GOVT. POLYTECHNIC, SECTOR-26 PANCHKULA

DEPARTMENT OF MECHANICAL ENGINEERING

SUBJECT : MECHANICAL ENGG. DRAWING-II

SEMESTER : 3RD

MECHANICAL ENGG. DRAWING

CHAPTER 1: Limits, Fits and Tolerances

INTRODUCTION

- No two parts can be produced with identical measurements by any manufacturing process.
- In any production process, regardless of how well it is designed or how carefully it is maintained, a certain amount of variation **(natural)** will always exist.

INTRODUCTION

Variations arises from;

- Improperly adjusted machines
- Operator error
- Tool wear
- Defective raw materials etc.

Such variations are referred as **‘assignable causes’** and can be identified and controlled.

INTRODUCTION

- It is impossible to produce a part to an **exact size or basic size**, some variations, known as tolerances, need to be allowed.

- The permissible level of tolerance depends on the functional requirements, which cannot be compromised.

INTRODUCTION

- No component can be manufactured precisely to a given dimension; it can only be made to lie between two limits, upper (maximum) and lower (minimum).

- Designer has to suggest these tolerance limits to ensure satisfactory operation.

- The difference between the upper and lower limits is termed ***permissive tolerance.***

INTRODUCTION

Example

Shaft has to be manufactured to a diameter of 40 ± 0.02 mm.

The shaft has a basic size of 40 mm.

It will be acceptable if its diameter lies between the limits of sizes.

Upper limit of 40+0.02 = 40.02 mm

Lower limit of 40-0.02 = 39.98 mm.

Then, permissive tolerance is equal to 40.02 − 39.98 = 0.04 mm.

Need of Limit, Fits and Tolerances

- Mass Production And Specialization
- Standardization
- Interchangeability

Tolerances

- To satisfy the ever-increasing demand for accuracy.
- Parts have to be produced with less dimensional variation.
- It is essential for the manufacturer to have an in-depth knowledge of the tolerances to manufacture parts economically, adhere to quality and reliability
- To achieve an increased compatibility between mating parts.

Tolerances

- The algebraic difference between the upper and lower acceptable dimensions.
- It is an absolute value.
- The basic purpose of providing tolerances is to permit dimensional variations in the manufacture of components, adhering to the performance criterion.

Tolerances

Classification of Tolerance

