Case 2

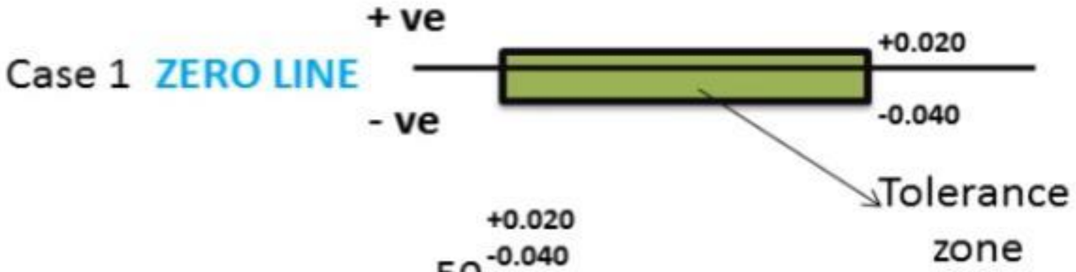
eg. $50^{+0.070}_{+0.030}$

In both the cases tolerance zone lies **above zero line.** It means +ve deviation only.

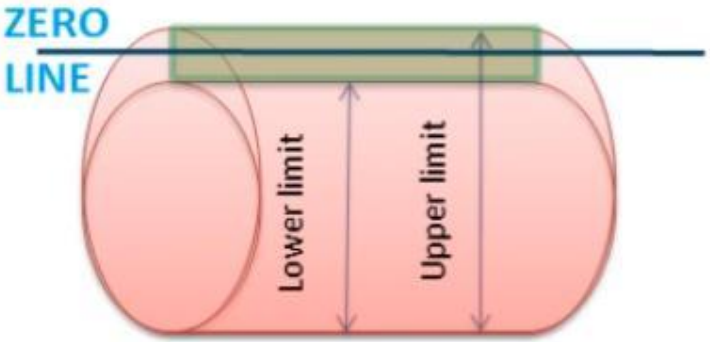
Bilateral Tolerances

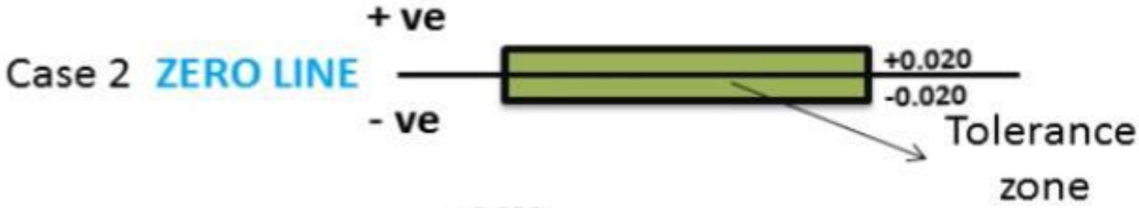
BILATERAL tolerance (Bi – Two, lateral – side)





$50^{+0.020}_{-0.040}$





$50^{+0.020}_{-0.020}$

In both the cases upper deviation or lower deviation **will not** be **zero value**. And always will be combination of +ve &-ve deviations.

BILATERAL TOLERANCE

(Bi-Two, lateral-side)

The tolerance zone always lie on both sides of aero line.

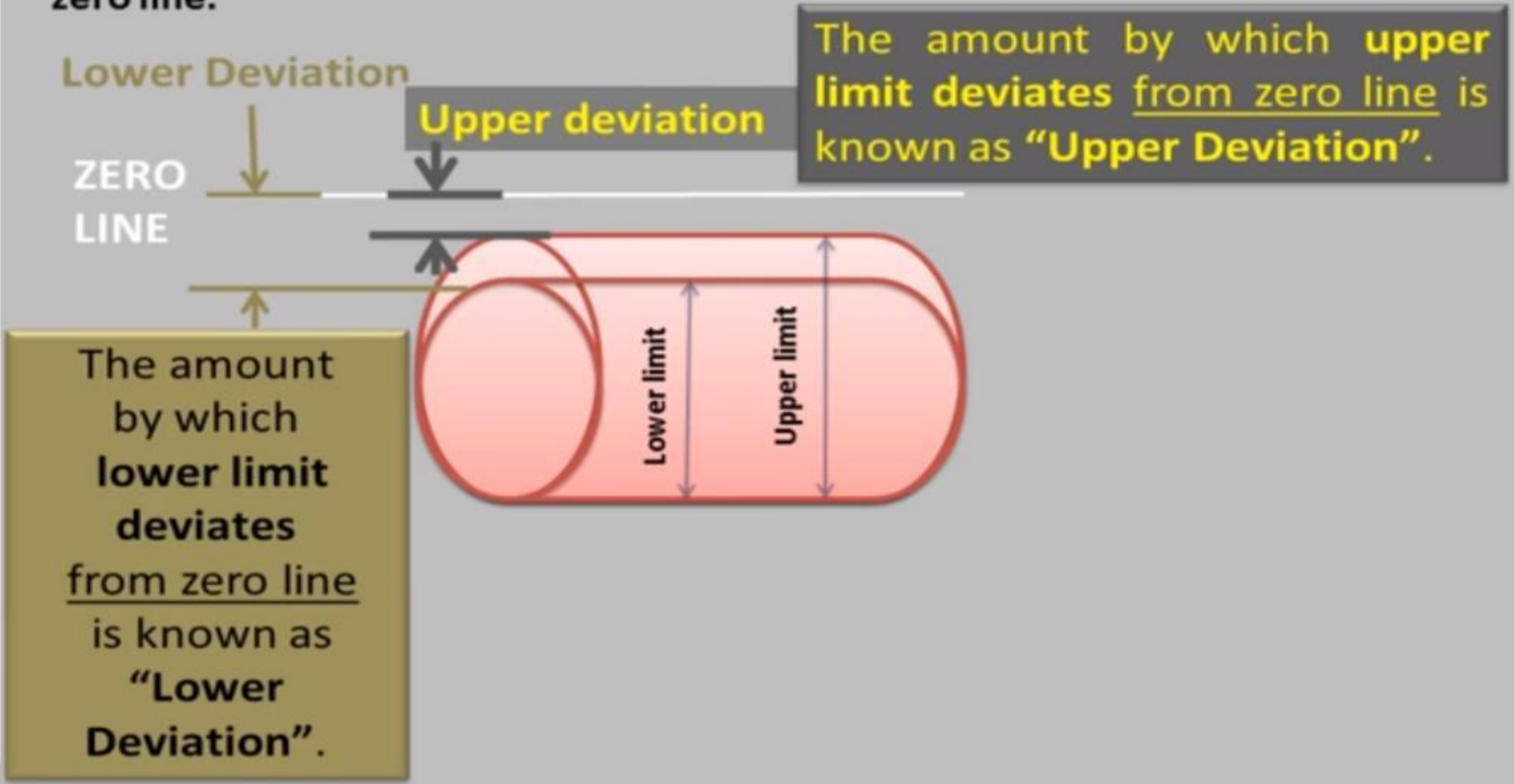
(above zero line & below zero line)

It is not necessary that zero line will divide tolerance zone equally on both sides, it may be equal or unequal.

- **Deviation:** It is the algebraic difference between a size and its corresponding basic size. It may be positive, negative, or zero.
- **Upper deviation:** It is the algebraic difference between the maximum limit of size and its corresponding basic size. This is designated as ‘ES’ for a hole and as ‘es’ for a shaft.
- **Lower deviation:** It is the algebraic difference between the minimum limit of size and its corresponding basic size. This is designated as ‘EI’ for a hole and as ‘ei’ for a shaft. Actual deviation: It is the algebraic difference between the actual size and its corresponding basic size.
- **Fundamental deviation:** It is the minimum difference between the size of a component and its basic size. This is identical to the upper deviation for shafts and lower deviation for holes.

LOWER DEVIATION & UPPER DEVIATION

Deviation means the amount by which the dimension differs (goes away) from zero line.



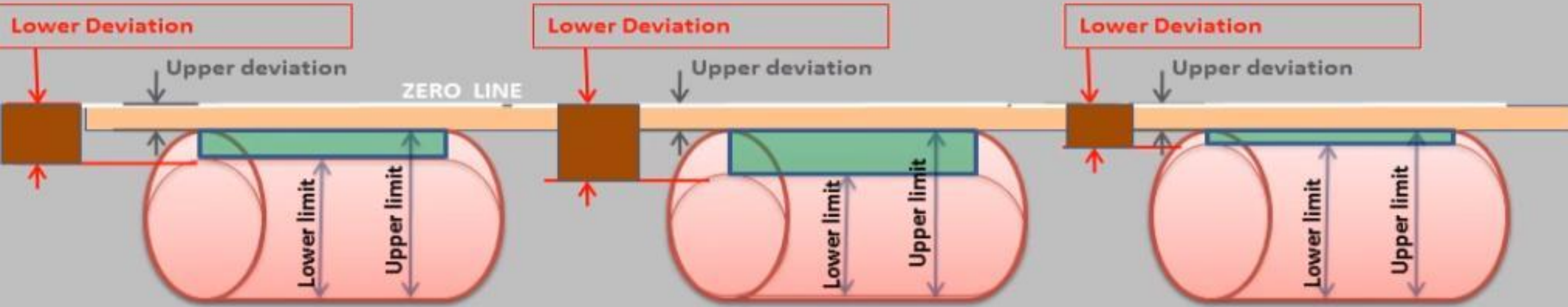
The amount by which **upper limit deviates** from zero line is known as **"Upper Deviation"**.

The amount by which **lower limit deviates** from zero line is known as **"Lower Deviation"**.

Fundamental deviation

It is either upper deviation or lower deviation which is conventionally chosen to define the position of tolerance zone in relation to the zero line.

It defines location of tolerance zone with respect to the zero line.



Suppose as shown in fig. **upper deviation chosen as fundamental** deviation. Then its position will not change with respect to zero line.

Case 1

to **increase** the tolerance zone.

Only lower deviation will be allowed to **move** down in order to increase tolerance zone.

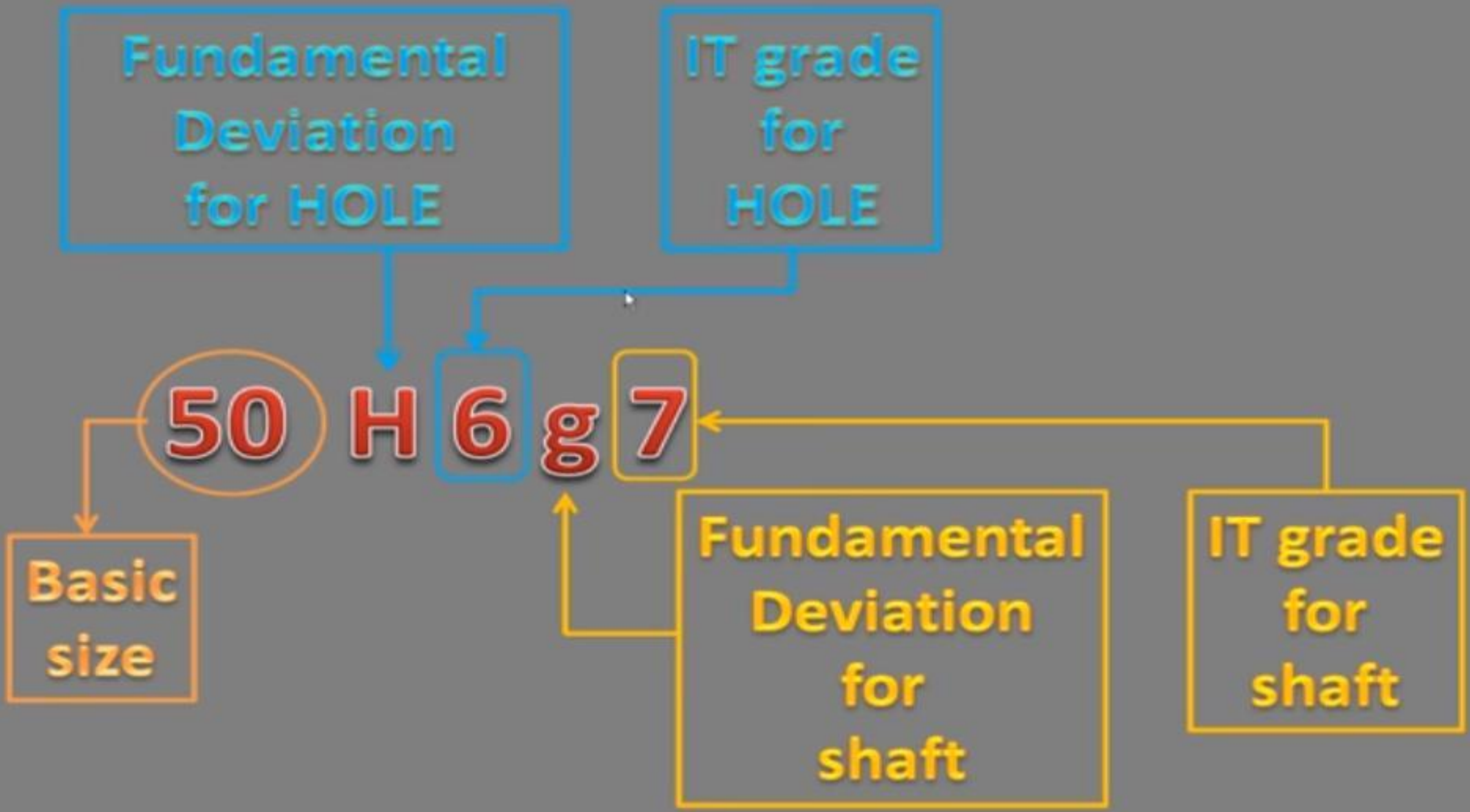
Case 2

to **decrease** the tolerance zone.

Only lower deviation will be allowed to **move** up in order to decrease tolerance zone.

Position of Fundamental deviation is fixed with respect to zero line. In both the case.

How to interpret Fit



Fundamental Deviation for HOLE

IT grade for HOLE

50 H 6 g 7

Basic size

Fundamental Deviation for shaft

IT grade for shaft

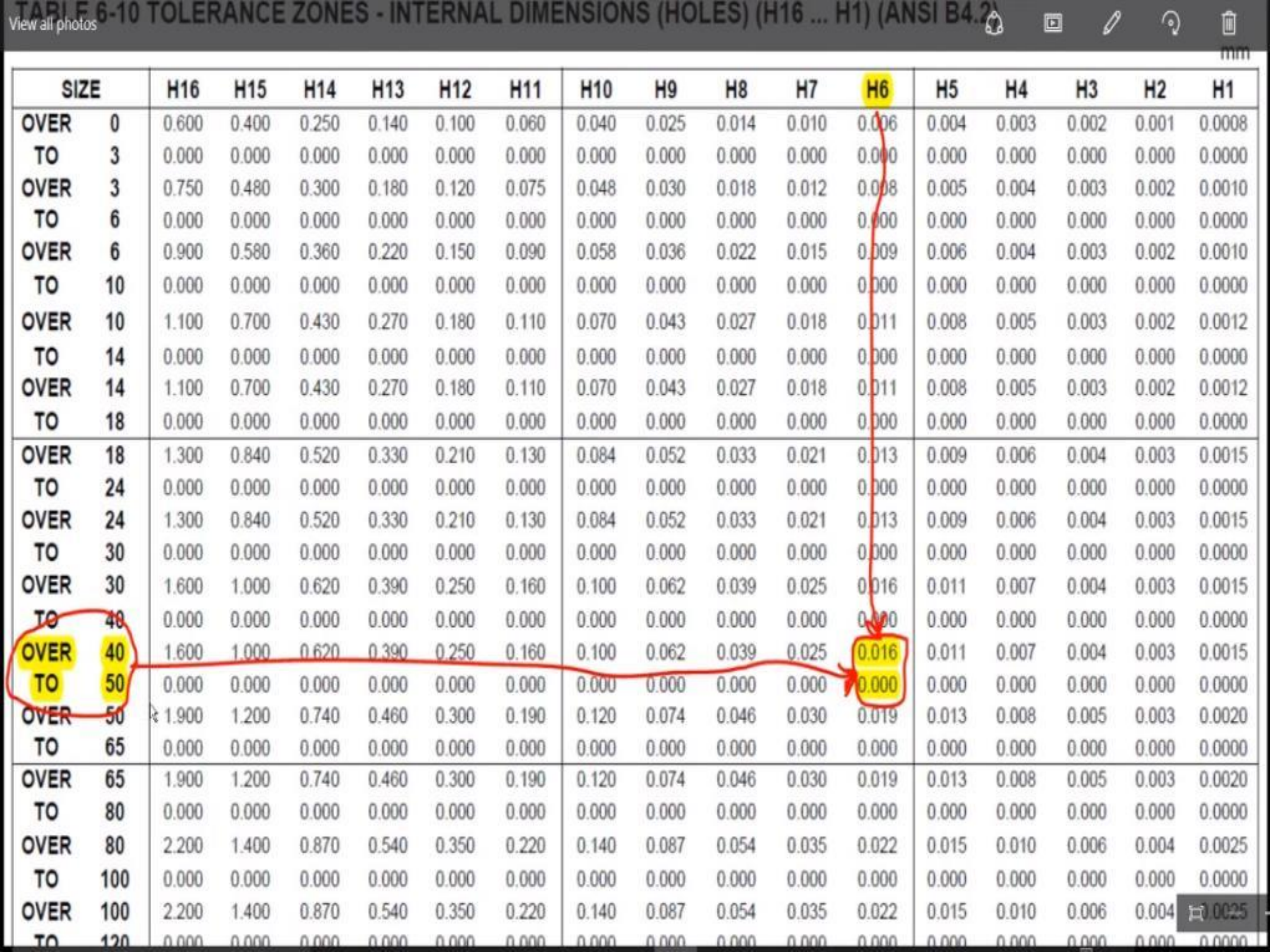
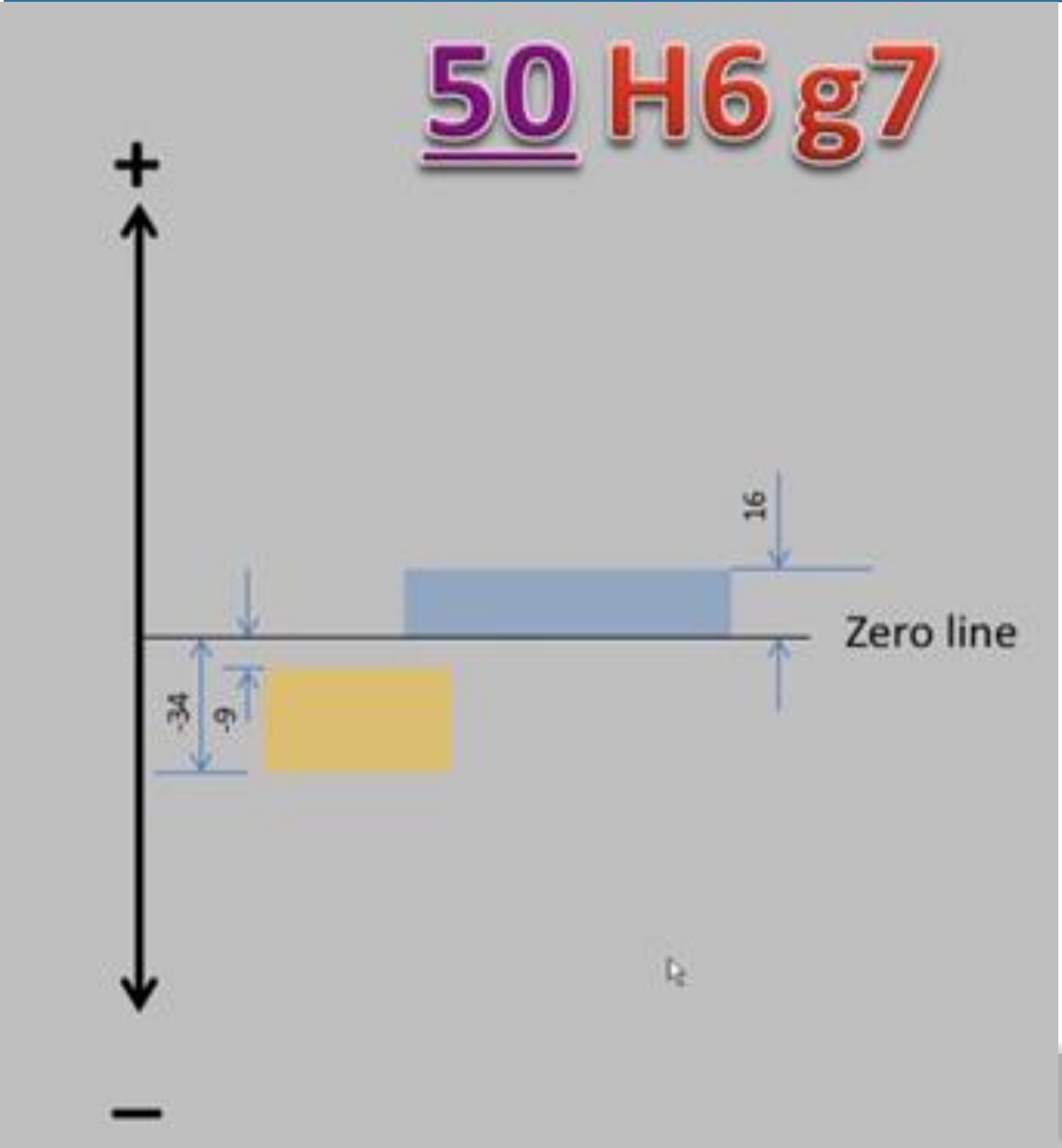


TABLE 6-10 TOLERANCE ZONES - INTERNAL DIMENSIONS (HOLES) (H16 ... H1) (ANSI B4.2)

mm

SIZE		H16	H15	H14	H13	H12	H11	H10	H9	H8	H7	H6	H5	H4	H3	H2	H1
OVER	0	0.600	0.400	0.250	0.140	0.100	0.060	0.040	0.025	0.014	0.010	0.006	0.004	0.003	0.002	0.001	0.0008
TO	3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	3	0.750	0.480	0.300	0.180	0.120	0.075	0.048	0.030	0.018	0.012	0.008	0.005	0.004	0.003	0.002	0.0010
TO	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	6	0.900	0.580	0.360	0.220	0.150	0.090	0.058	0.036	0.022	0.015	0.009	0.006	0.004	0.003	0.002	0.0010
TO	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	10	1.100	0.700	0.430	0.270	0.180	0.110	0.070	0.043	0.027	0.018	0.011	0.008	0.005	0.003	0.002	0.0012
TO	14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	14	1.100	0.700	0.430	0.270	0.180	0.110	0.070	0.043	0.027	0.018	0.011	0.008	0.005	0.003	0.002	0.0012
TO	18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	18	1.300	0.840	0.520	0.330	0.210	0.130	0.084	0.052	0.033	0.021	0.013	0.009	0.006	0.004	0.003	0.0015
TO	24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	24	1.300	0.840	0.520	0.330	0.210	0.130	0.084	0.052	0.033	0.021	0.013	0.009	0.006	0.004	0.003	0.0015
TO	30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	30	1.600	1.000	0.620	0.390	0.250	0.160	0.100	0.062	0.039	0.025	0.016	0.011	0.007	0.004	0.003	0.0015
TO	40	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	40	1.600	1.000	0.620	0.390	0.250	0.160	0.100	0.062	0.039	0.025	0.016	0.011	0.007	0.004	0.003	0.0015
TO	50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	50	1.900	1.200	0.740	0.460	0.300	0.190	0.120	0.074	0.046	0.030	0.019	0.013	0.008	0.005	0.003	0.0020
TO	65	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	65	1.900	1.200	0.740	0.460	0.300	0.190	0.120	0.074	0.046	0.030	0.019	0.013	0.008	0.005	0.003	0.0020
TO	80	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	80	2.200	1.400	0.870	0.540	0.350	0.220	0.140	0.087	0.054	0.035	0.022	0.015	0.010	0.006	0.004	0.0025
TO	100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	100	2.200	1.400	0.870	0.540	0.350	0.220	0.140	0.087	0.054	0.035	0.022	0.015	0.010	0.006	0.004	0.0025
TO	120	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000



If **hole** has fundamental deviation **“H”** means it is hole basis system of fits

If **shaft** has fundamental deviation **“h”** means it is shaft basis system of fits

Here
Fundamental deviation for Hole – H
Shaft – g
Means hole basis system and we know IT grades define tolerance Zone

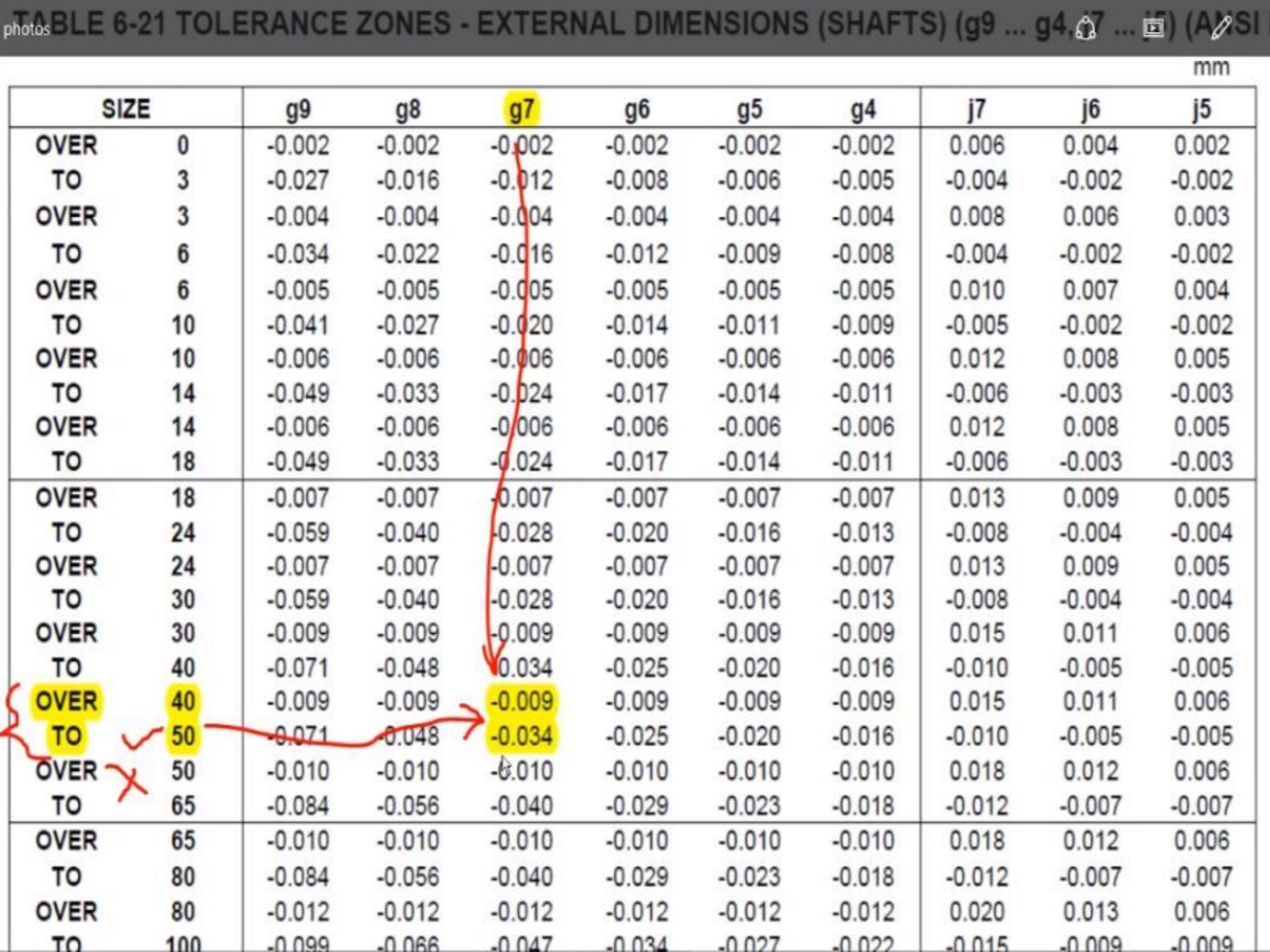
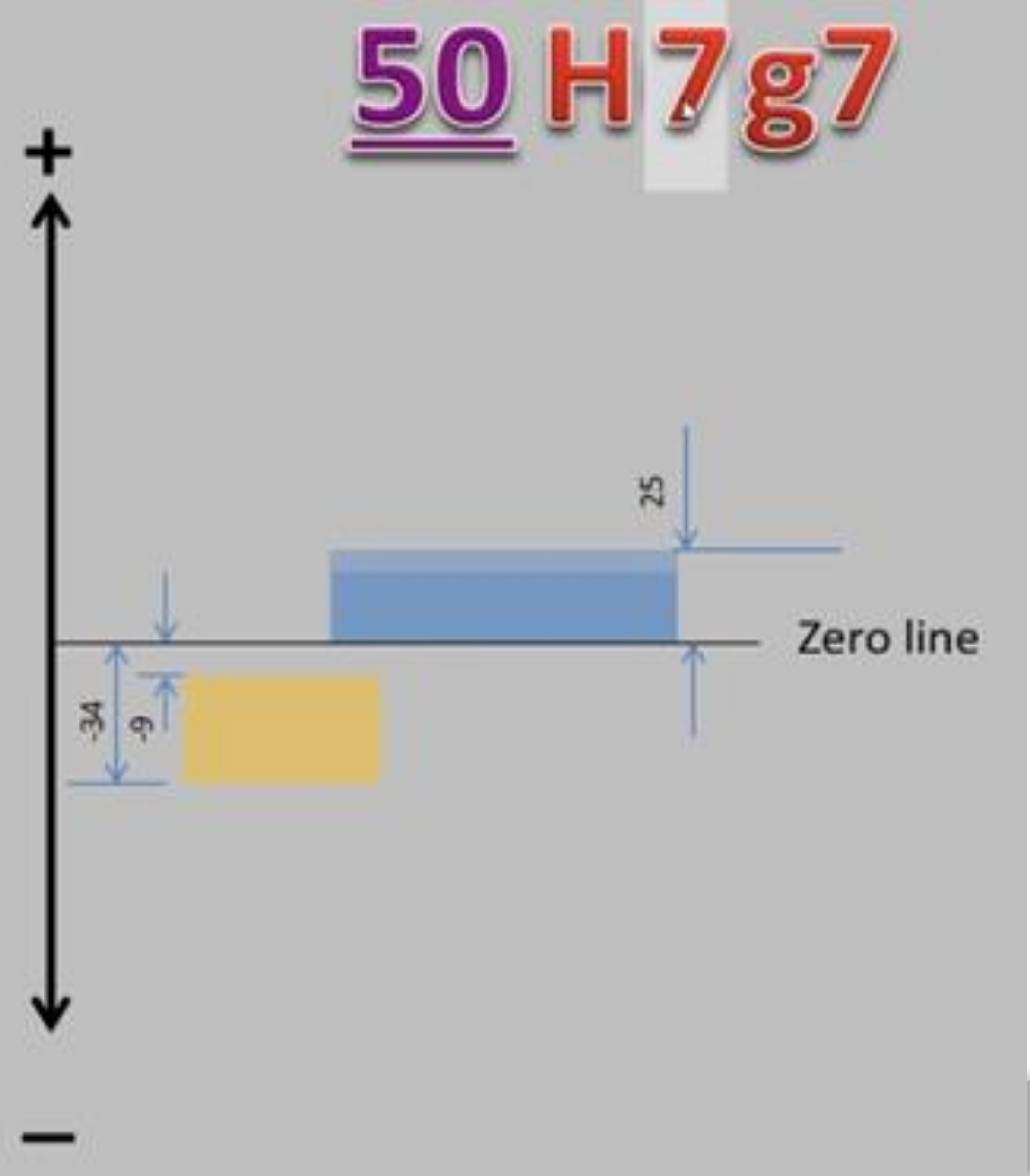


TABLE 6-21 TOLERANCE ZONES - EXTERNAL DIMENSIONS (SHAFTS) (g9 ... g4, j7 ... j5) (ANSI

mm

SIZE		g9	g8	g7	g6	g5	g4	j7	j6	j5
OVER	0	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	0.006	0.004	0.002
TO	3	-0.027	-0.016	-0.012	-0.008	-0.006	-0.005	-0.004	-0.002	-0.002
OVER	3	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	0.008	0.006	0.003
TO	6	-0.034	-0.022	-0.016	-0.012	-0.009	-0.008	-0.004	-0.002	-0.002
OVER	6	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	0.010	0.007	0.004
TO	10	-0.041	-0.027	-0.020	-0.014	-0.011	-0.009	-0.005	-0.002	-0.002
OVER	10	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	0.012	0.008	0.005
TO	14	-0.049	-0.033	-0.024	-0.017	-0.014	-0.011	-0.006	-0.003	-0.003
OVER	14	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	0.012	0.008	0.005
TO	18	-0.049	-0.033	-0.024	-0.017	-0.014	-0.011	-0.006	-0.003	-0.003
OVER	18	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007	0.013	0.009	0.005
TO	24	-0.059	-0.040	-0.028	-0.020	-0.016	-0.013	-0.008	-0.004	-0.004
OVER	24	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007	0.013	0.009	0.005
TO	30	-0.059	-0.040	-0.028	-0.020	-0.016	-0.013	-0.008	-0.004	-0.004
OVER	30	-0.009	-0.009	-0.009	-0.009	-0.009	-0.009	0.015	0.011	0.006
TO	40	-0.071	-0.048	-0.034	-0.025	-0.020	-0.016	-0.010	-0.005	-0.005
OVER	40	-0.009	-0.009	-0.009	-0.009	-0.009	-0.009	0.015	0.011	0.006
TO	50	-0.071	-0.048	-0.034	-0.025	-0.020	-0.016	-0.010	-0.005	-0.005
OVER	50	-0.010	-0.010	-0.010	-0.010	-0.010	-0.010	0.018	0.012	0.006
TO	65	-0.084	-0.056	-0.040	-0.029	-0.023	-0.018	-0.012	-0.007	-0.007
OVER	65	-0.010	-0.010	-0.010	-0.010	-0.010	-0.010	0.018	0.012	0.006
TO	80	-0.084	-0.056	-0.040	-0.029	-0.023	-0.018	-0.012	-0.007	-0.007
OVER	80	-0.012	-0.012	-0.012	-0.012	-0.012	-0.012	0.020	0.013	0.006
TO	100	-0.099	-0.066	-0.047	-0.034	-0.027	-0.022	-0.015	-0.009	-0.009



If **hole** has fundamental deviation **“H”** means it is hole basis system of fits

If **shaft** has fundamental deviation **“h”** means it is shaft basis system of fits

Here
Fundamental deviation for
Hole – H
Shaft – g
Means hole basis system and we know it grades define tolerance Zone

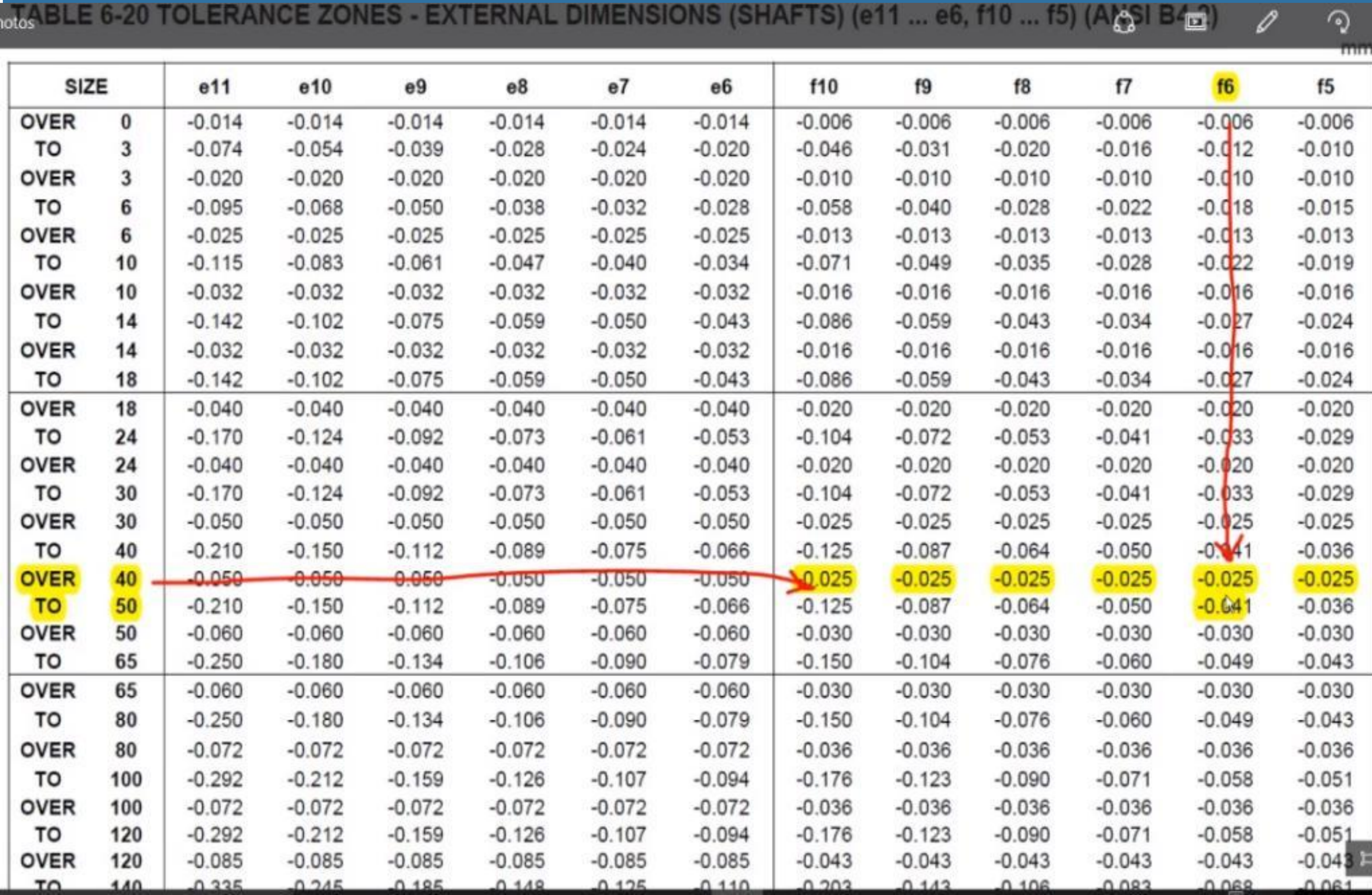
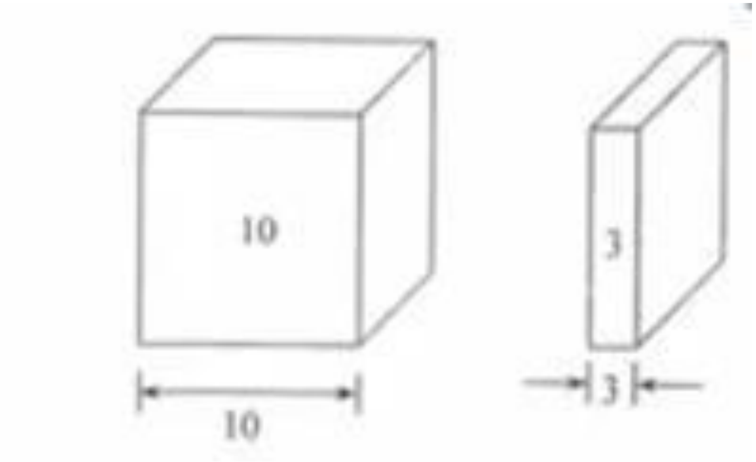


TABLE 6-20 TOLERANCE ZONES - EXTERNAL DIMENSIONS (SHAFTS) (e11 ... e6, f10 ... f5) (ANSI B4.2)

mm

SIZE		e11	e10	e9	e8	e7	e6	f10	f9	f8	f7	f6	f5
OVER	0	-0.014	-0.014	-0.014	-0.014	-0.014	-0.014	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006
TO	3	-0.074	-0.054	-0.039	-0.028	-0.024	-0.020	-0.046	-0.031	-0.020	-0.016	-0.012	-0.010
OVER	3	-0.020	-0.020	-0.020	-0.020	-0.020	-0.020	-0.010	-0.010	-0.010	-0.010	-0.010	-0.010
TO	6	-0.095	-0.068	-0.050	-0.038	-0.032	-0.028	-0.058	-0.040	-0.028	-0.022	-0.018	-0.015
OVER	6	-0.025	-0.025	-0.025	-0.025	-0.025	-0.025	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013
TO	10	-0.115	-0.083	-0.061	-0.047	-0.040	-0.034	-0.071	-0.049	-0.035	-0.028	-0.022	-0.019
OVER	10	-0.032	-0.032	-0.032	-0.032	-0.032	-0.032	-0.016	-0.016	-0.016	-0.016	-0.016	-0.016
TO	14	-0.142	-0.102	-0.075	-0.059	-0.050	-0.043	-0.086	-0.059	-0.043	-0.034	-0.027	-0.024
OVER	14	-0.032	-0.032	-0.032	-0.032	-0.032	-0.032	-0.016	-0.016	-0.016	-0.016	-0.016	-0.016
TO	18	-0.142	-0.102	-0.075	-0.059	-0.050	-0.043	-0.086	-0.059	-0.043	-0.034	-0.027	-0.024
OVER	18	-0.040	-0.040	-0.040	-0.040	-0.040	-0.040	-0.020	-0.020	-0.020	-0.020	-0.020	-0.020
TO	24	-0.170	-0.124	-0.092	-0.073	-0.061	-0.053	-0.104	-0.072	-0.053	-0.041	-0.033	-0.029
OVER	24	-0.040	-0.040	-0.040	-0.040	-0.040	-0.040	-0.020	-0.020	-0.020	-0.020	-0.020	-0.020
TO	30	-0.170	-0.124	-0.092	-0.073	-0.061	-0.053	-0.104	-0.072	-0.053	-0.041	-0.033	-0.029
OVER	30	-0.050	-0.050	-0.050	-0.050	-0.050	-0.050	-0.025	-0.025	-0.025	-0.025	-0.025	-0.025
TO	40	-0.210	-0.150	-0.112	-0.089	-0.075	-0.066	-0.125	-0.087	-0.064	-0.050	-0.041	-0.036
OVER	40	-0.050	-0.050	-0.050	-0.050	-0.050	-0.050	-0.025	-0.025	-0.025	-0.025	-0.025	-0.025
TO	50	-0.210	-0.150	-0.112	-0.089	-0.075	-0.066	-0.125	-0.087	-0.064	-0.050	-0.041	-0.036
OVER	50	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.030	-0.030	-0.030	-0.030	-0.030	-0.030
TO	65	-0.250	-0.180	-0.134	-0.106	-0.090	-0.079	-0.150	-0.104	-0.076	-0.060	-0.049	-0.043
OVER	65	-0.060	-0.060	-0.060	-0.060	-0.060	-0.060	-0.030	-0.030	-0.030	-0.030	-0.030	-0.030
TO	80	-0.250	-0.180	-0.134	-0.106	-0.090	-0.079	-0.150	-0.104	-0.076	-0.060	-0.049	-0.043
OVER	80	-0.072	-0.072	-0.072	-0.072	-0.072	-0.072	-0.036	-0.036	-0.036	-0.036	-0.036	-0.036
TO	100	-0.292	-0.212	-0.159	-0.126	-0.107	-0.094	-0.176	-0.123	-0.090	-0.071	-0.058	-0.051
OVER	100	-0.072	-0.072	-0.072	-0.072	-0.072	-0.072	-0.036	-0.036	-0.036	-0.036	-0.036	-0.036
TO	120	-0.292	-0.212	-0.159	-0.126	-0.107	-0.094	-0.176	-0.123	-0.090	-0.071	-0.058	-0.051
OVER	120	-0.085	-0.085	-0.085	-0.085	-0.085	-0.085	-0.043	-0.043	-0.043	-0.043	-0.043	-0.043
TO	140	-0.335	-0.245	-0.185	-0.148	-0.125	-0.110	-0.203	-0.143	-0.106	-0.083	-0.068	-0.061

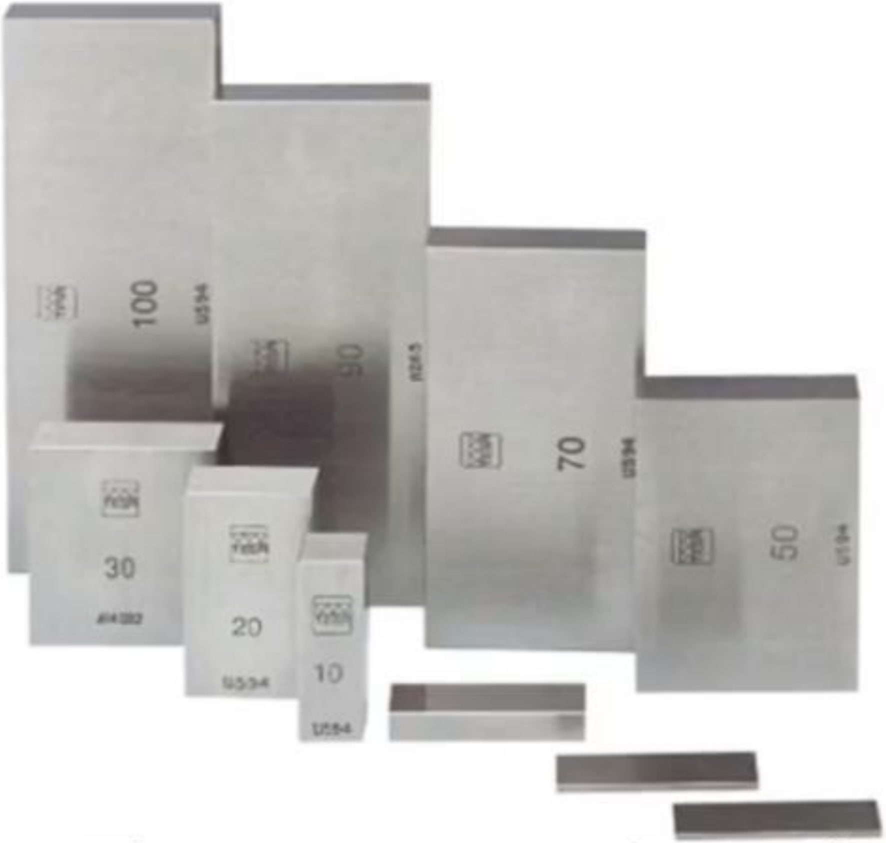
SLIP GUAGES



- Also called precision gauge blocks Johamnsen gauges
- Used as measuring blocks
- Made of hardened alloy steel of rectangular cross section
- These rectangular block of steel will have cross section 30mm X 10mm
- Standard sets of slip gauges 32 pieces, 45 pieces, 88 pieces etc.

SLIP GUAGES

- Slip gauges are rectangular block of high grade steel with close tolerance
- Also called precision gauge blocks or Johannsen gauges
- Used as measuring blocks
- Made of hardened alloy of rectangular cross section
- These rectangular bock of steel will have cross section 30mm x 10mm
- Standard sets of slip gauges 32 pieces, 45 pieces, 88 pieces, etc

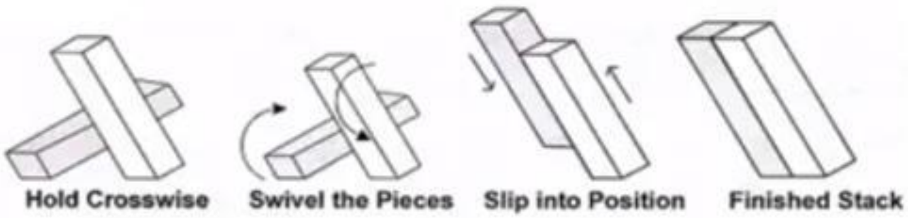


The cross section of the gauges are
(i)9mmx30mm for sizes up to 10mm
(ii)9mmx35mm for larger sizes.

Range (mm)	Step (mm)	Total Nos. of Pcs.
1.0005	-	1
1.001 – 1.009	0.001	9
1.01 – 1.49	0.01	49
0.5 - 25	0.5	50
50 - 100	25	3

Wringing of slip gauges

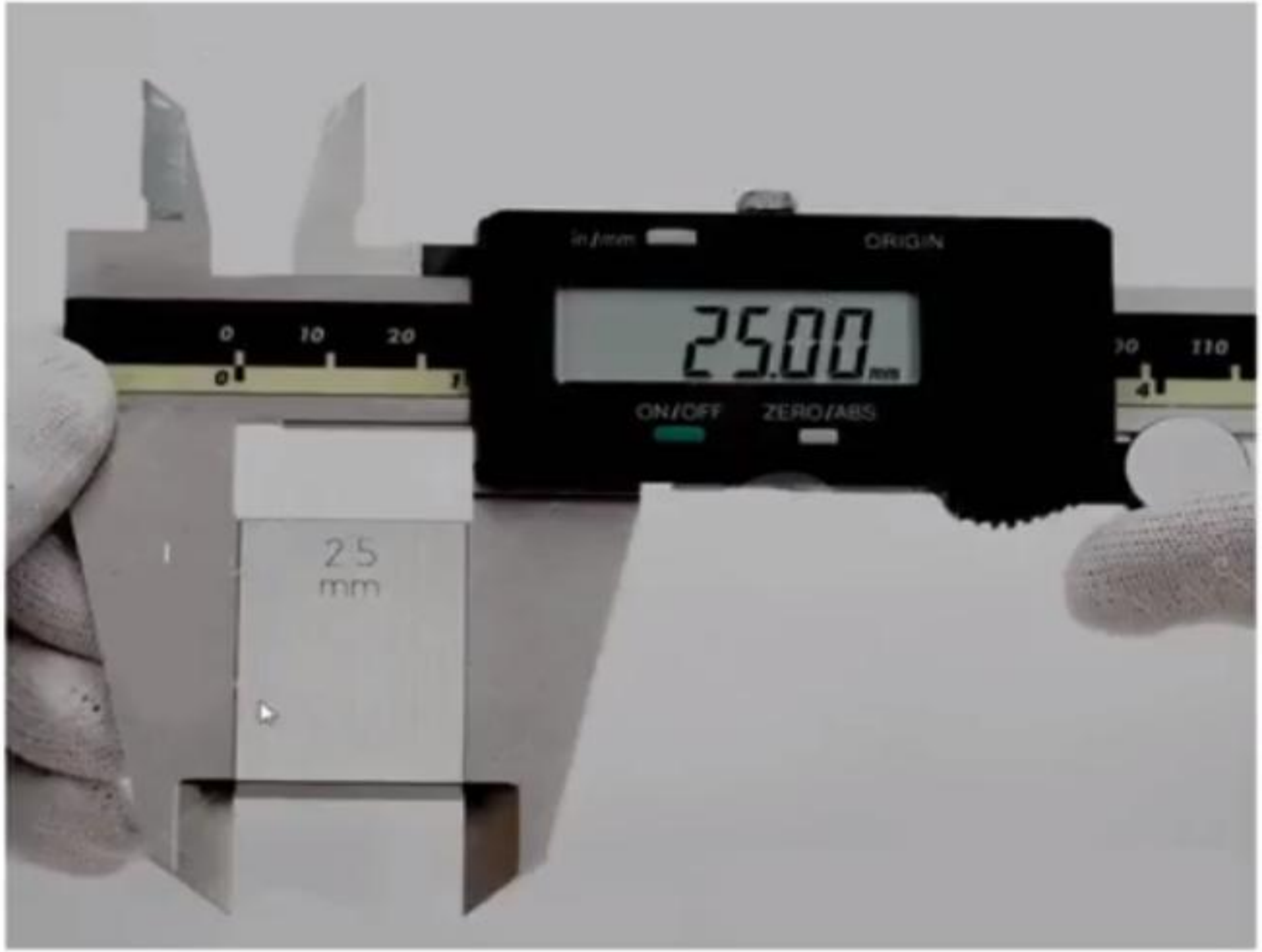
The accuracy of measurement depends on the phenomenon of wringing. The slip gauges are wrung together by hand through a combined sliding and rising motion.



Uses of Gauge block

- Direct precise measurement where accuracy is required
- For calibration of Vernier callipers, micrometer etc
- Setting up a comparator to a specific dimension
- It is used for angle measurement with sine bar
- To check gap between parallel locations such as in gap gauges or between 2 mating parts
- Some other uses also in manufacturing sector.

Checking the width of a job



Calibration of Digital vernier caliper with slip gauge

Calibration of Micrometer with slip gauge

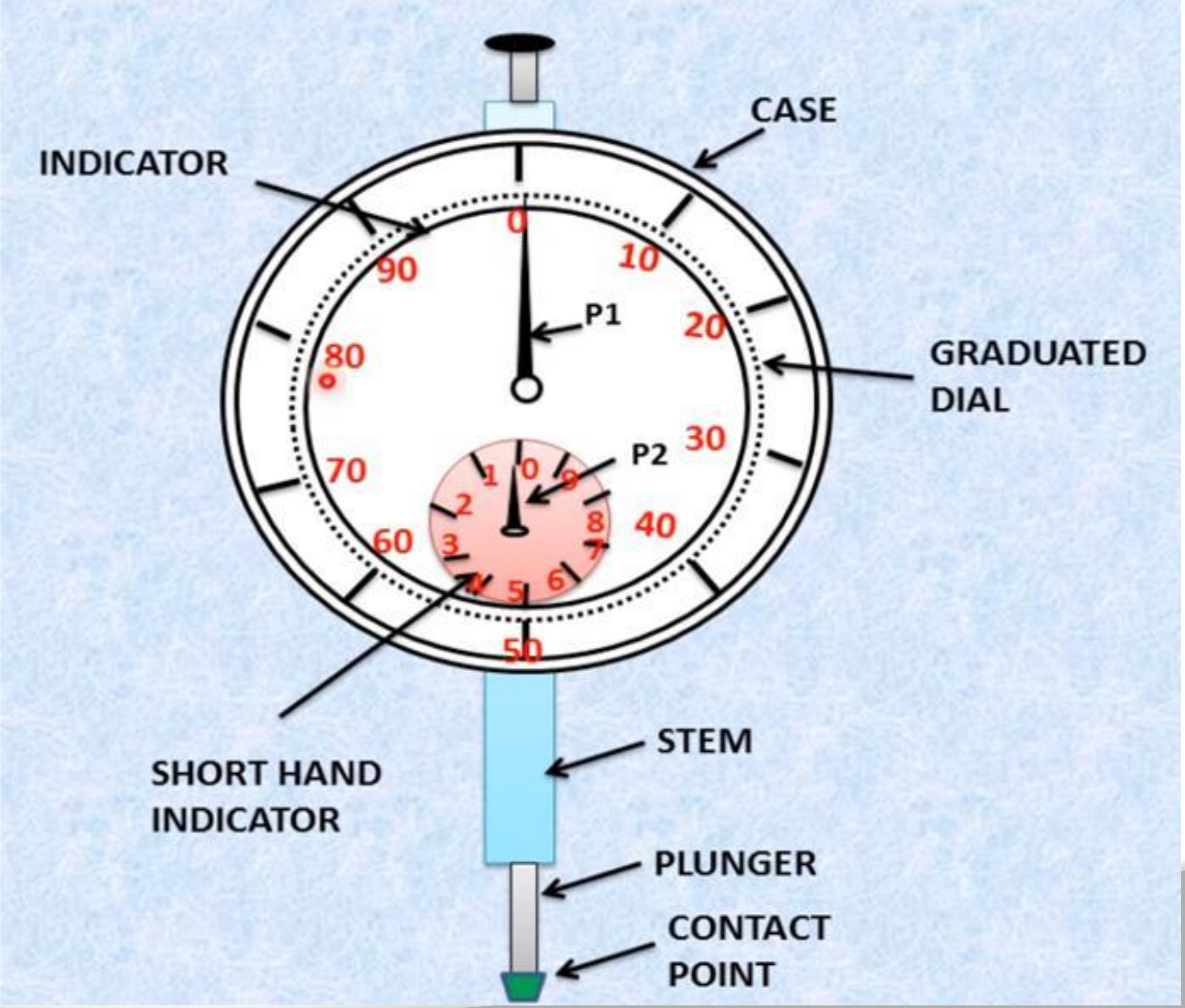
Measurement of angle of a job with sine bar and slip gauge

DIAL GAUGE INDICATOR

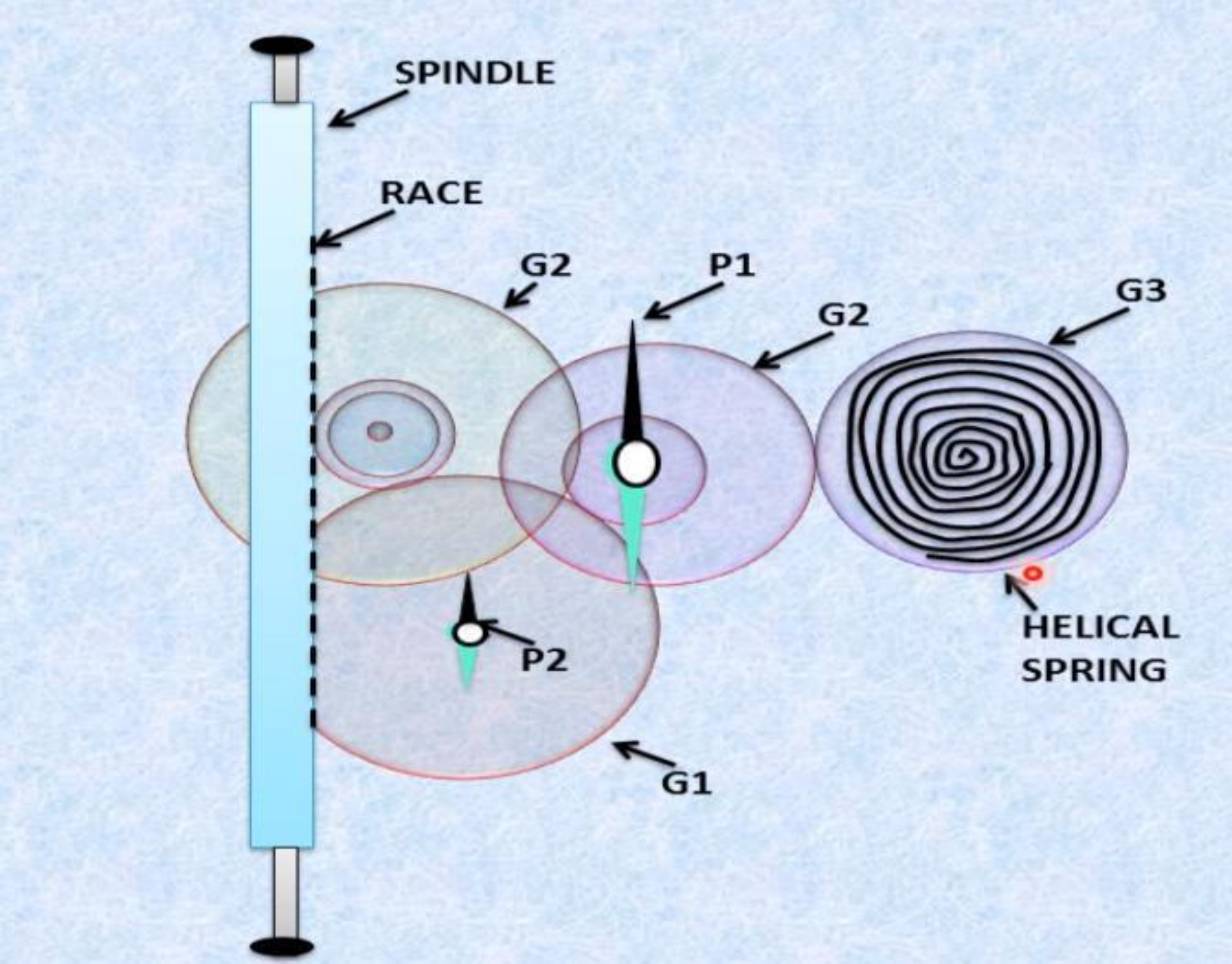
- **It is used for measuring flatness and inclination of objects**

Based on the principle of “Rack and Pinion”

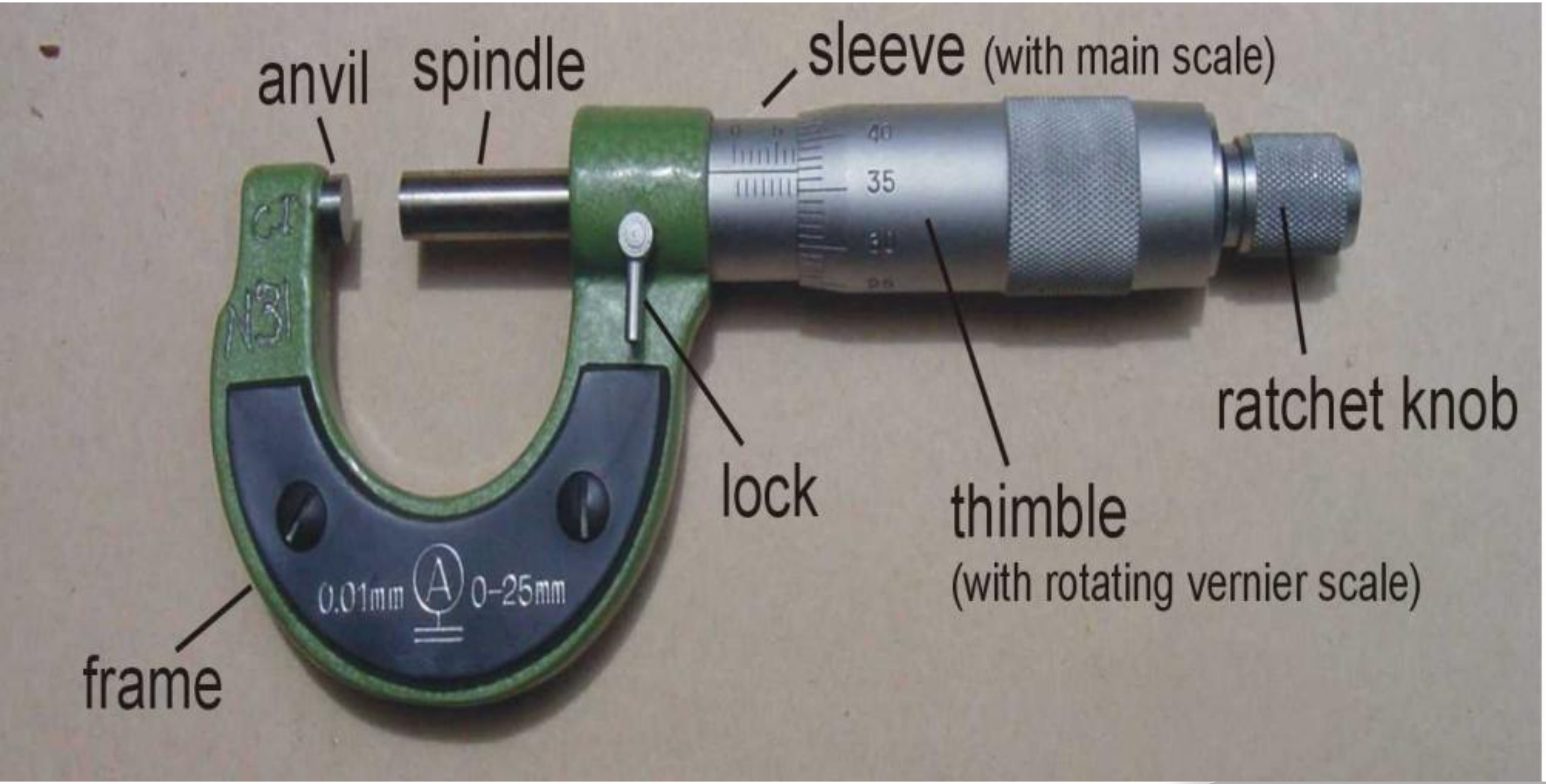
It can measure up to 0.01mm-Least count

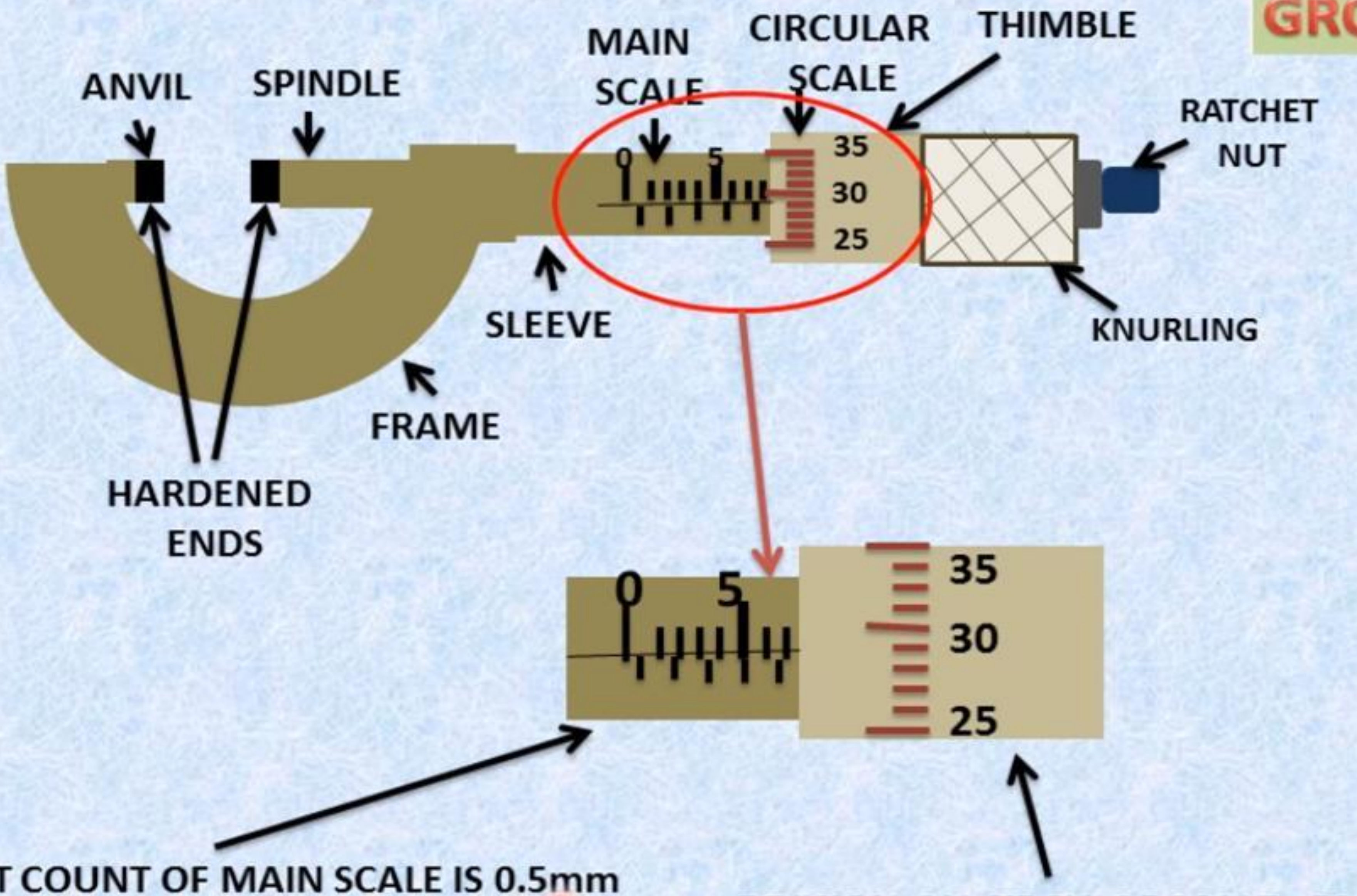

CASE
INDICATOR
0
10
20
30
40
50
60
70
80
90
P1
GRADUATED DIAL
P2
0
1
2
3
4
5
6
7
8
9
SHORT HAND INDICATOR
STEM
PLUNGER
CONTACT POINT

Internal Arrangement of Dial Gauge Indicator



MICROMETRE


anvil
spindle
sleeve (with main scale)
ratchet knob
lock
thimble
(with rotating vernier scale)
frame
40
35
30
0.01mm
0-25mm



ANVIL

SPINDLE

MAIN SCALE

CIRCULAR SCALE

THIMBLE

RATCHET NUT

SLEEVE

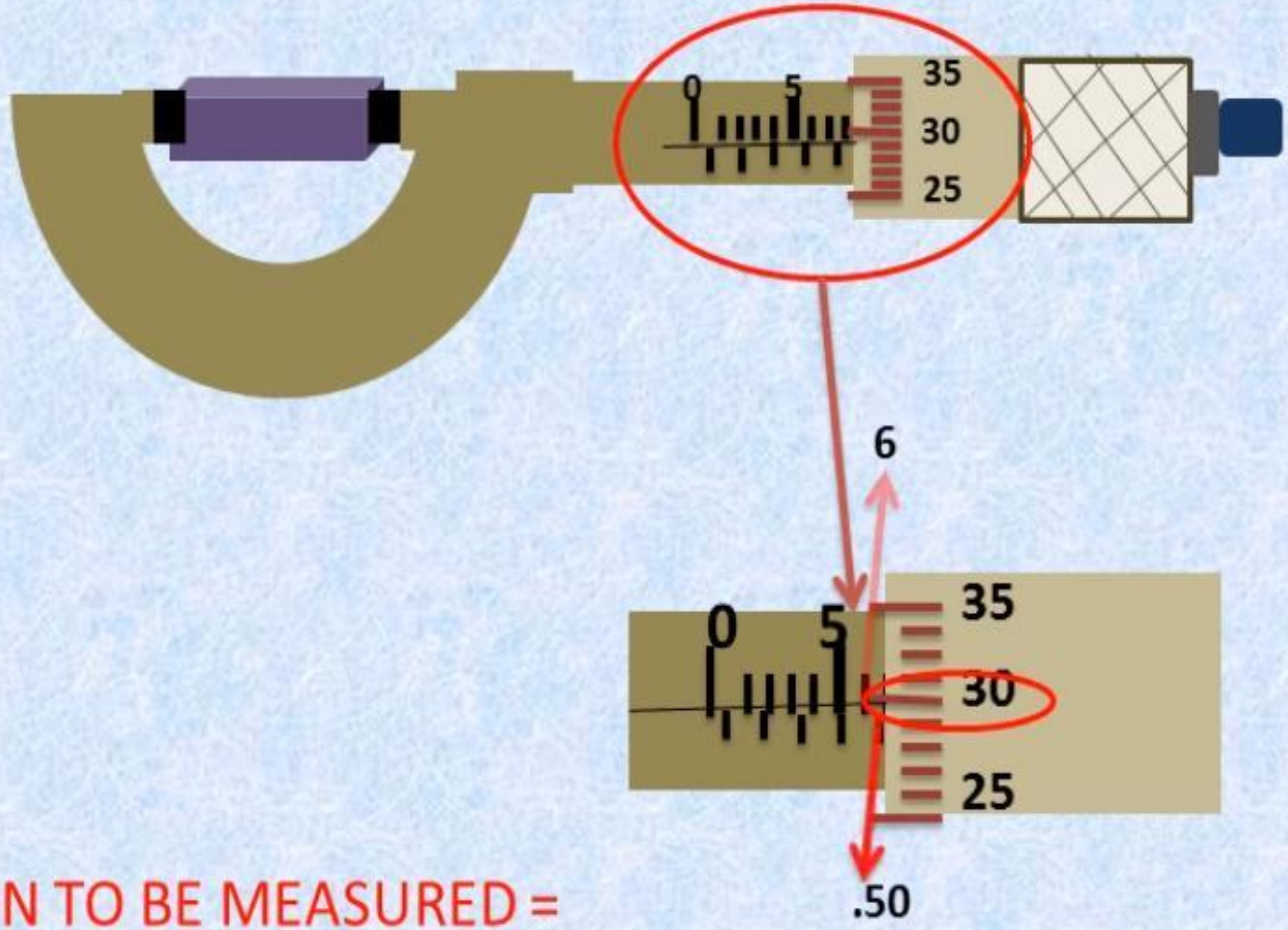
KNURLING

FRAME

HARDENED ENDS

LEAST COUNT OF MAIN SCALE IS 0.5mm

DIVISION ON CIRCULAR SCALE =50

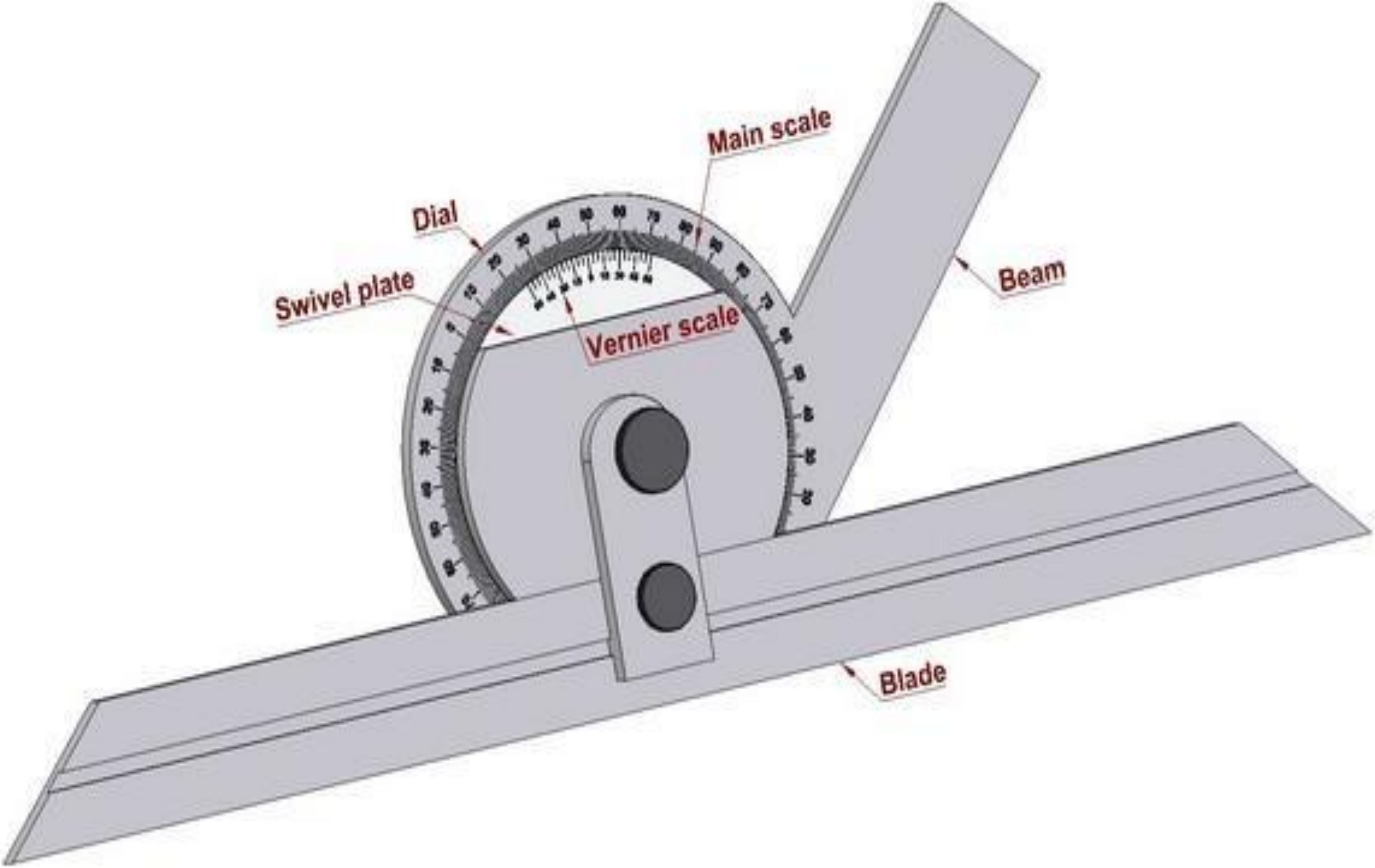


DIMENTION TO BE MEASURED =

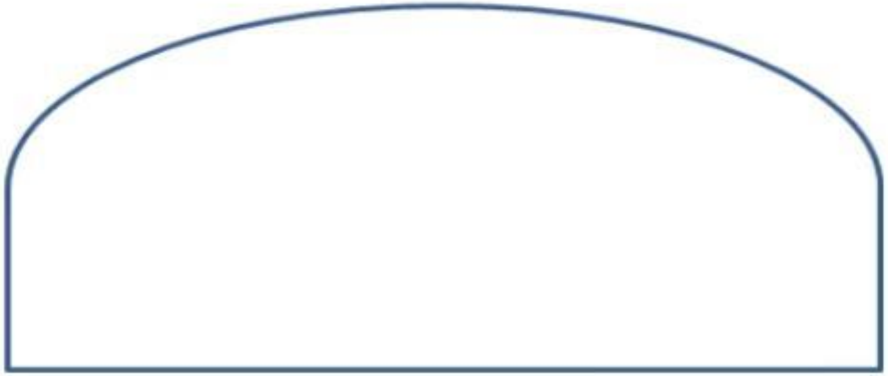
MAIN SCALE READING + (THIMBLE SCALE READING x LEAST COUNT)

$(6 + 0.50) + (30 \times 0.01) = 6.50 + 0.3 = 6.8$ mm

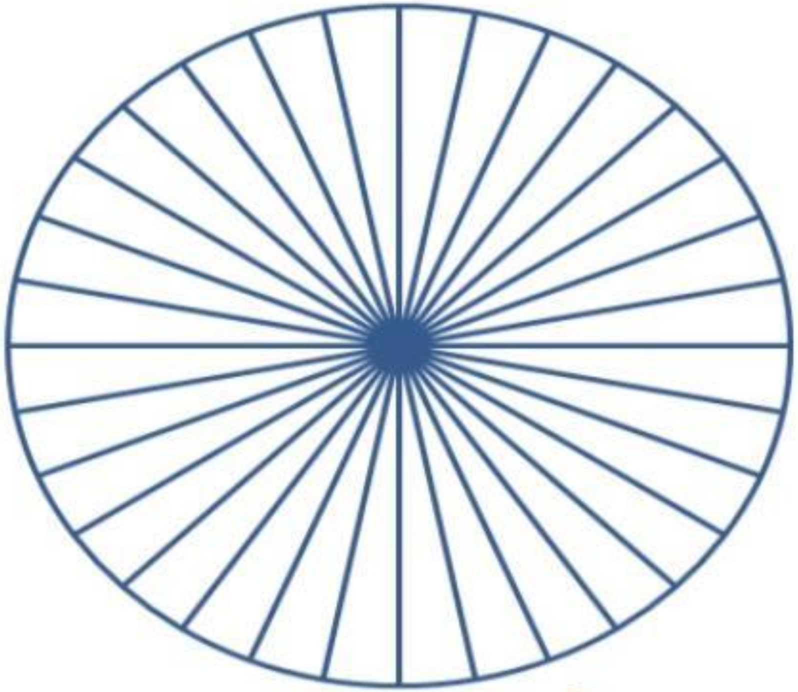
BEVEL PROTRACTOR



BEVEL PROTRACTOR



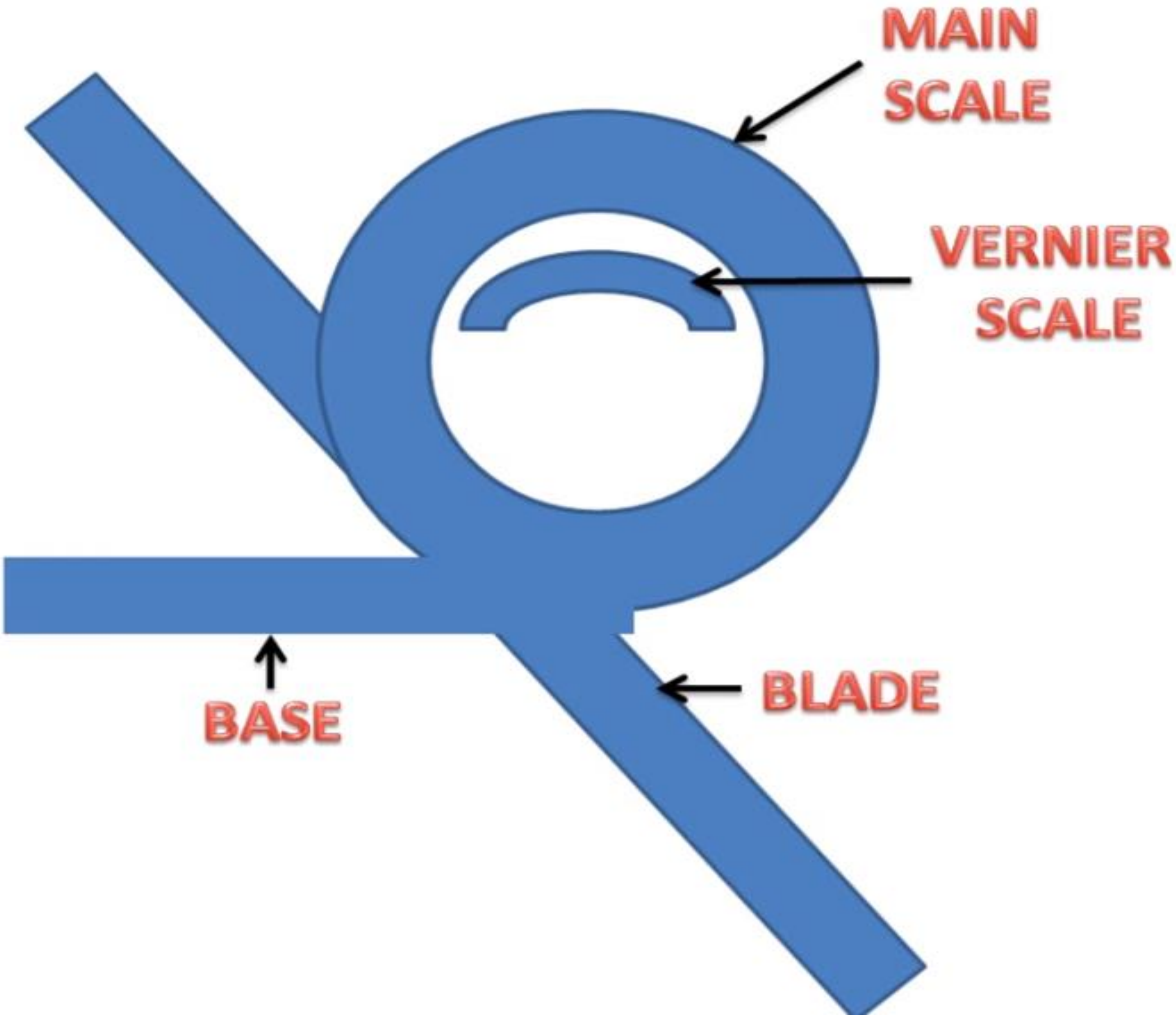
D-PROTRACTOR (180^0)

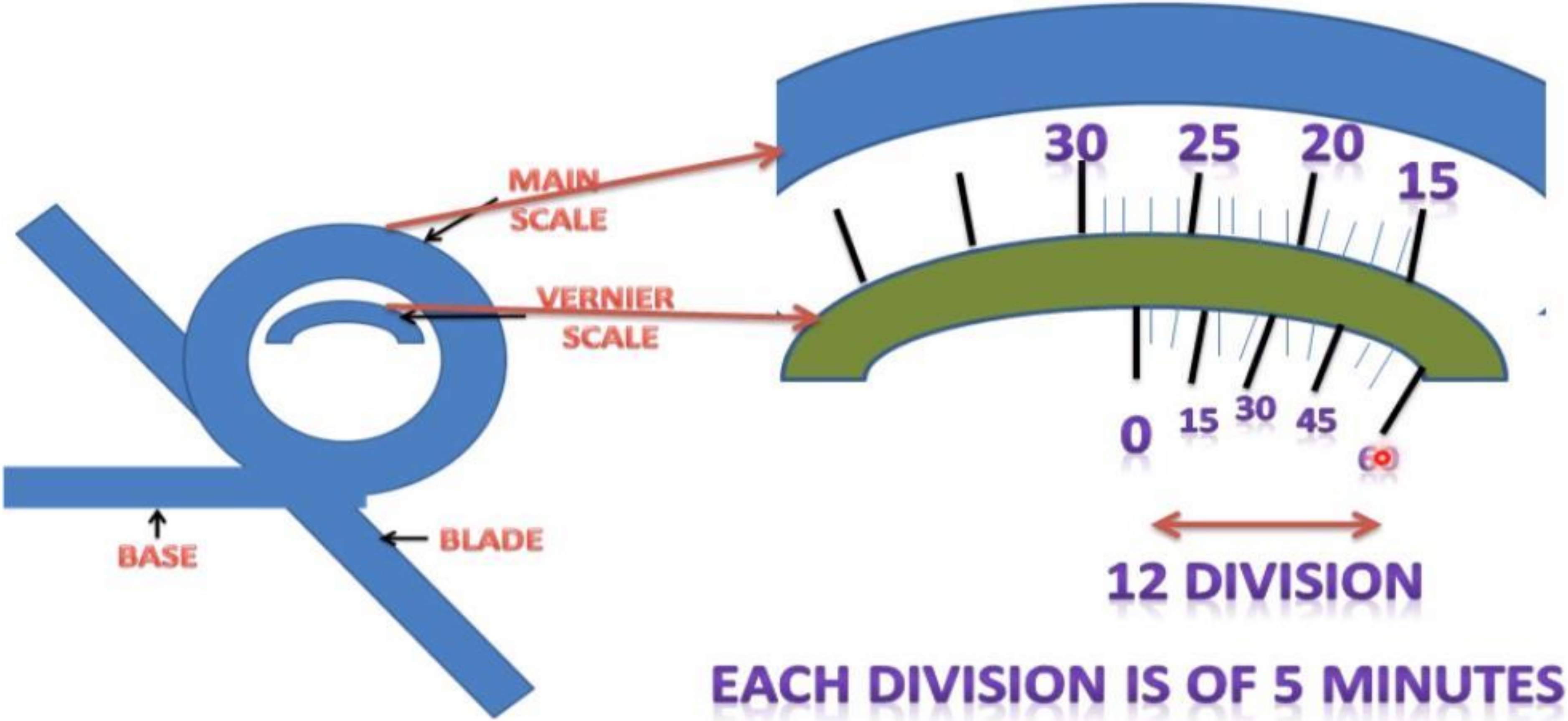


CIRCLE(360^0)

CIRCLE IS DIVIDED IN TO 360 PARTS EACH PART IS CALLED A DEGREE.

PARTS OF BEVEL PROTRACTOR

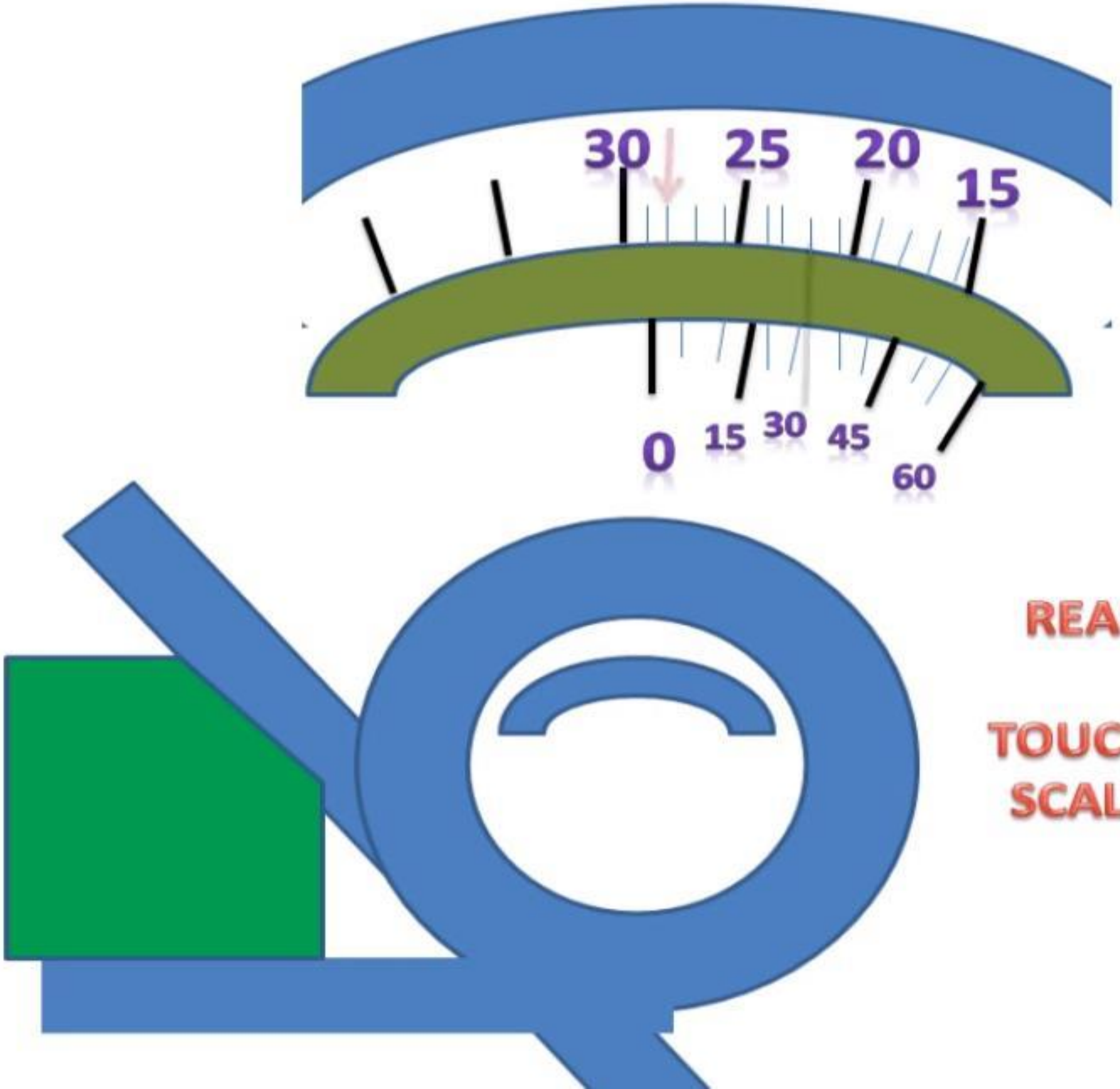




12 DIVISION

EACH DIVISION IS OF 5 MINUTES

12 X 5 = 60 MINUTES



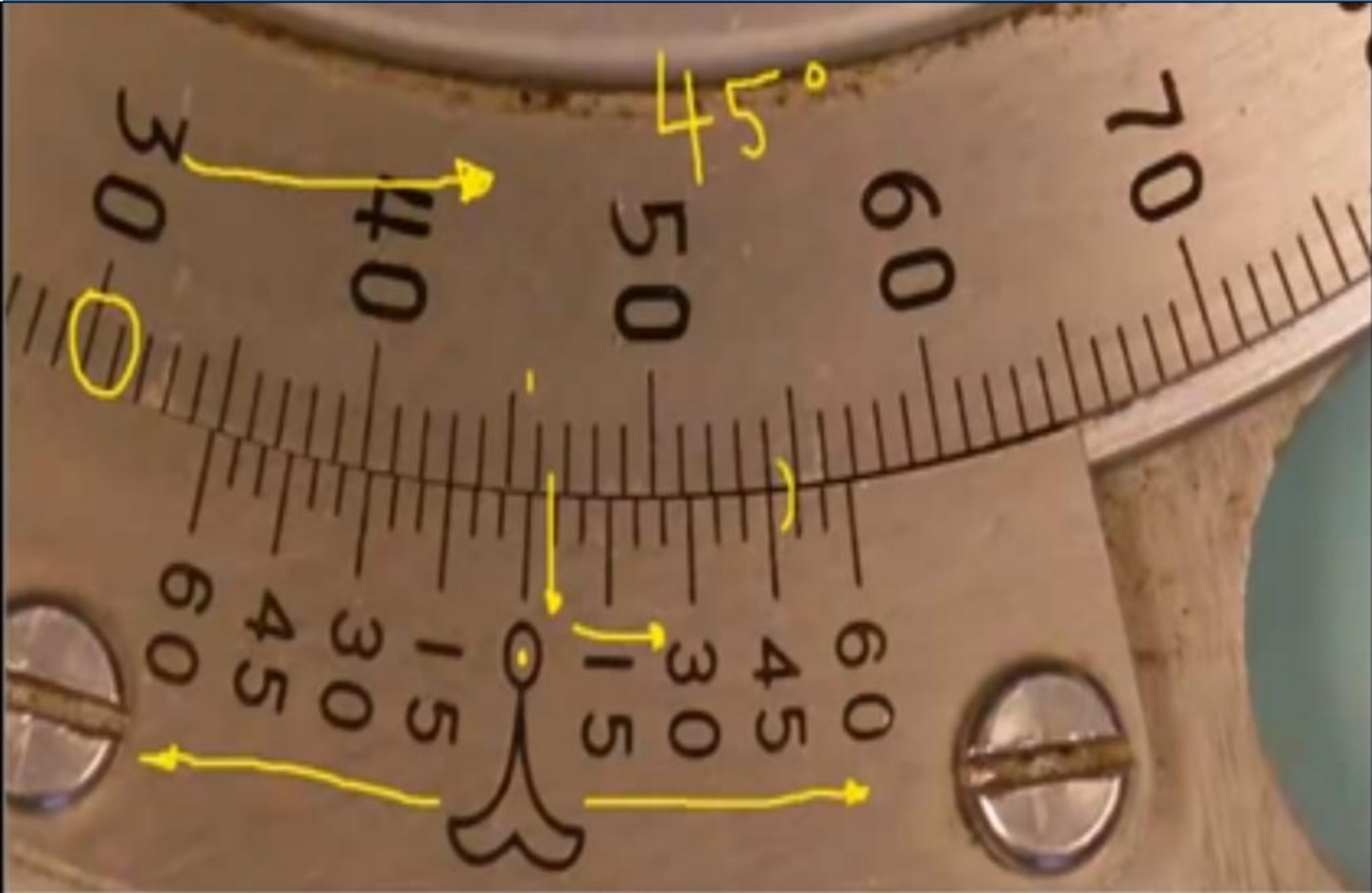
READING OF MAIN SCALE
+
TOUCHING LINE OF VERNIER SCALE TO THE MAIN SCALE

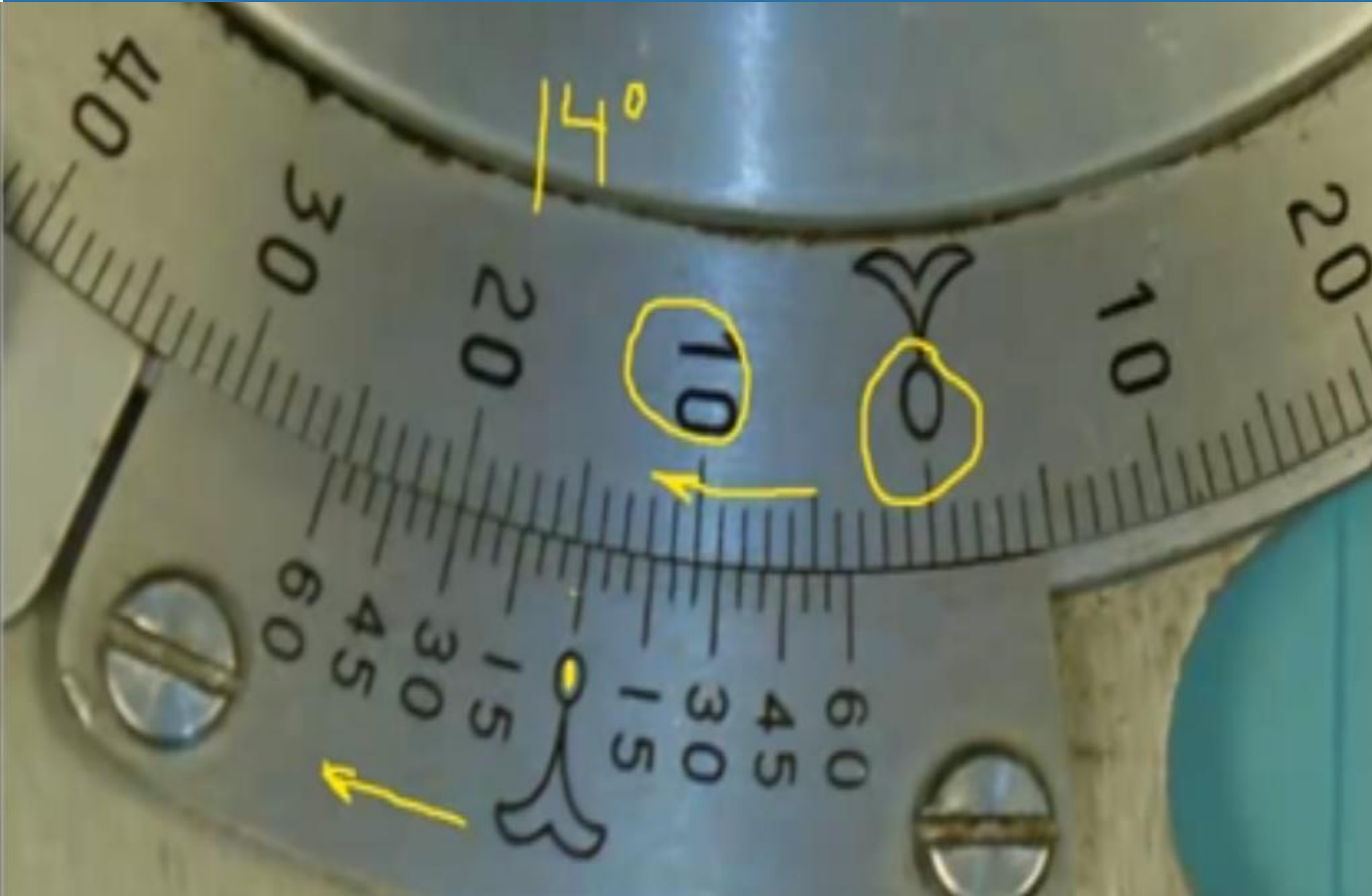
28 DEGREE
+
30 MINUTE

- Bevel protractors are nothing but angular measuring instruments.
- Types of bevel protractors:

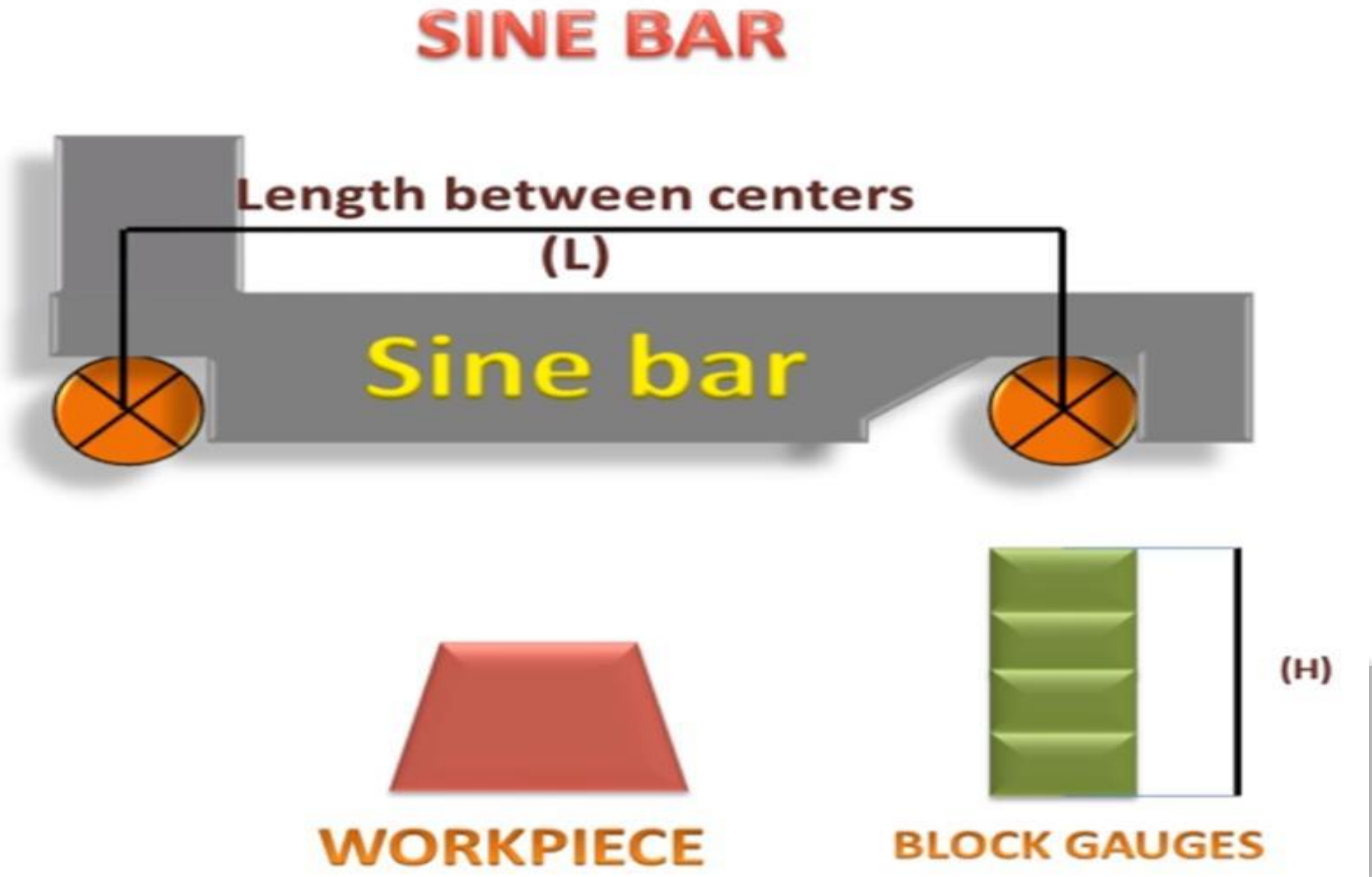
The different types of bevel protractors used are:

1) Vernier bevel protractor
2) Universal protractor
3) Optical protractor

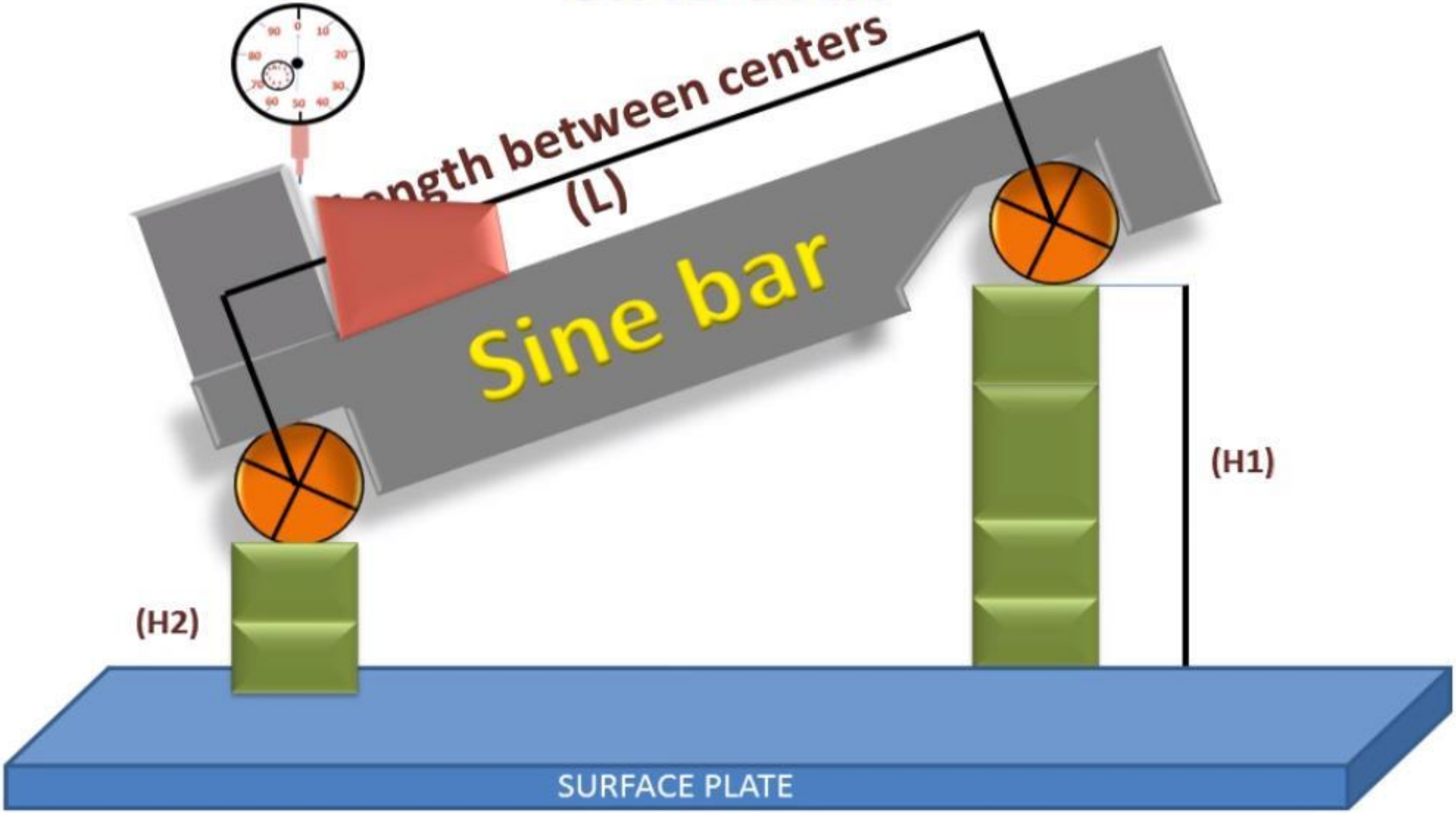

45°
30
40
50
60
70
60
45
30
15
0
15
30
45
60


14°
40
30
20
10
0
10
20
60
45
30
15
15
30
45
60

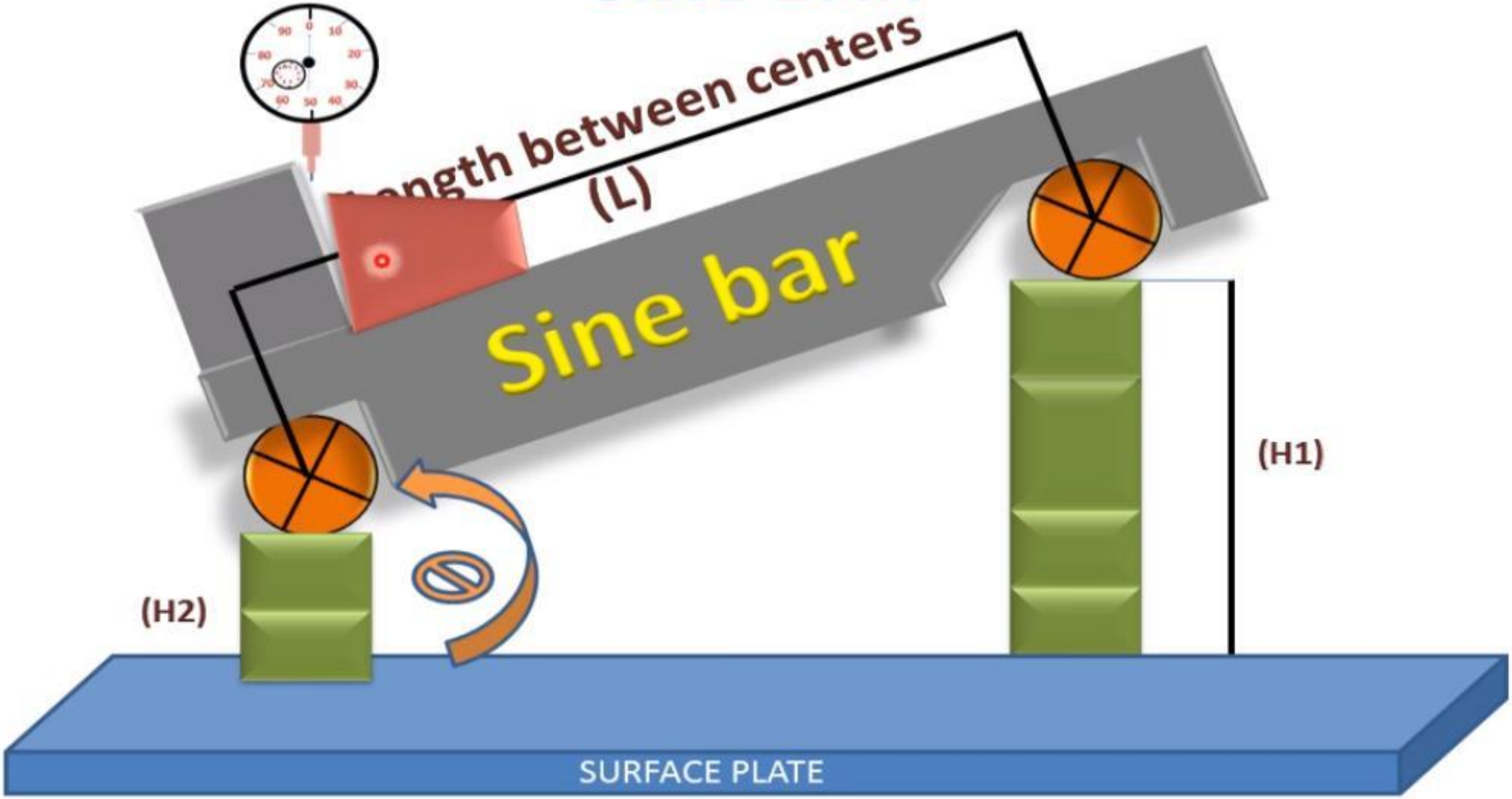
SINE BAR


SINE BAR
Length between centers
(L)
Sine bar
(H)
WORKPIECE
BLOCK GAUGES

SINE BAR

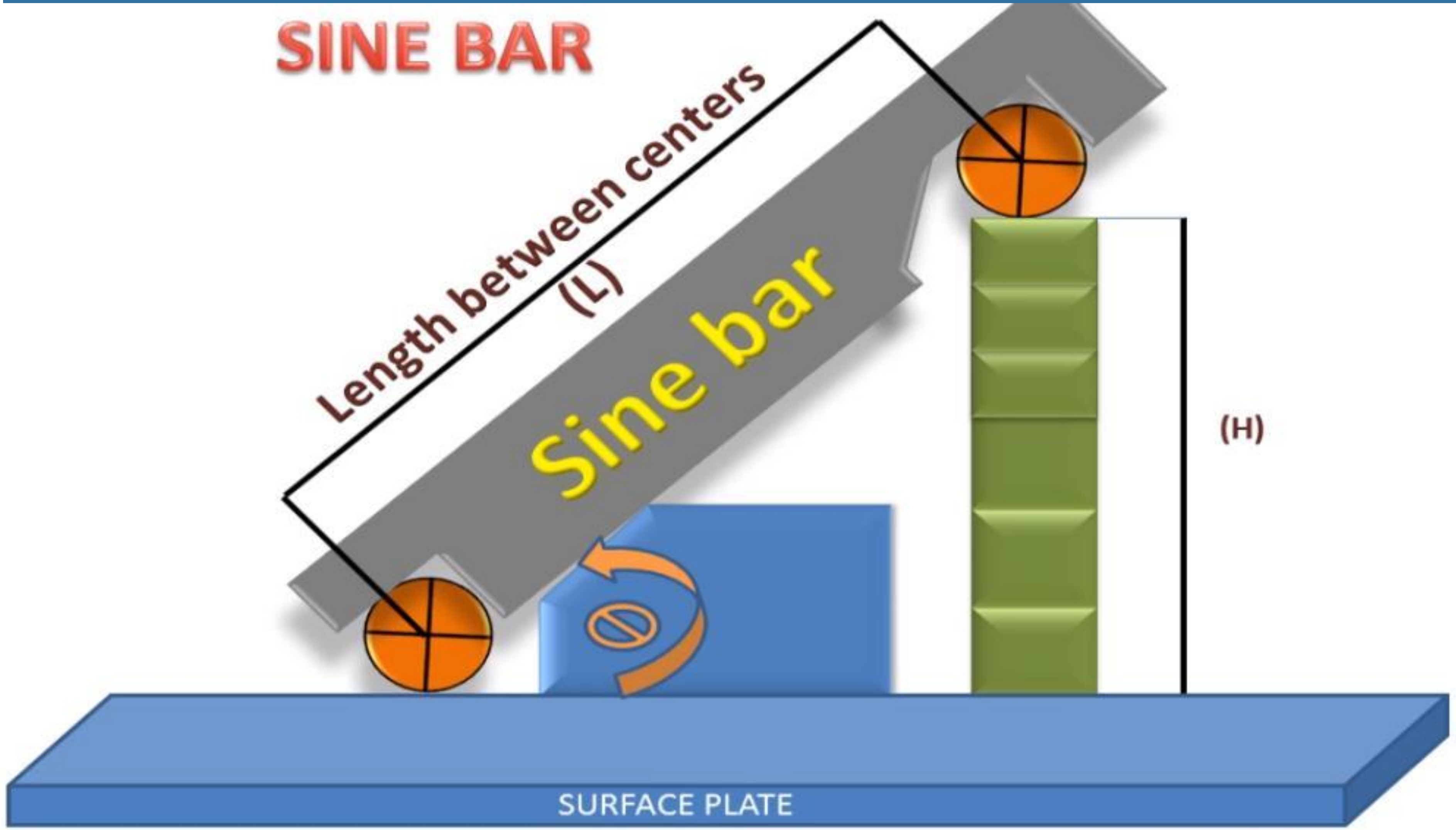


SINE BAR



SIN⊘ = H1-H2/L

SINE BAR



$SIN\,\theta = H/L \qquad \theta = SIN^{-1}\, H/L$

SPIRIT LEVEL


60cm
Accuracy 0.5 mm/m=0.029°

UNIT-V

MEASURING INSTRUMENTS

UNIT-V SYLLABUS

- Optical measuring instruments: Tool maker's microscope and its uses, collimators, optical projector, interferometer
- Screw thread measurement: Element of measurement, errors in screw threads, measurement of effective diameter
- Angle of thread and thread pitch, profile thread gauges
- Surface roughness measurement: Numerical assessment of surface finish: CLA, R.M.S Values, Rz values
- Methods of measurement of surface finish: profilograph, talysurf - ISI symbol for indication of surface finish

UNIT-V

At the end of the course students are able to :

Course Outcomes		**Knowledge Level (Bloom's Taxonomy)**
CO 11	**Apply** various methods for the measurements of screw threads, surface roughness parameters and the working of optical measuring instruments	**Apply (L3)**
CO 12	**Analyze** the results of various measuring systems and instruments for motion and dimensional measurements	**Analyze (L4)**

UNIT-V

Program Outcomes (POs)		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE / Quiz / AAT
PO 2	**Problem Analysis:** An ability to analyze complex engineering problems to arrive at a relevant conclusion using knowledge of mathematics, science and engineering.	1	CIE / Quiz / AAT
PO 3	**Design/ development of solutions:** Competence to design a system, component or process to meet societal needs within realistic constraints.	1	Discussion /AAT

Screw Thread Terminology

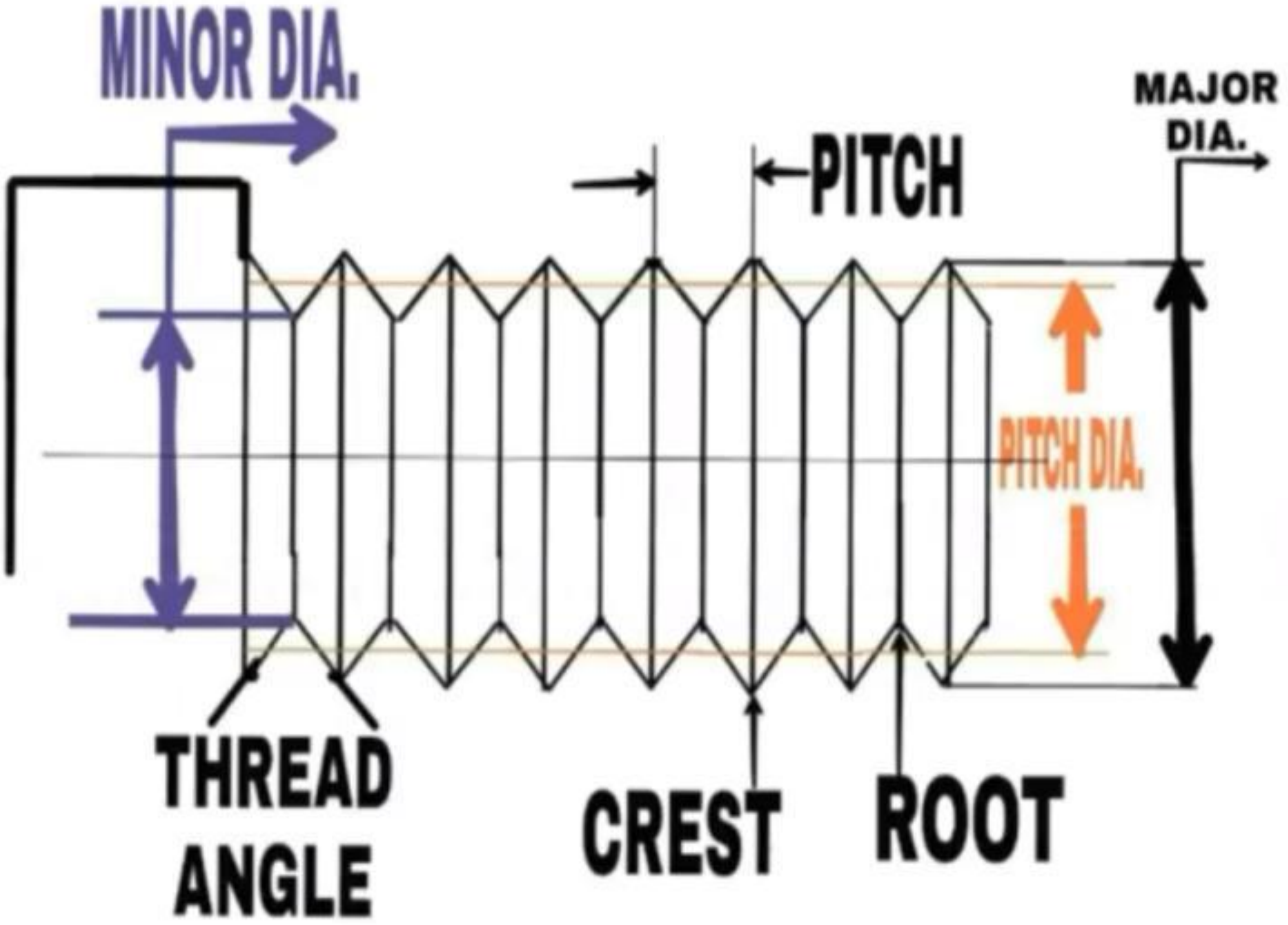


Fig-Screw Thread Terminology

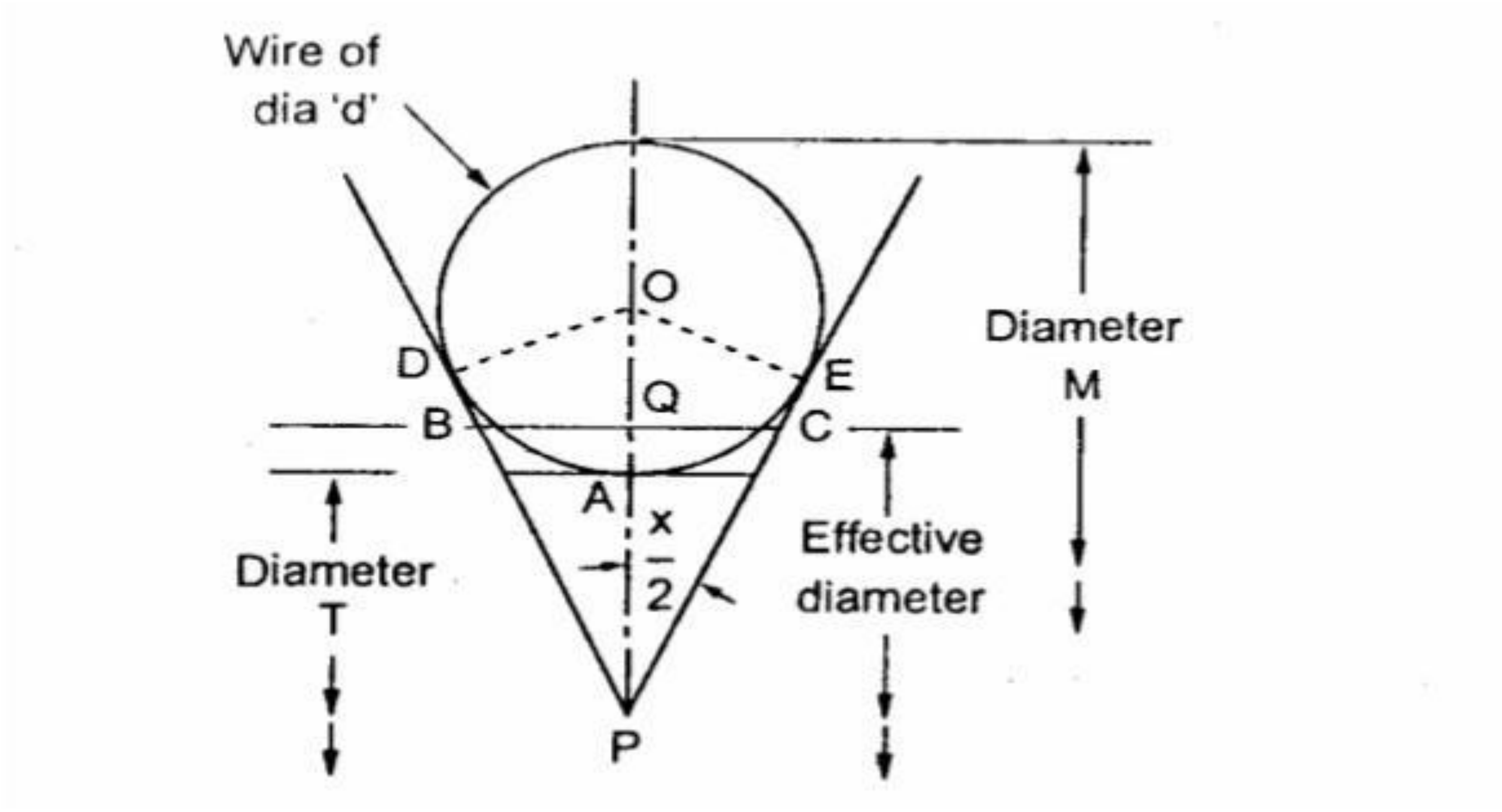
Measurement of Effective Diameter

1. **Thread micrometre method**

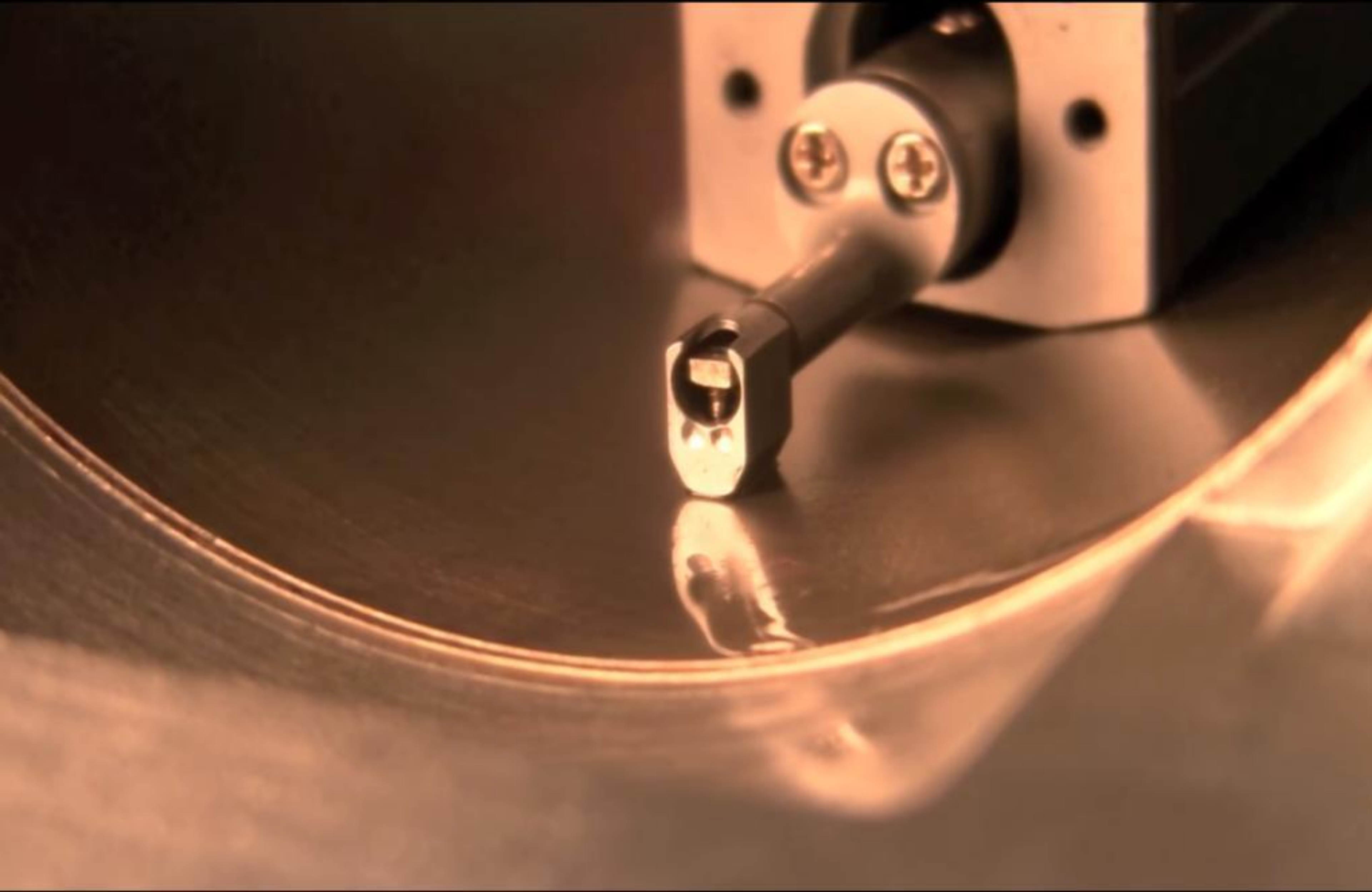
2. **one wire, two wire and three wire method**

Two wire method

Two wire method:



PROFILOMETER



PROFILOMETER

- A fine pointed stylus mounted in the pick-up unit is traversed across the surface either by hand or by motor drive.

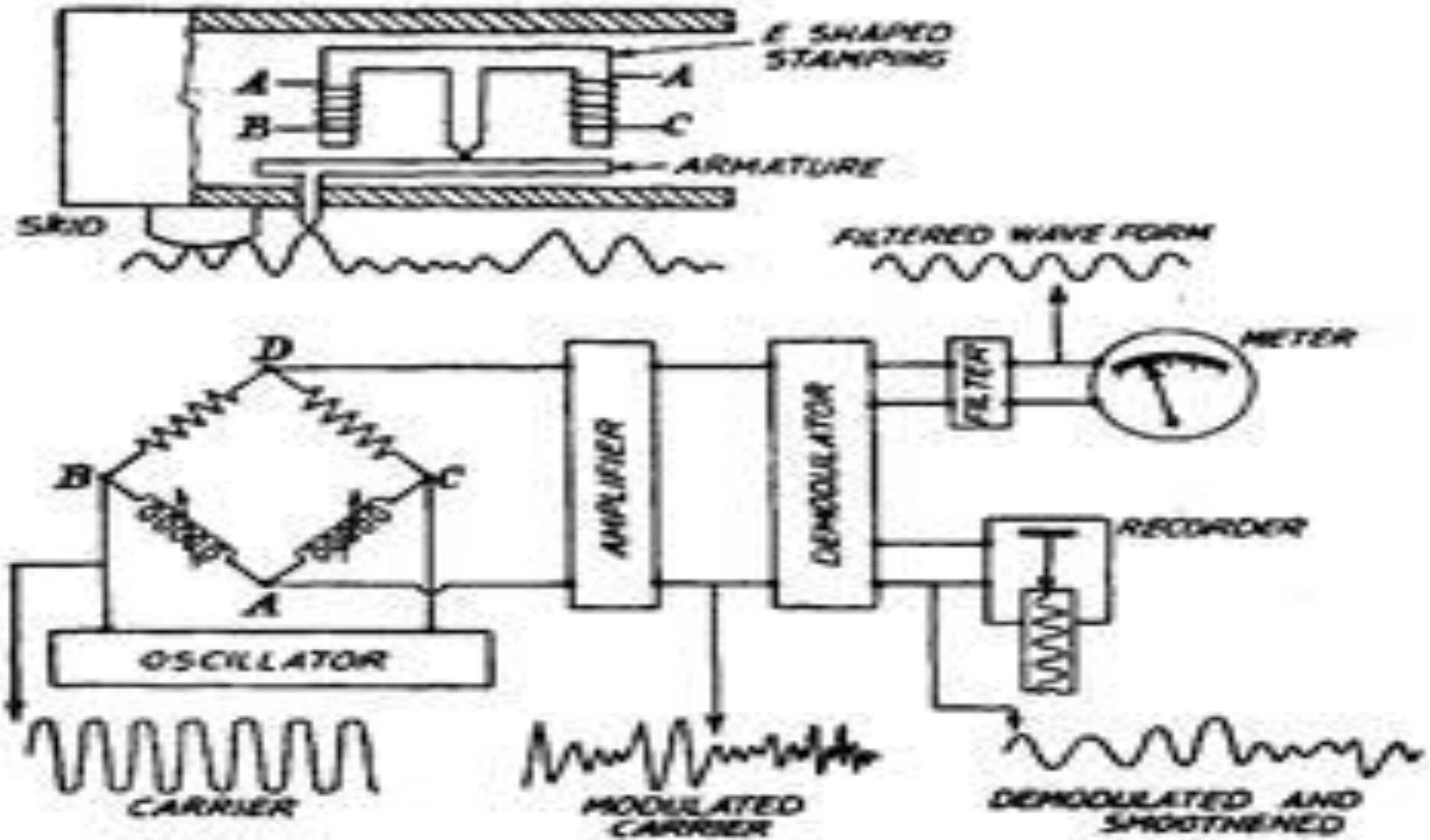
- Instruments records the rectified output from the pick-up which is amplified further and operates an indicating device.

- Thus this records the average height of the surface roughness.

- Roughness together with waviness and flaws comprises the irregularities found on the surface

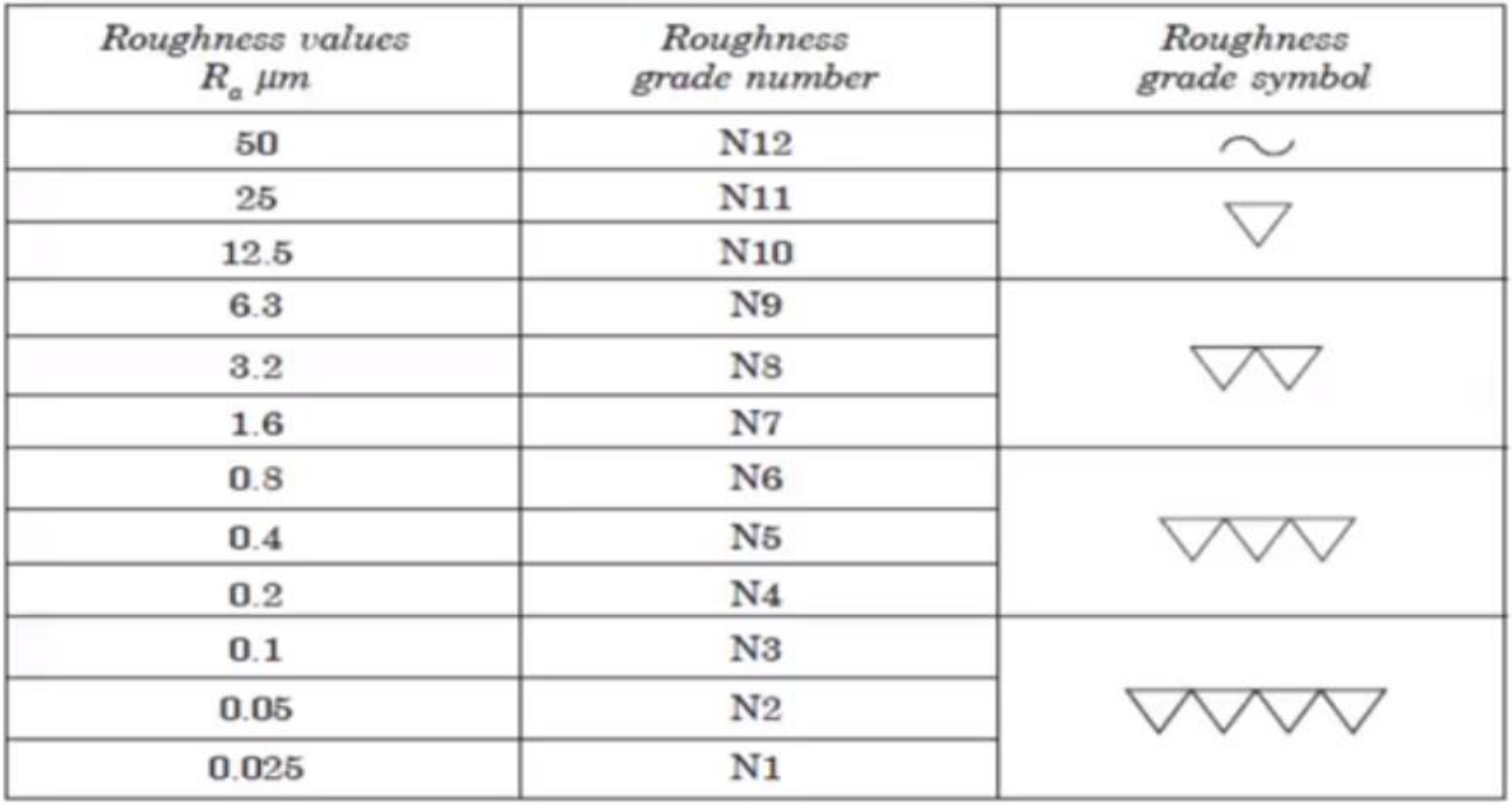
- Instrument is best in surface finish of deep bores.

TAYLOR HOBSON TALYSURF



ISI symbol for indication of surface finish

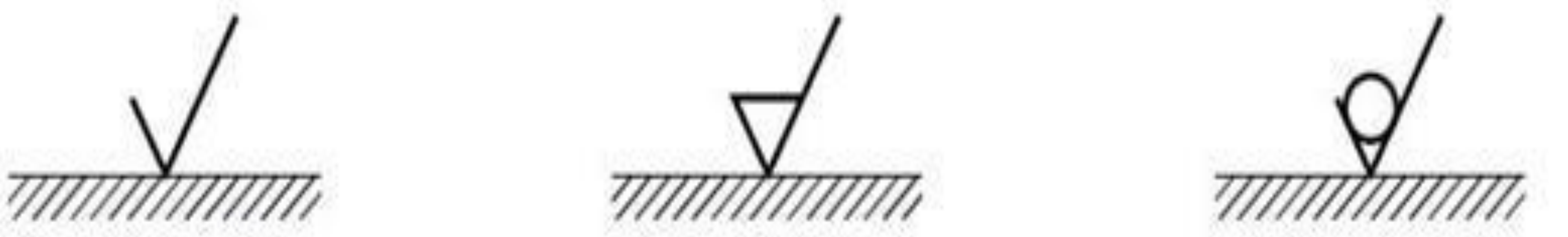
Equivalent Surface Roughness Symbols



Roughness values R_a *µm*	*Roughness grade number*	*Roughness grade symbol*
50	N12	∼
25	N11	∇
12.5	N10	
6.3	N9	∇∇
3.2	N8	
1.6	N7	
0.8	N6	∇∇∇
0.4	N5	
0.2	N4	
0.1	N3	∇∇∇∇
0.05	N2	
0.025	N1	

Symbols indicating target surface and the position of these symbols

When pictorially representing the surface texture, the symbol that indicates the target surface is expressed with two lines having different lengths with an angle of 60 0 between them



Symbol indicating the surface

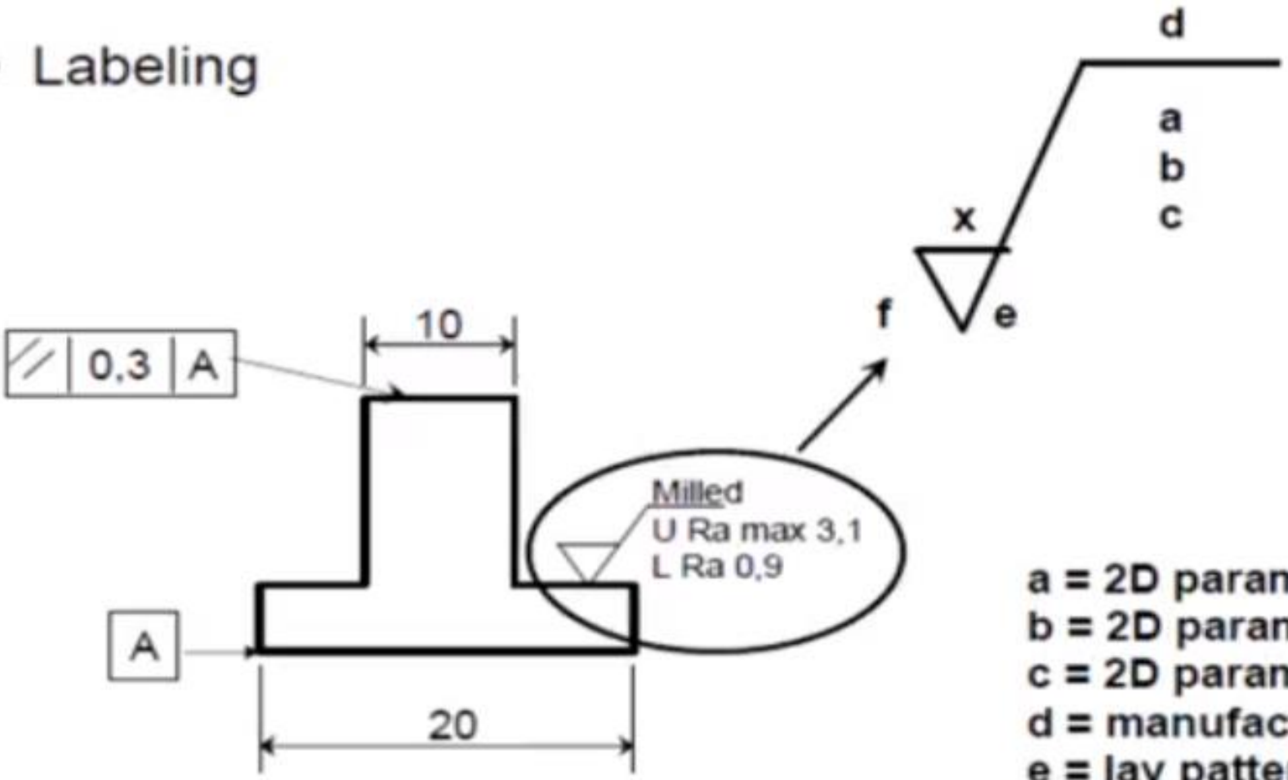
Symbol indicating a surface that requires material removal

Symbol indicating a surface that does not require material removal

This surface roughness indication method pictorially displays information such as the surface roughness value, cut-off value, sampling length, machining method, crease direction symbol, and surface waviness on the surface indication symbol as shown below

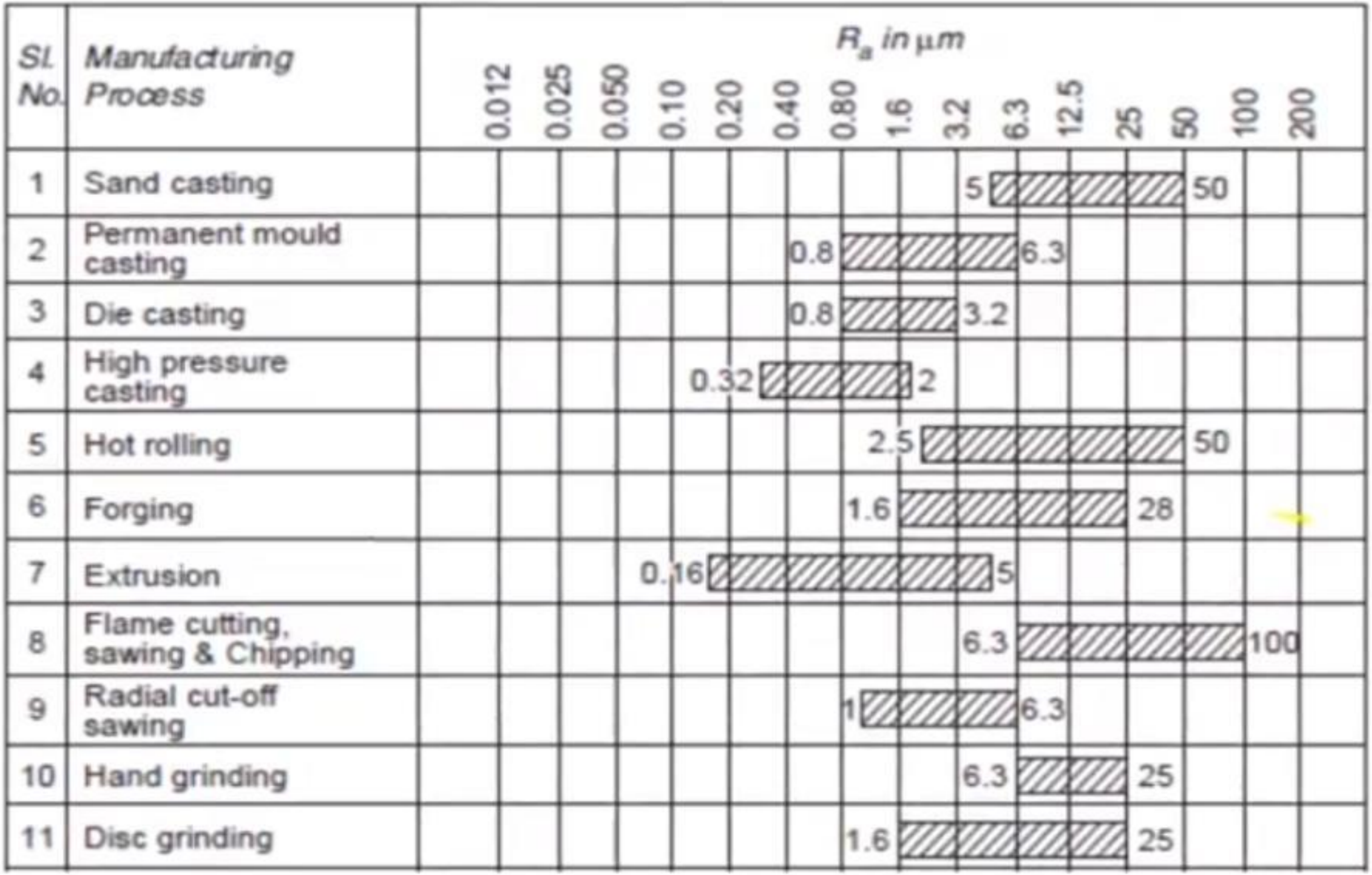
Indication of Surface Roughness

- Labeling

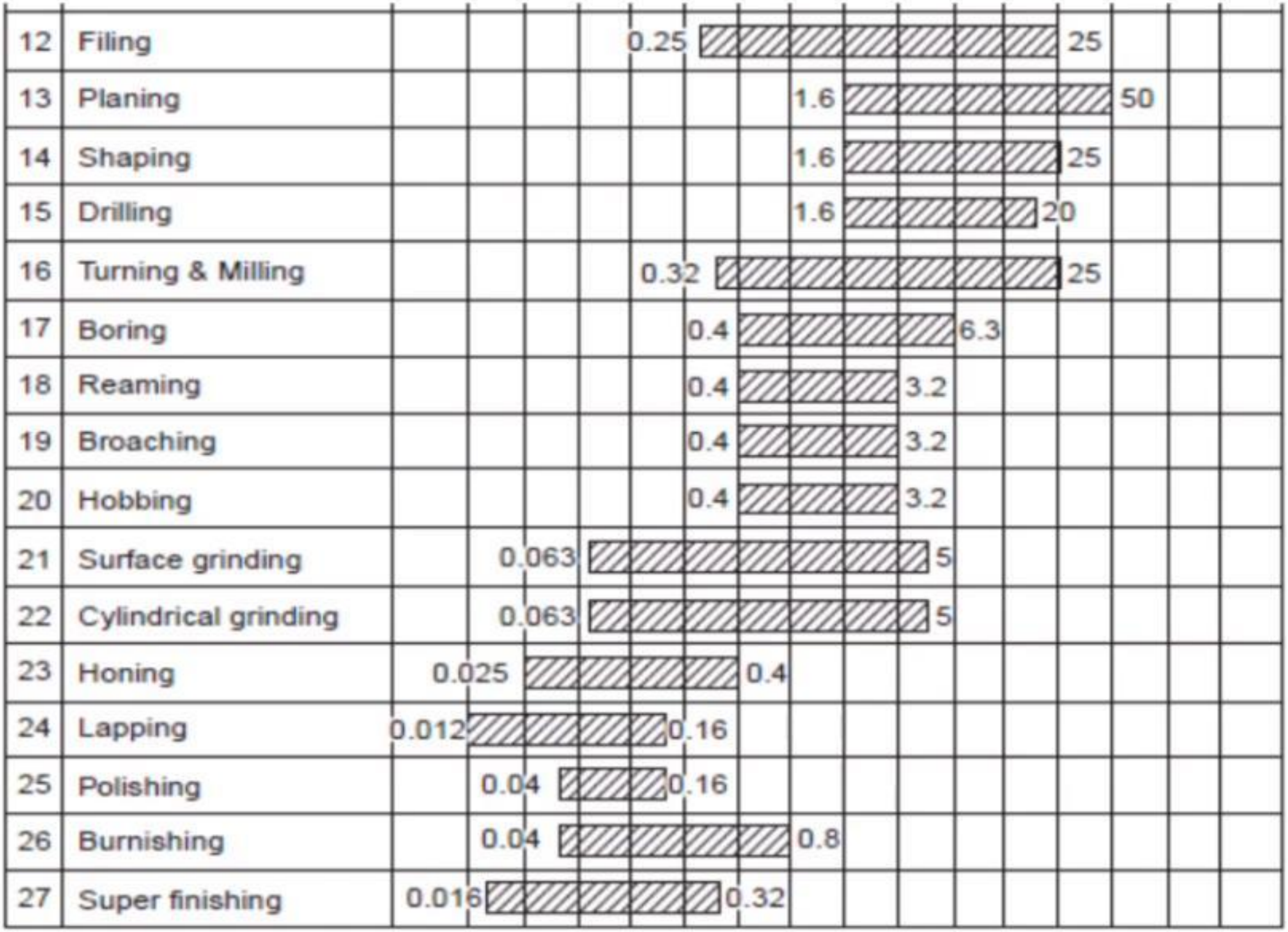


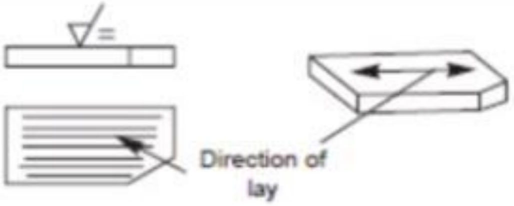
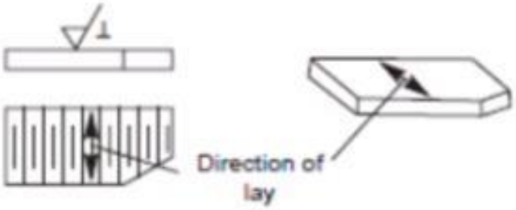
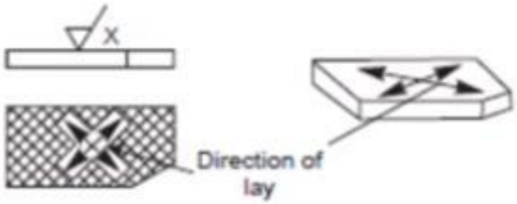
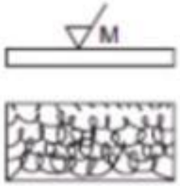
a = 2D parameter 1
b = 2D parameter 2
c = 2D parameter 3
d = manufacturing method
e = lay pattern
f = allowance
x = not allowed

Surface roughness expected from various manufacturing processes

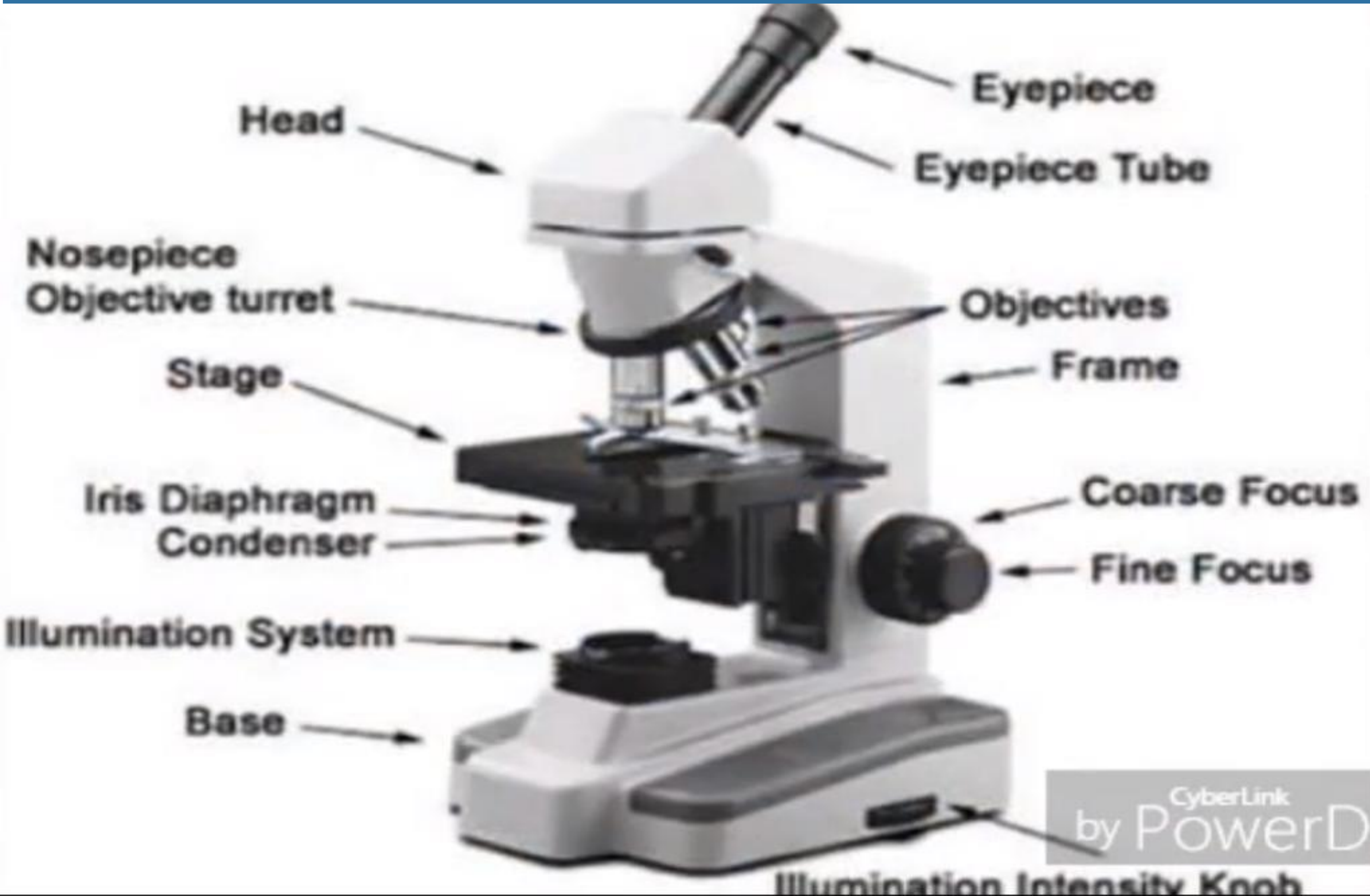


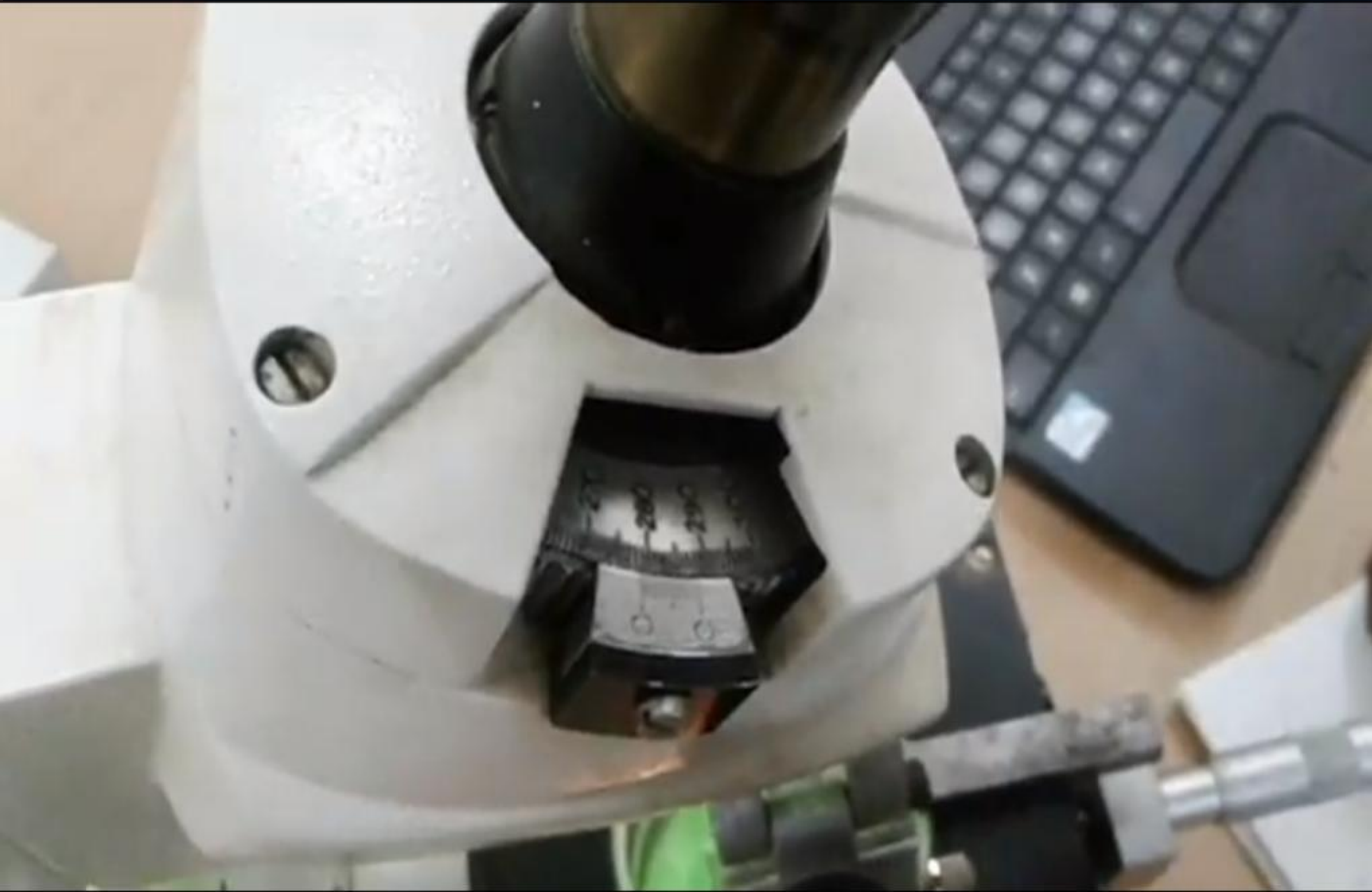
Sl. No.	Manufacturing Process	R_a in µm (0.012, 0.025, 0.050, 0.10, 0.20, 0.40, 0.80, 1.6, 3.2, 6.3, 12.5, 25, 50, 100, 200)
1	Sand casting	5 ▨ 50
2	Permanent mould casting	0.8 ▨ 6.3
3	Die casting	0.8 ▨ 3.2
4	High pressure casting	0.32 ▨ 2
5	Hot rolling	2.5 ▨ 50
6	Forging	1.6 ▨ 28
7	Extrusion	0.16 ▨ 5
8	Flame cutting, sawing & Chipping	6.3 ▨ 100
9	Radial cut-off sawing	1 ▨ 6.3
10	Hand grinding	6.3 ▨ 25
11	Disc grinding	1.6 ▨ 25

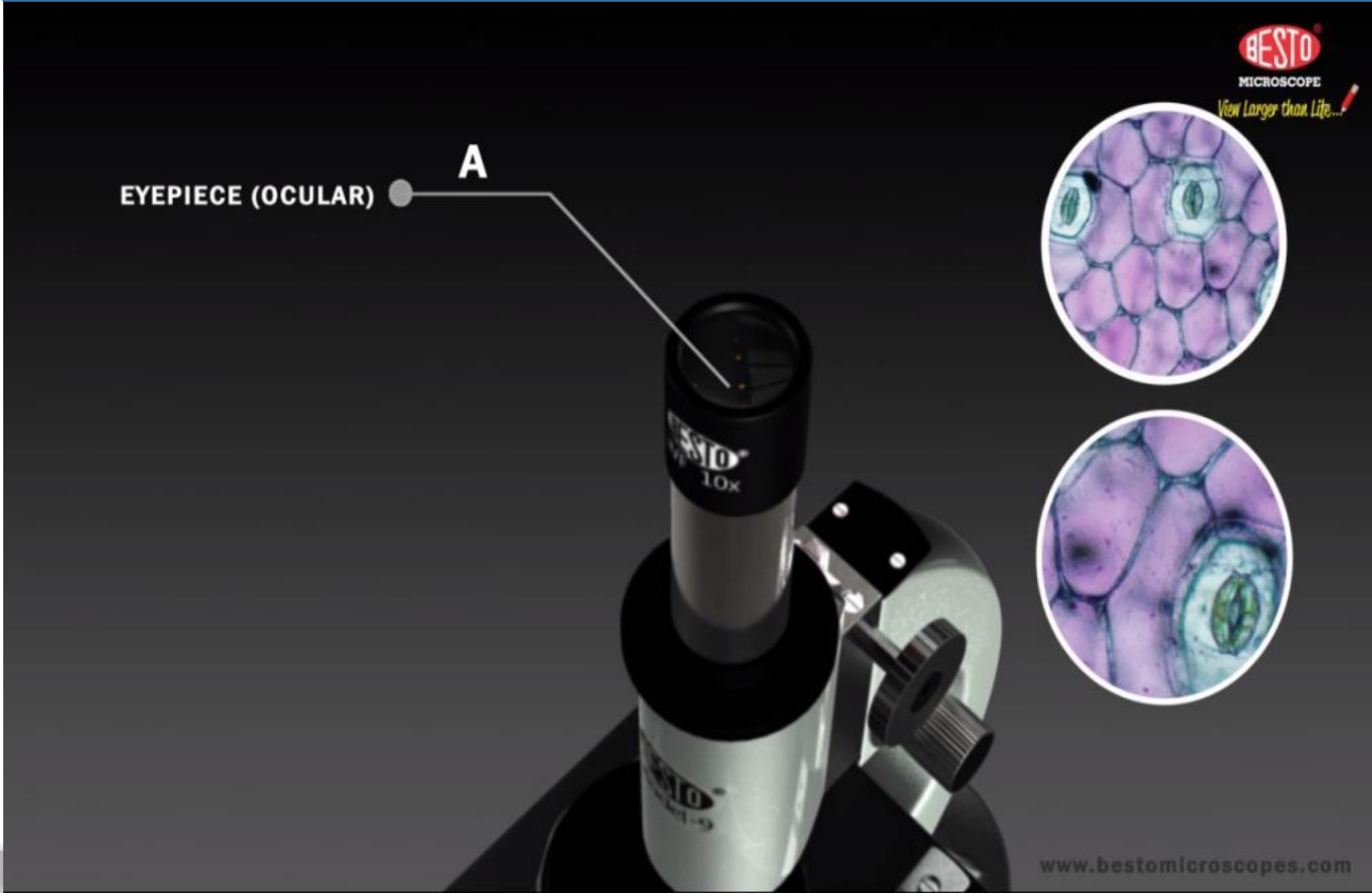

12 Filing 0.25 25
13 Planing 1.6 50
14 Shaping 1.6 25
15 Drilling 1.6 20
16 Turning & Milling 0.32 25
17 Boring 0.4 6.3
18 Reaming 0.4 3.2
19 Broaching 0.4 3.2
20 Hobbing 0.4 3.2
21 Surface grinding 0.063 5
22 Cylindrical grinding 0.063 5
23 Honing 0.025 0.4
24 Lapping 0.012 0.16
25 Polishing 0.04 0.16
26 Burnishing 0.04 0.8
27 Super finishing 0.016 0.32

Symbol	*Interpretation*	
=	Parallel to the plane of projection of the view in which the symbol is used	
⊥	Perpendicular to the plane of projection of the view in which the symbol is used	
X	Crossed in two slant directions relative to the plane of projection of the view in which the symbol is used	
M	Multi-directional	
C	Approximately circular, relative to the centre of the surface to which the symbol is applied	

Tools Makers Microscope






A
EYEPIECE (OCULAR)
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MICROSCOPE
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10x
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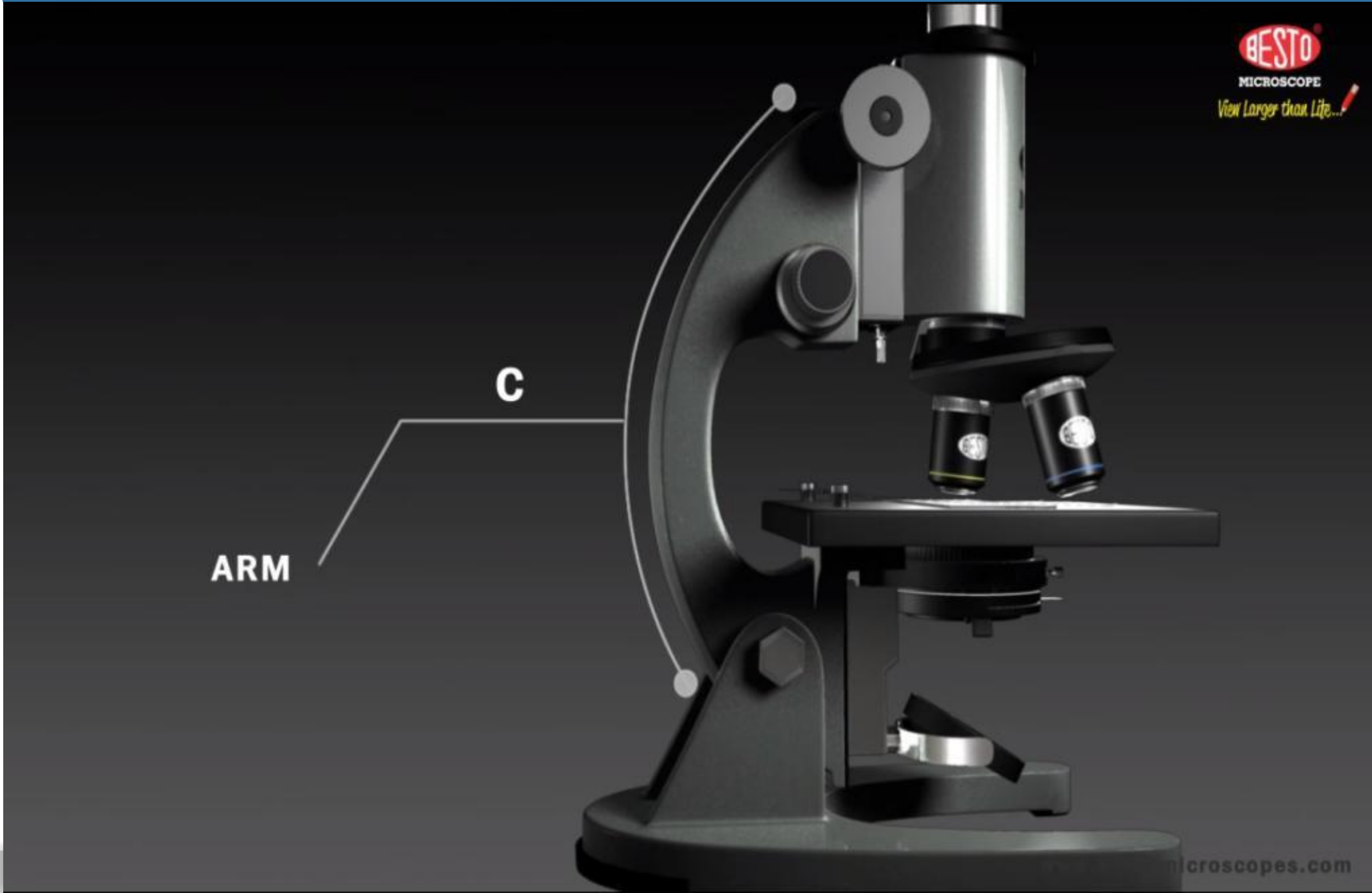
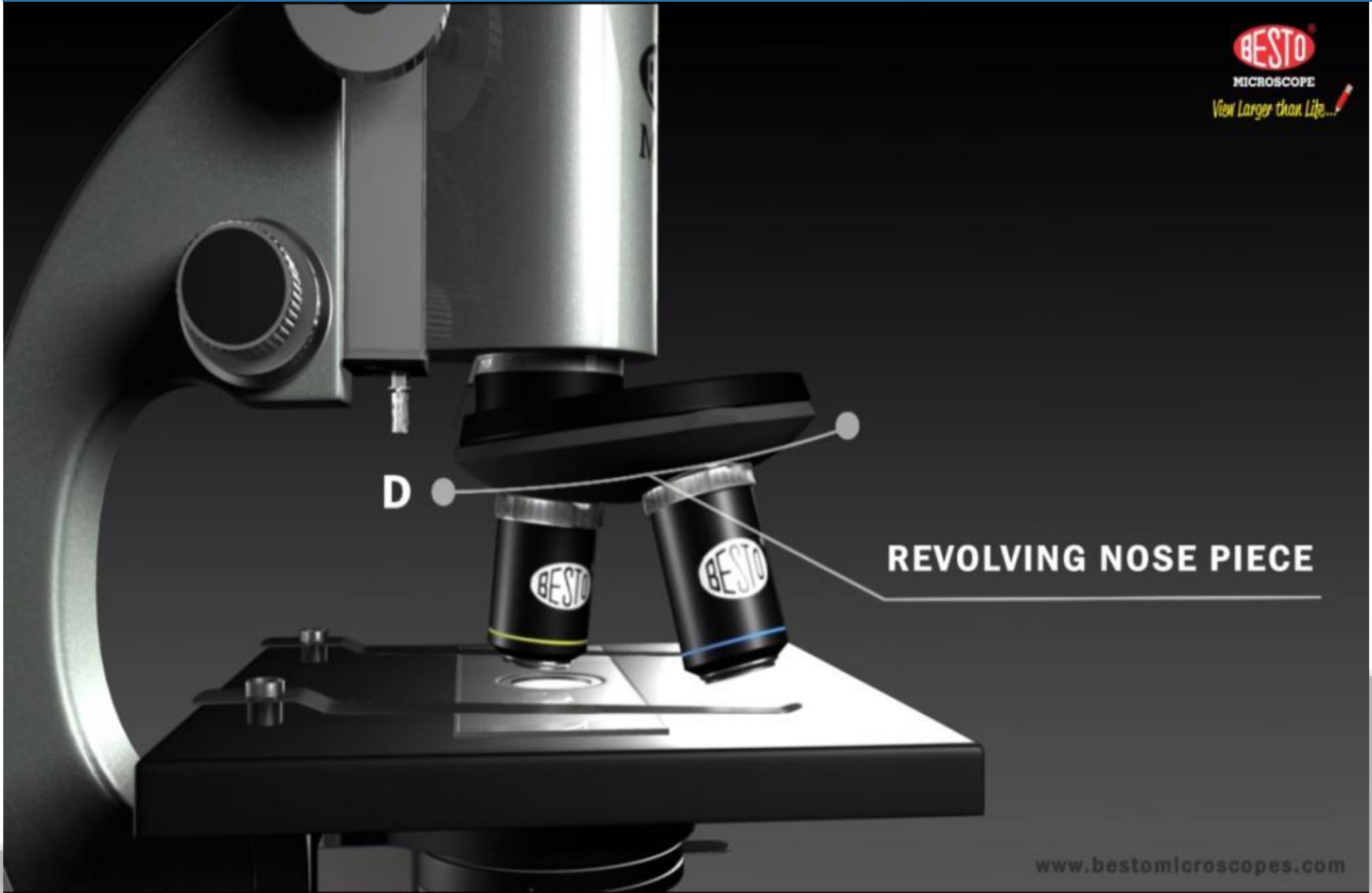
BODY TUBE


C
ARM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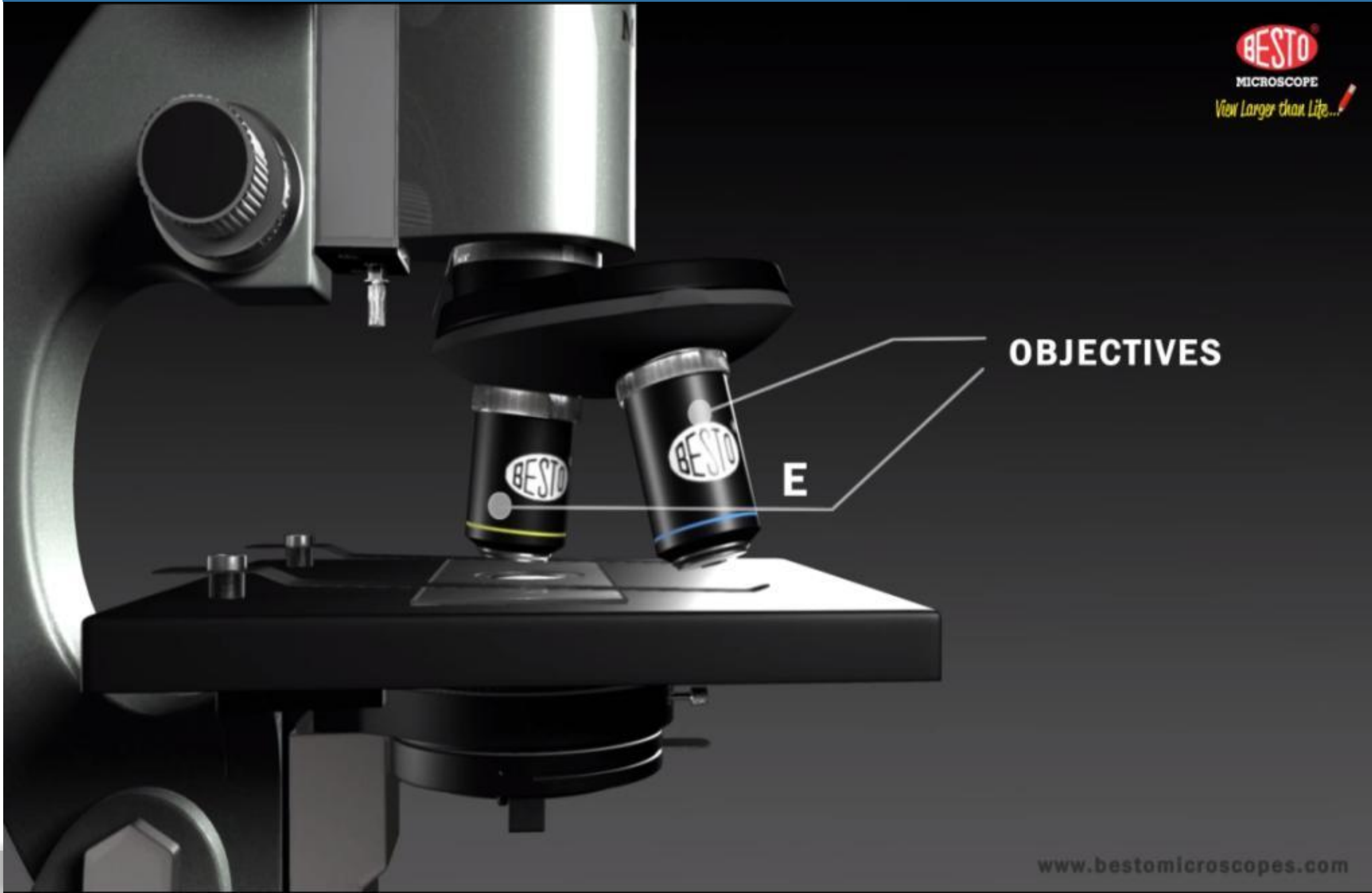
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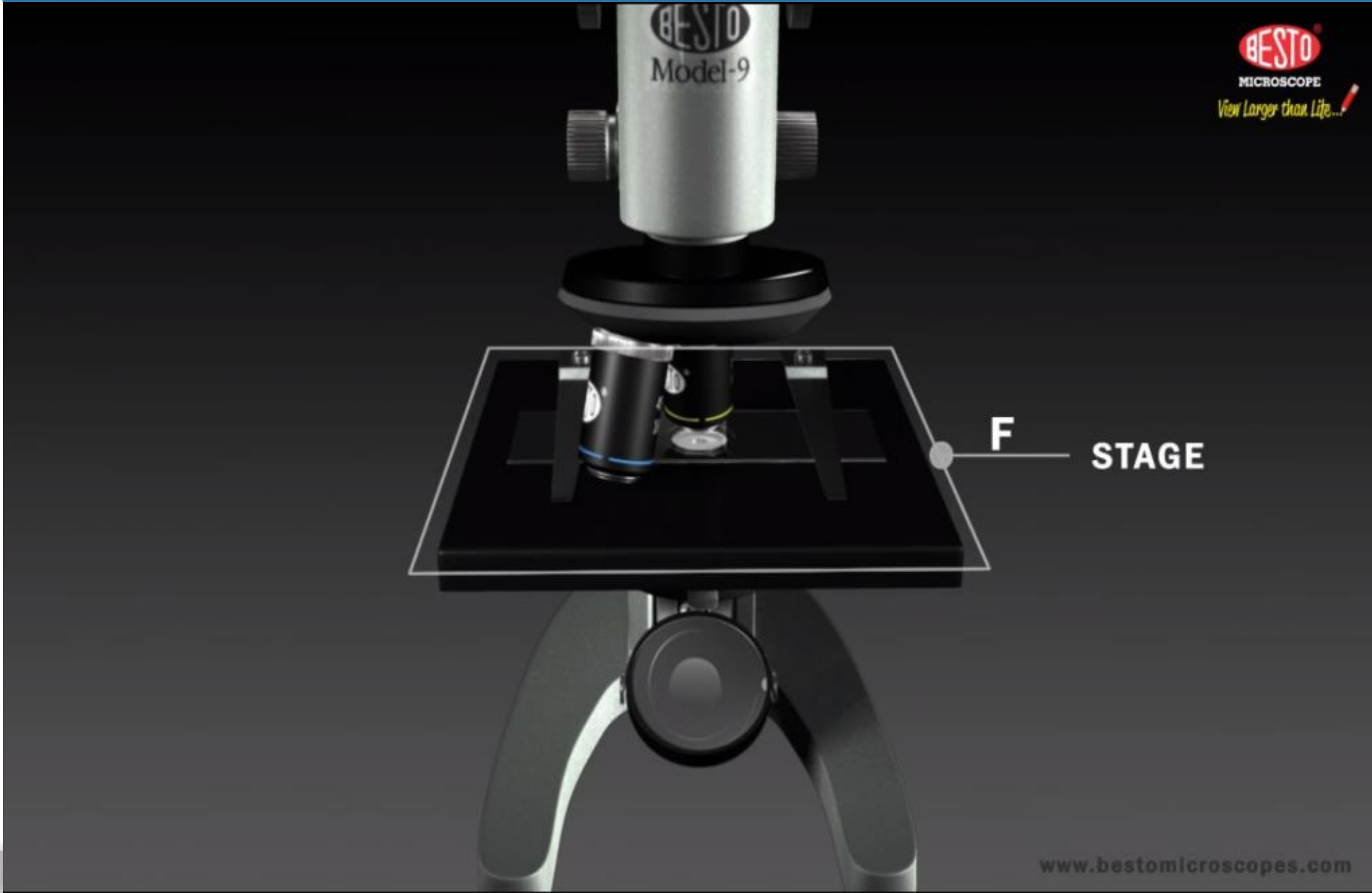
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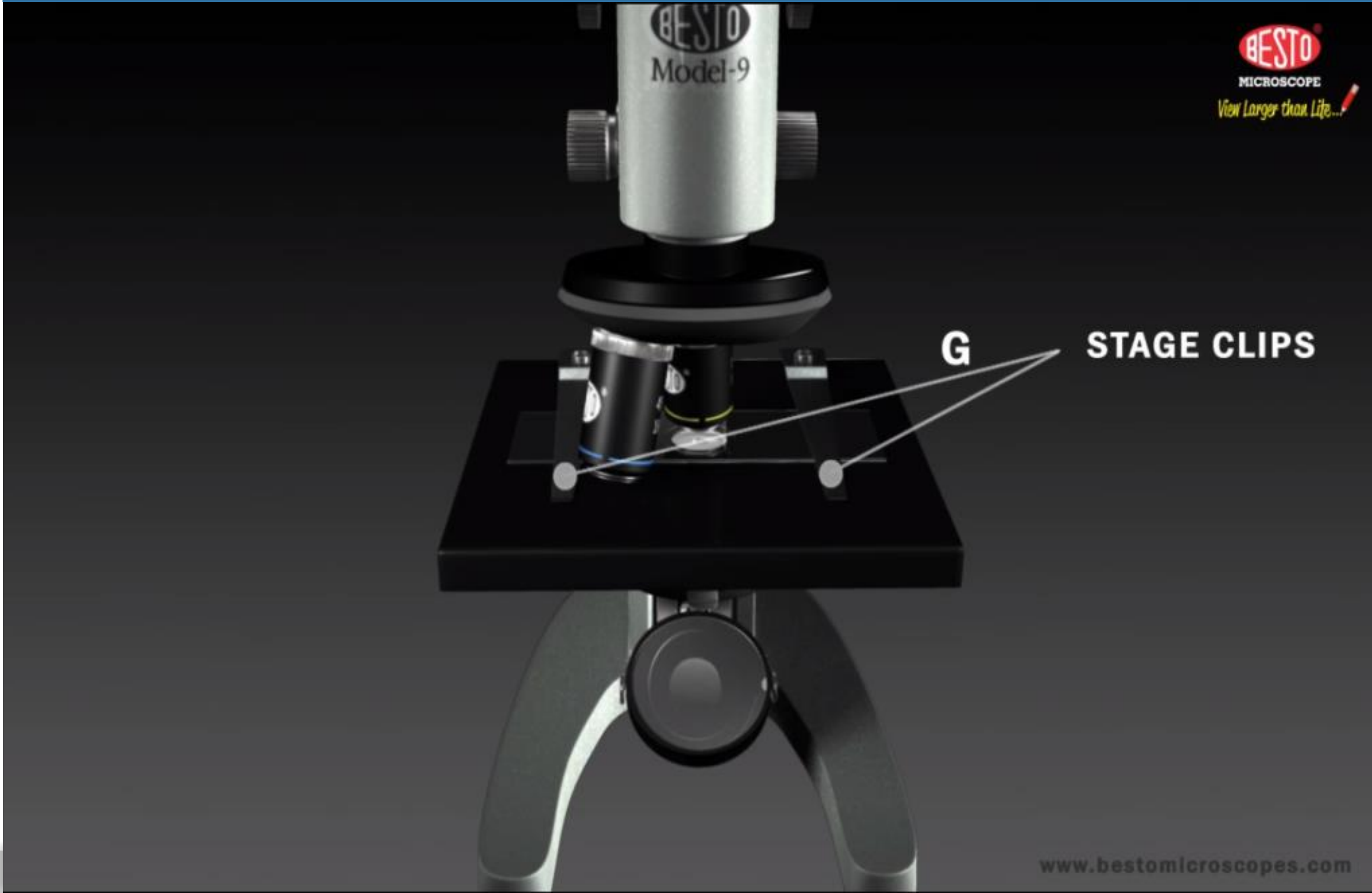
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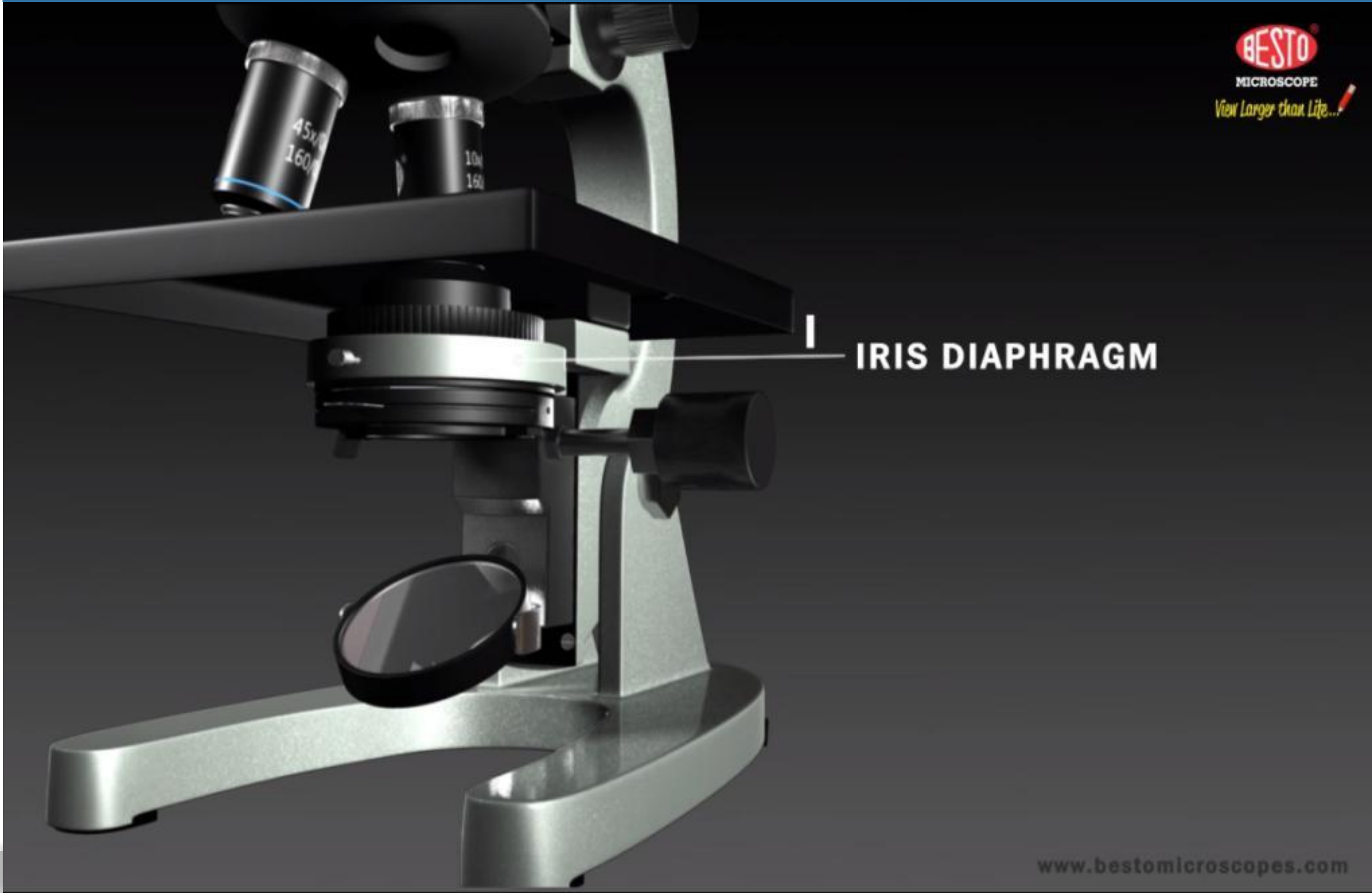
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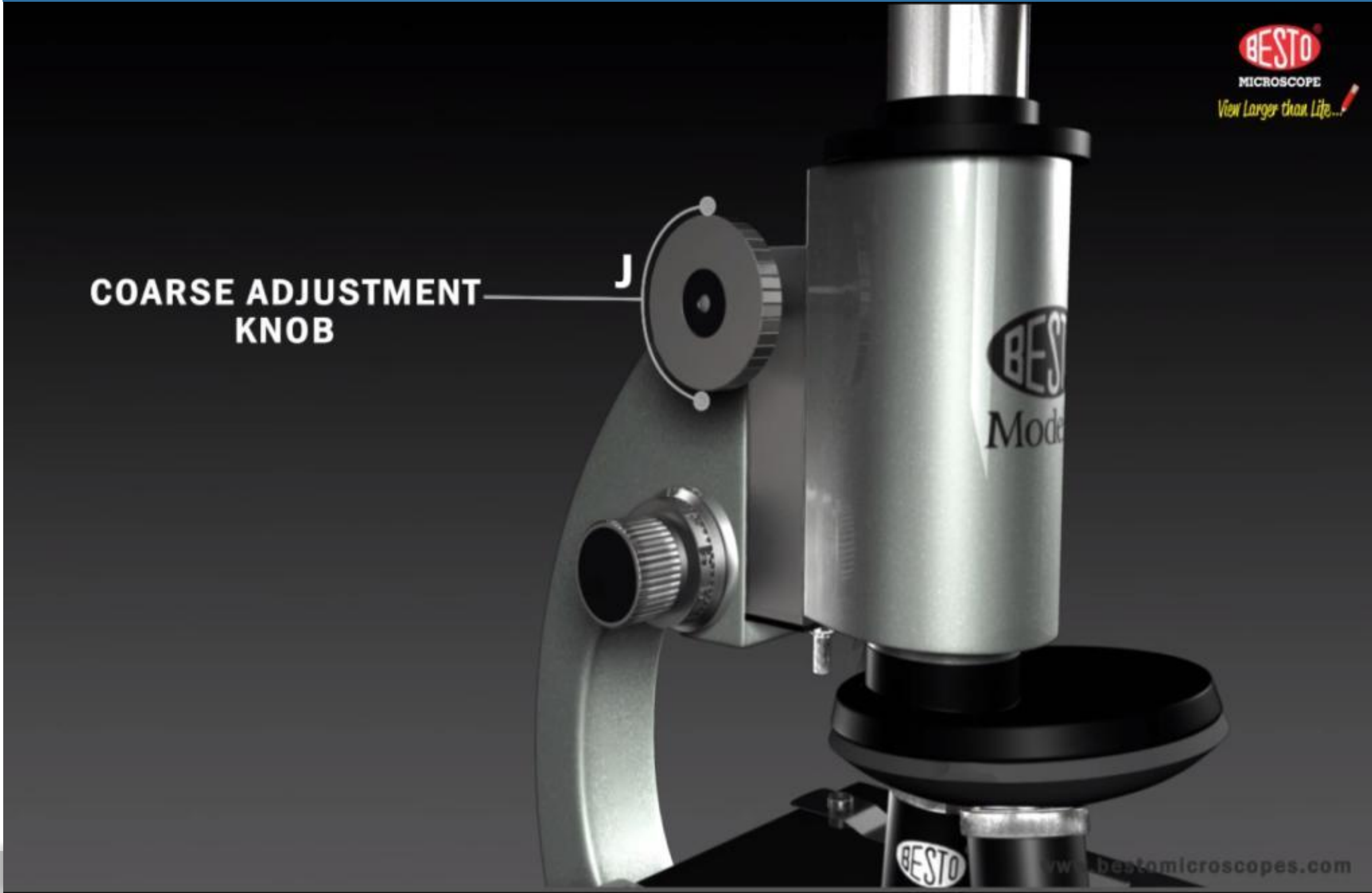
COARSE ADJUSTMENT KNOB
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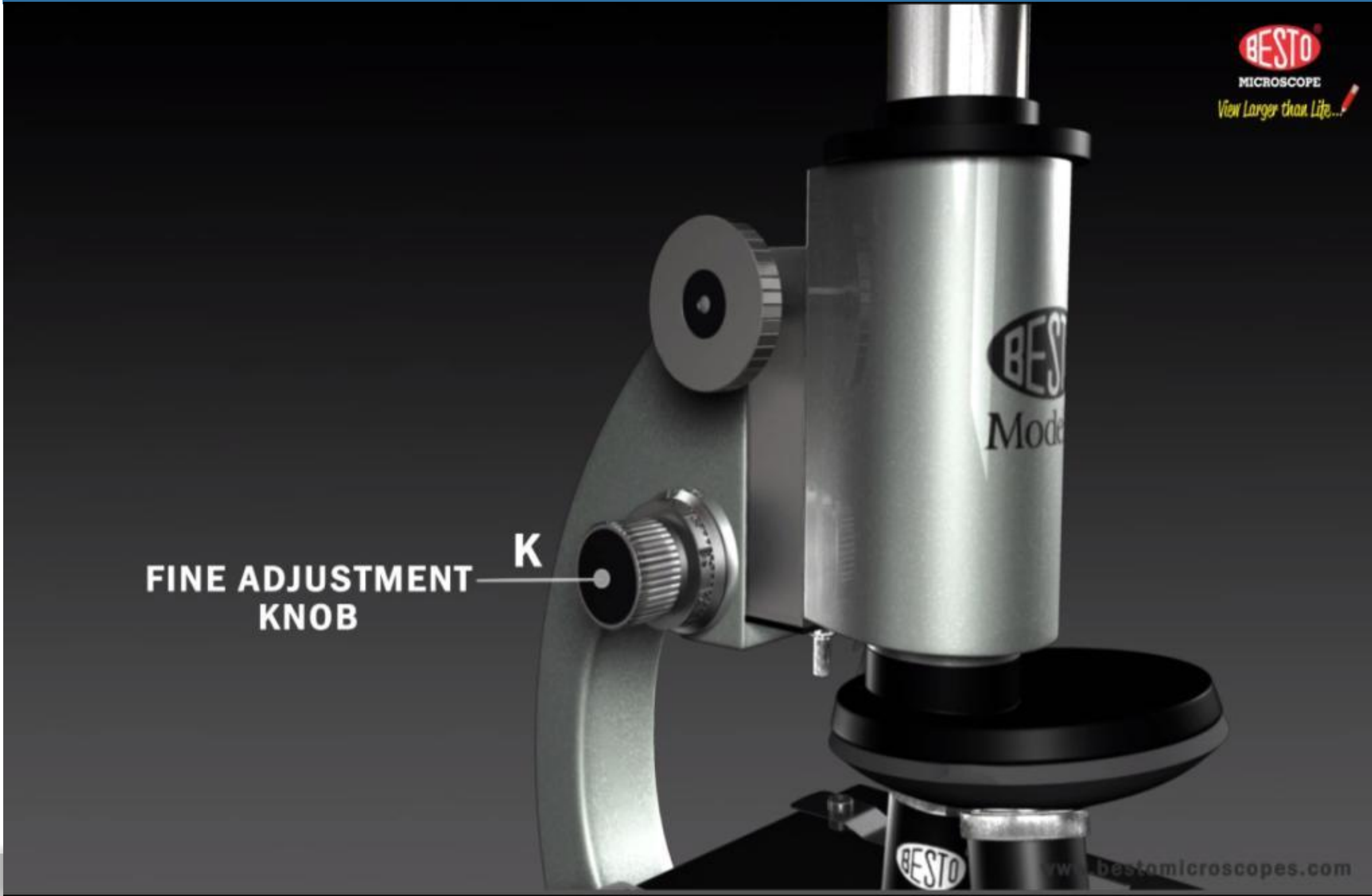
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FINE ADJUSTMENT KNOB
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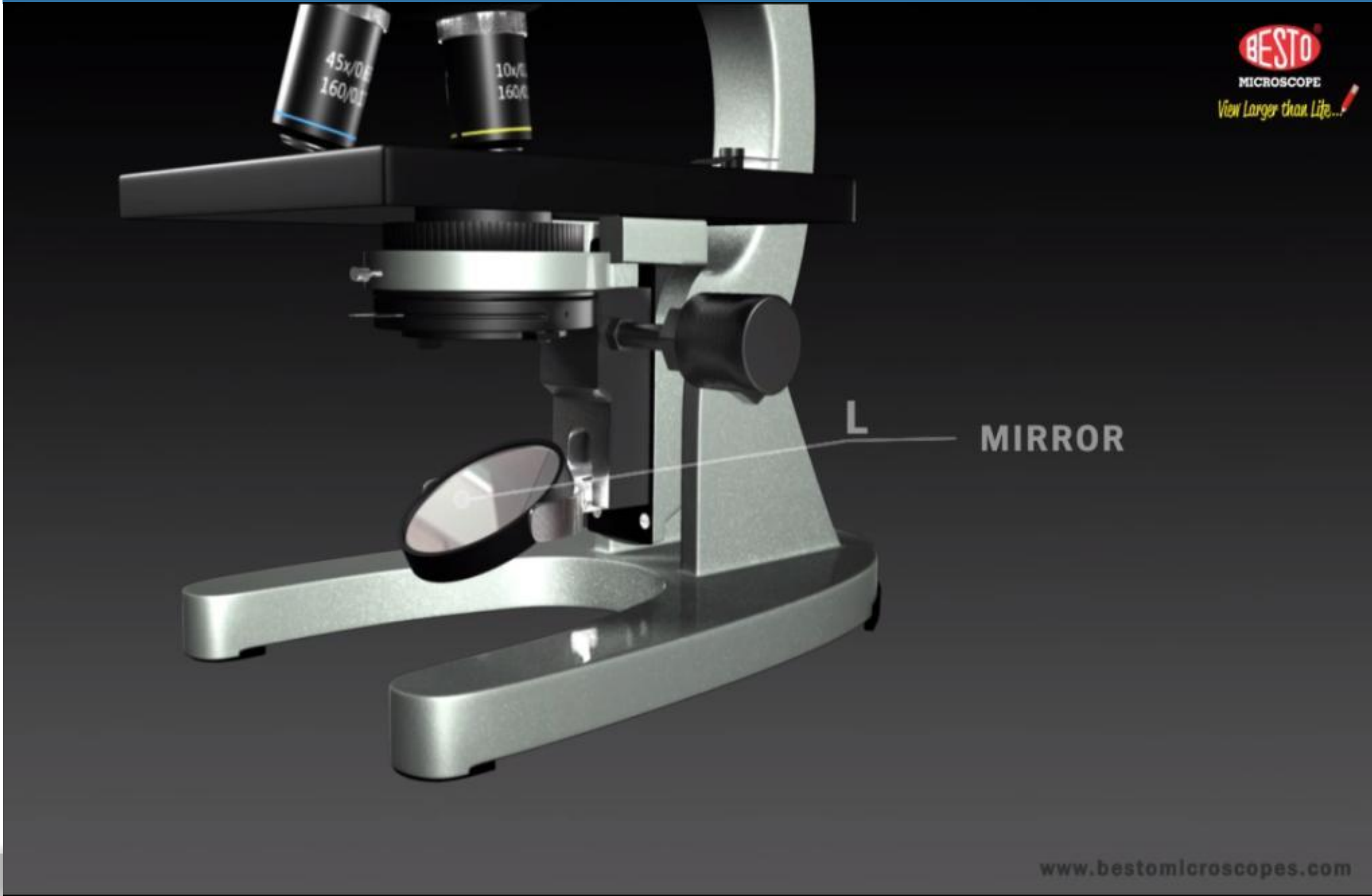

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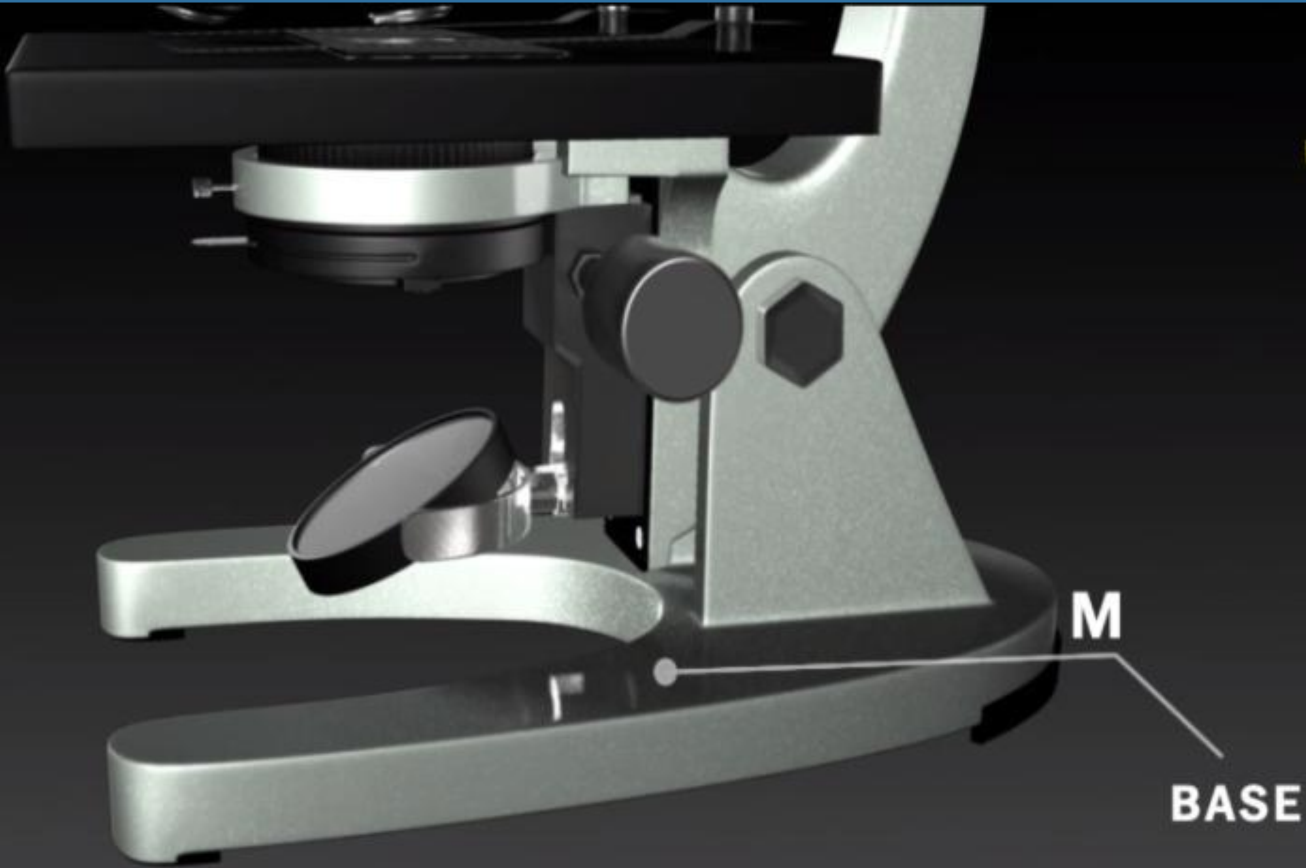
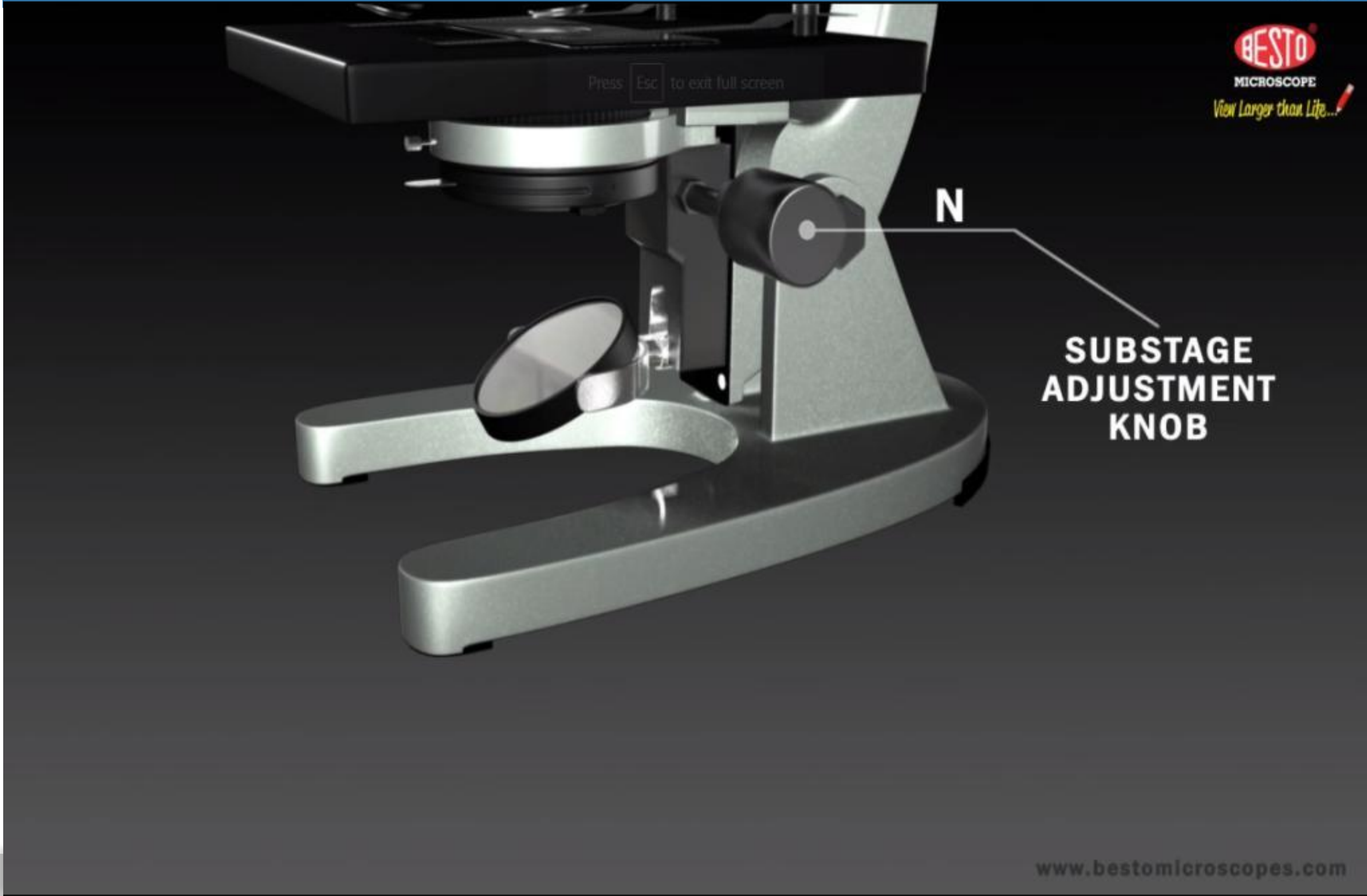

M
BASE



N

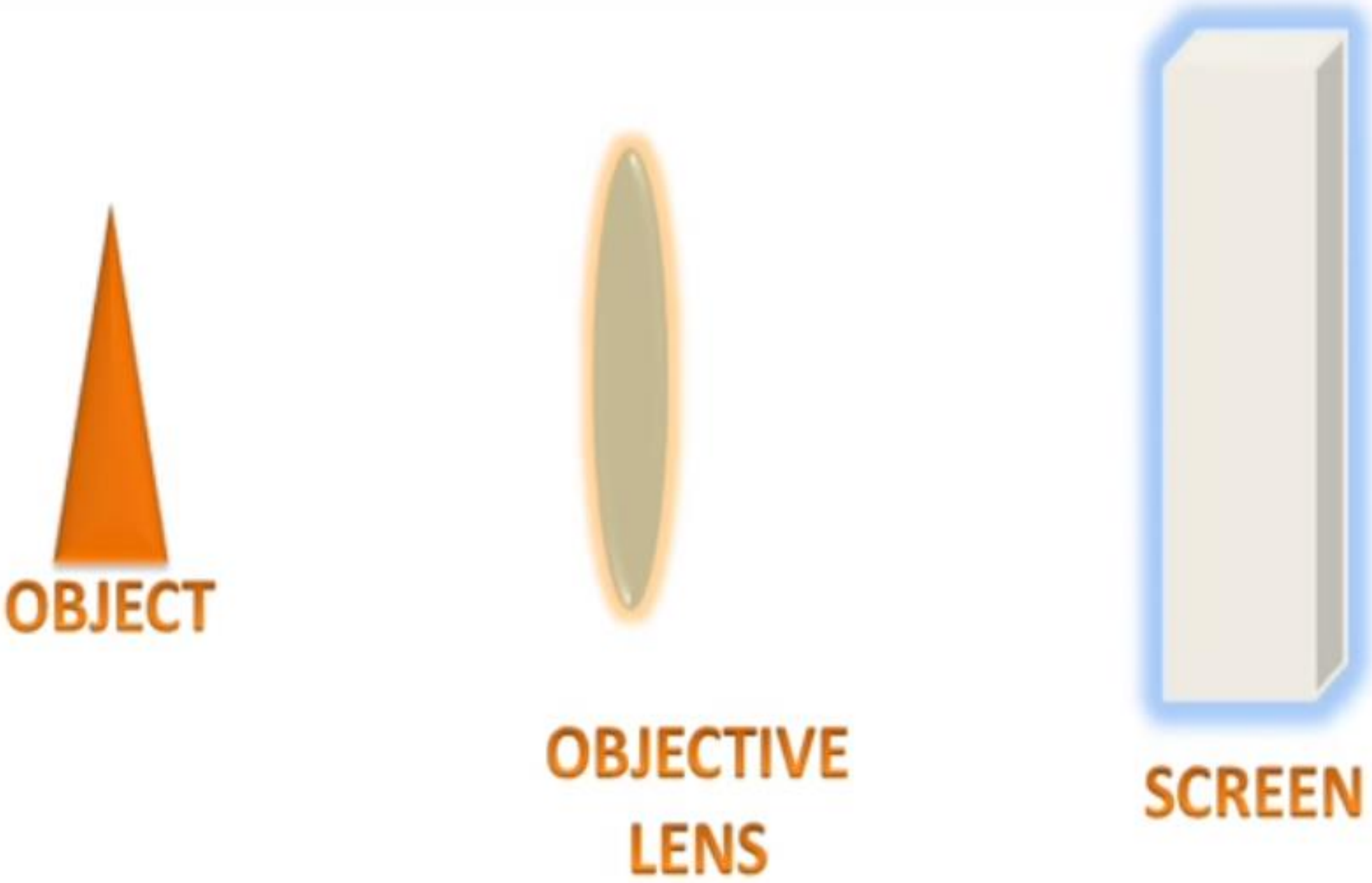
SUBSTAGE ADJUSTMENT KNOB

Collimator

- ❑ An optical device that generates a parallel beam of light. Often used to compensate for laser beam divergence.
- ❑ A similar device that produces a parallel beam of particles such as neutrons.
- ❑ A small telescope attached to a larger one, used to point it in the correct general direction.

Autocollimator

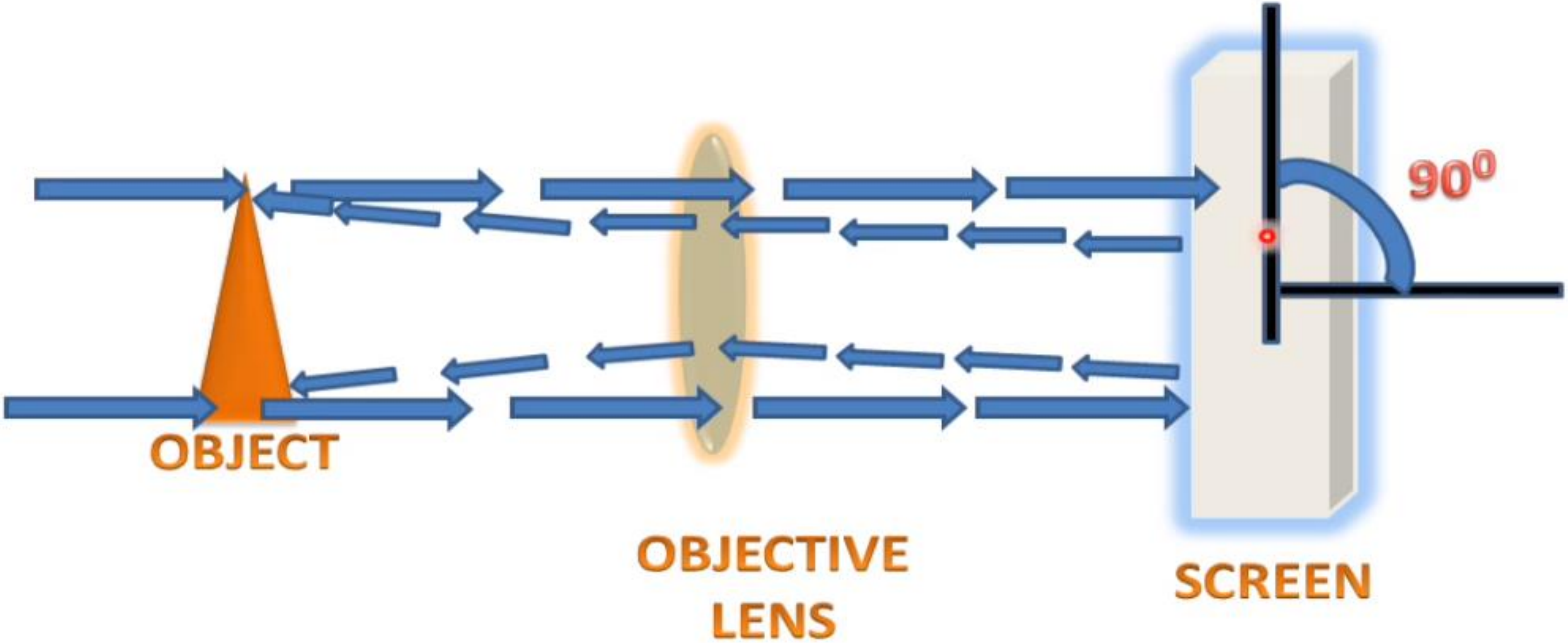
- It is an optical angular measuring instruments
- Used for non contact measurement of small angles with very high sensitivity
- It has high accuracy



OBJECT

OBJECTIVE
LENS

SCREEN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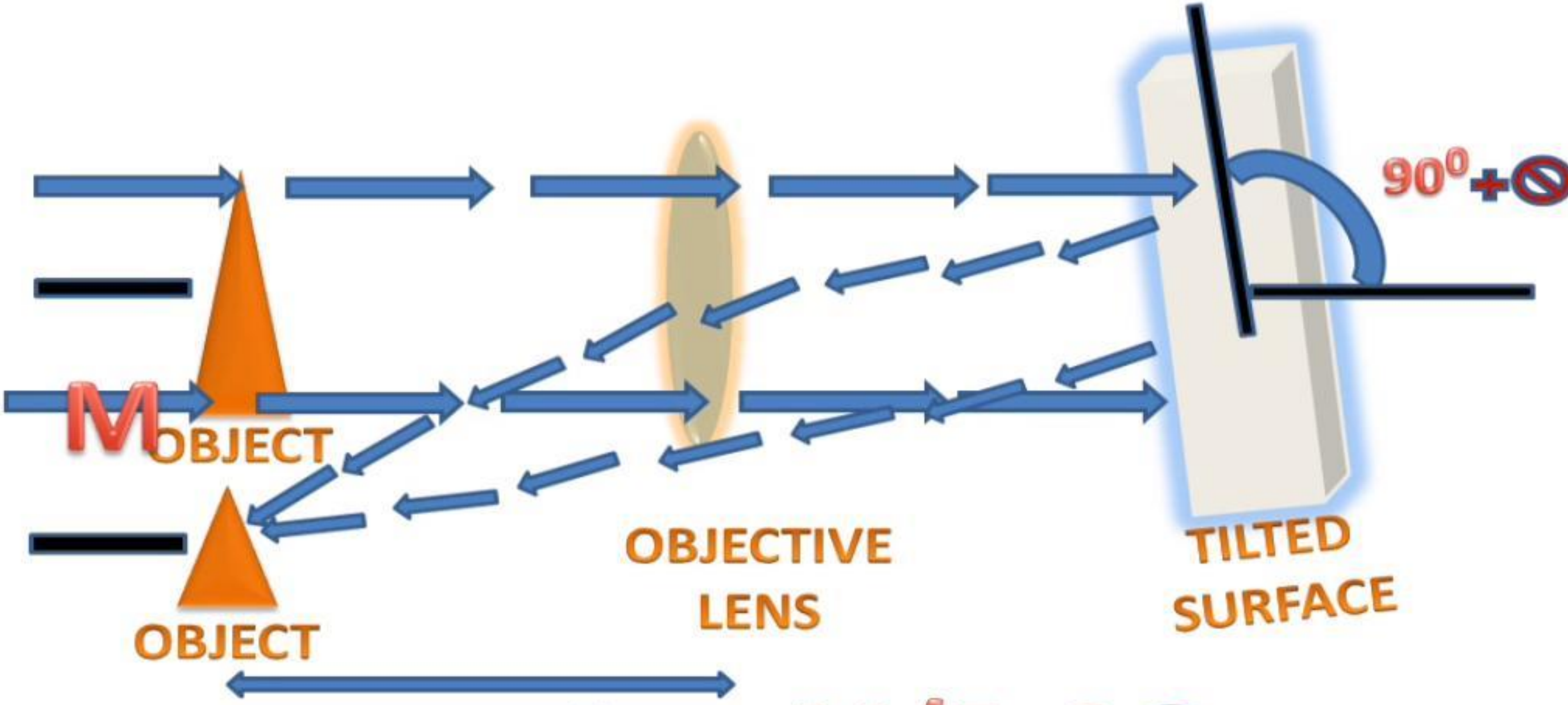
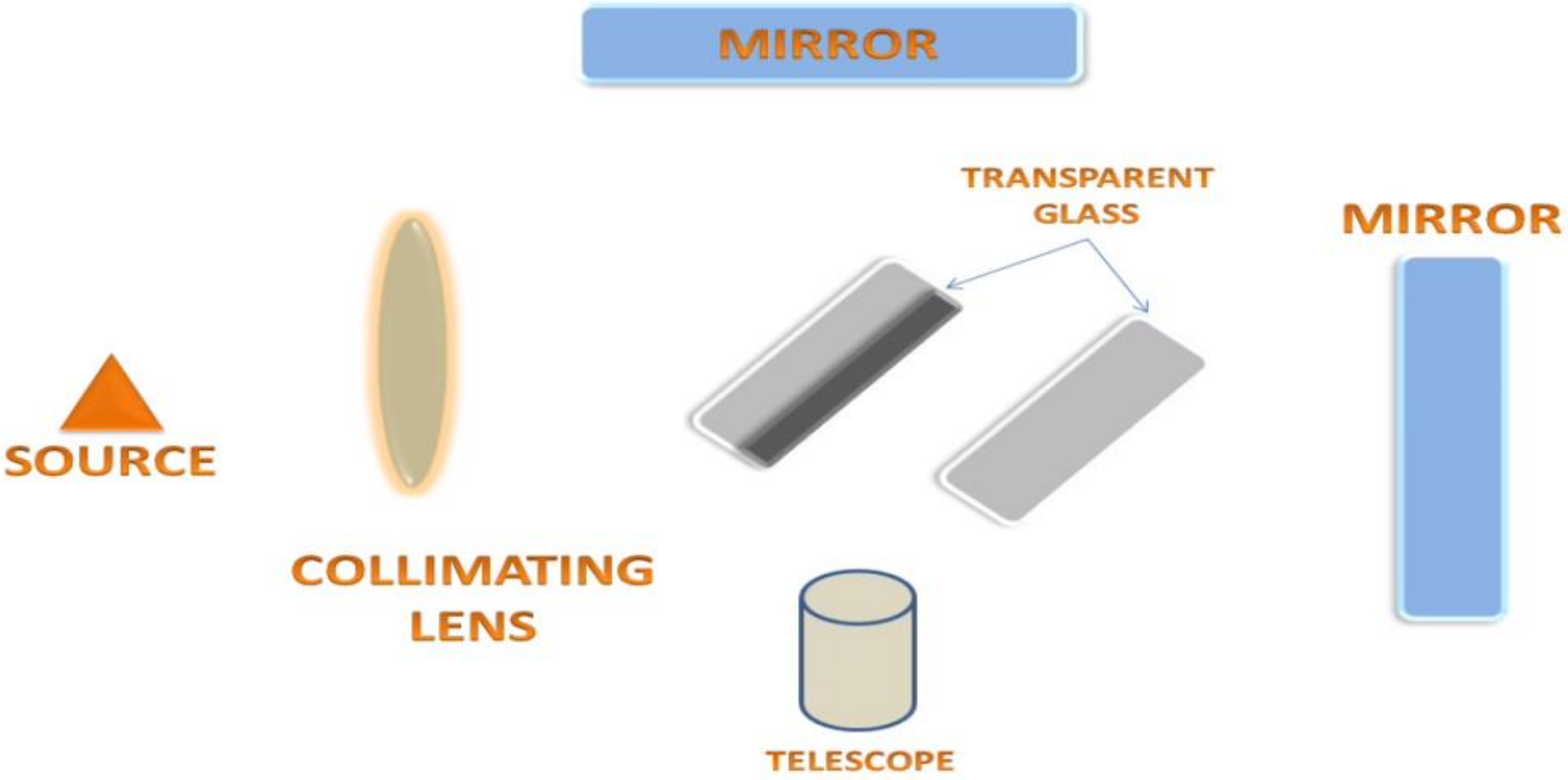


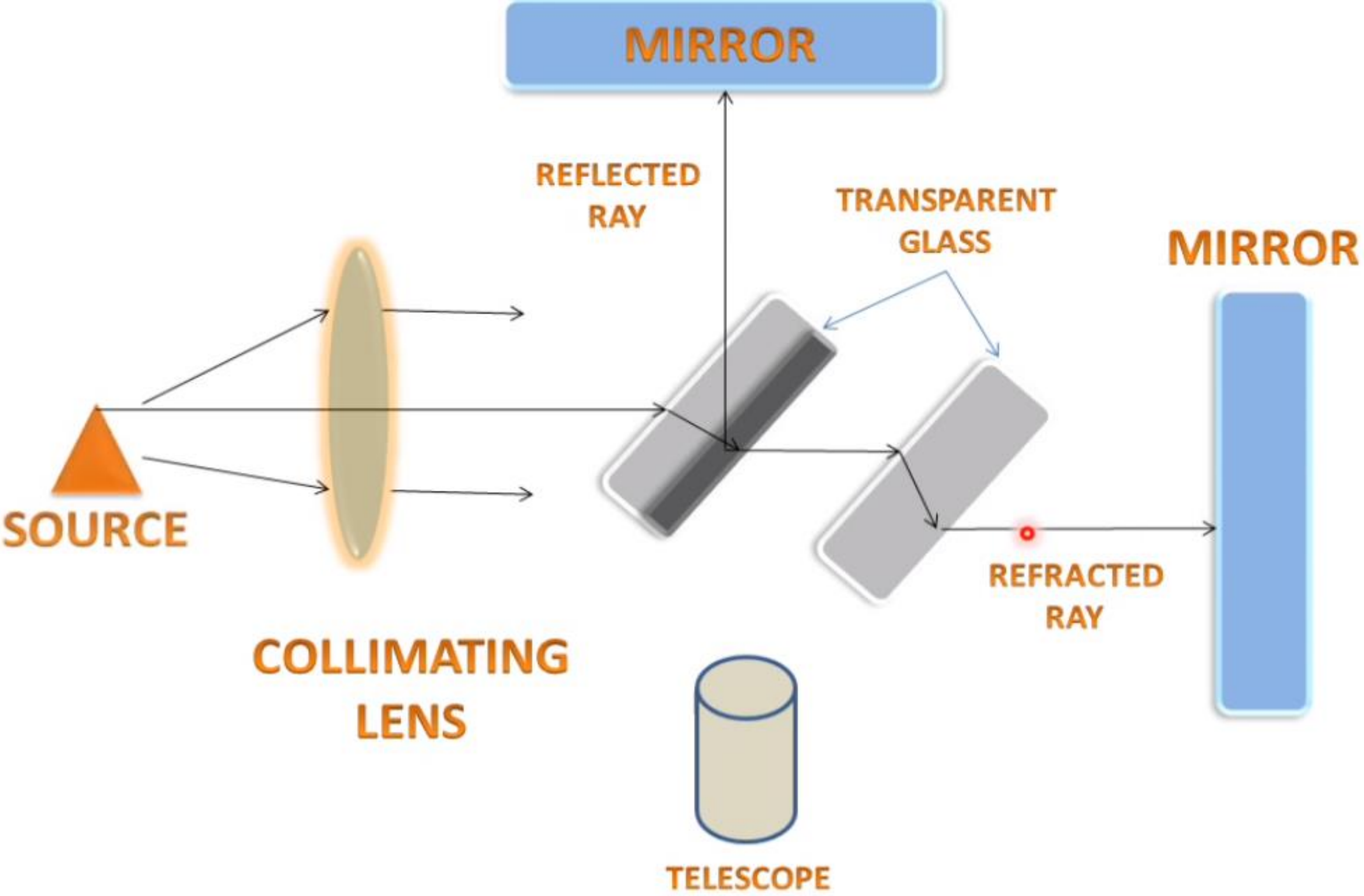
FOCAL LENGTH(F)

M/F=2⊘

Interferometer

Used to study fine structure of spectral lines to determine wavelength of monochromatic light




MIRROR
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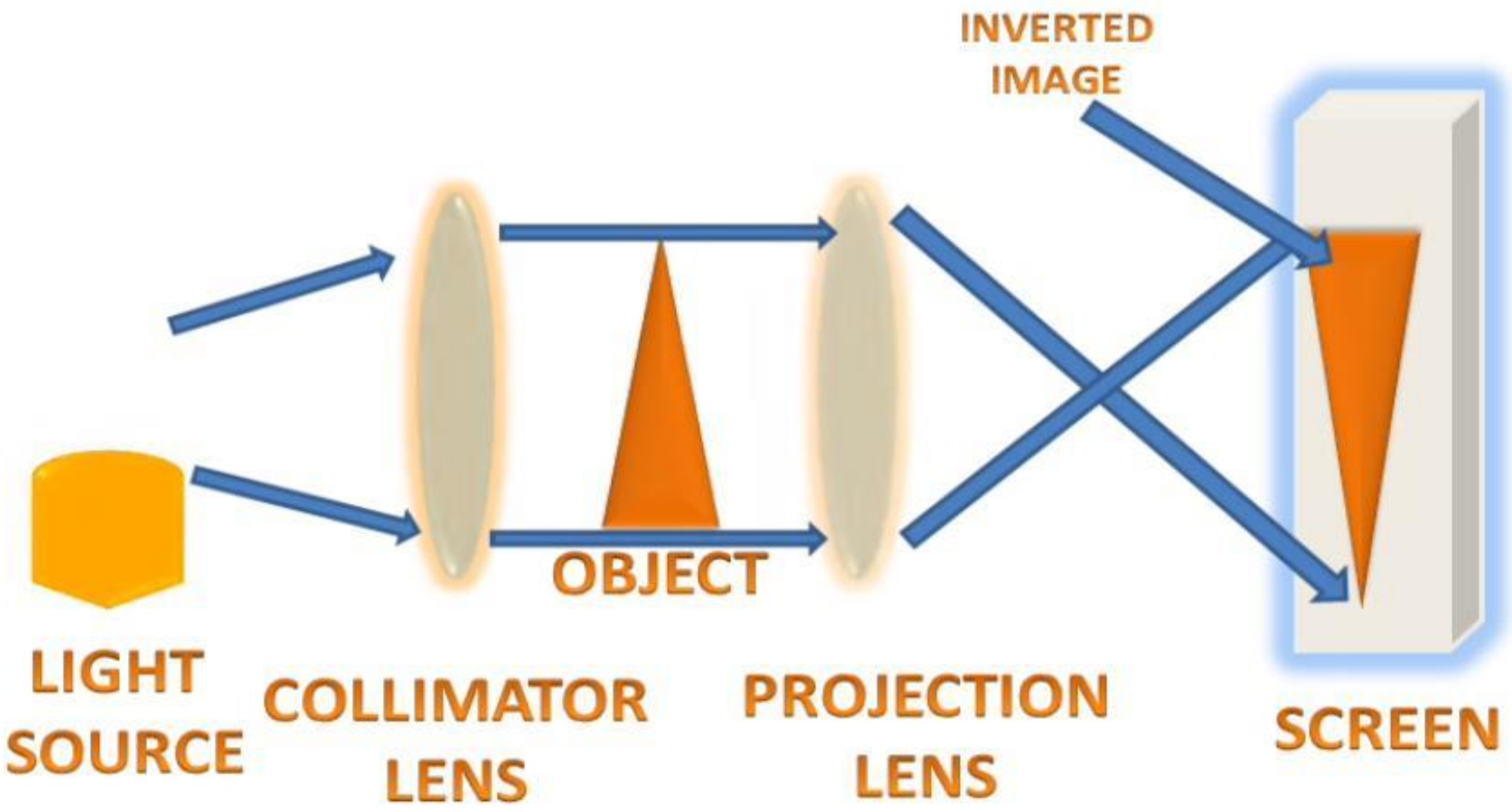
TRANSPARENT GLASS
MIRROR
SOURCE
REFRACTED RAY
COLLIMATING LENS
TELESCOPE

OPTICAL PROJECTOR




Thank You!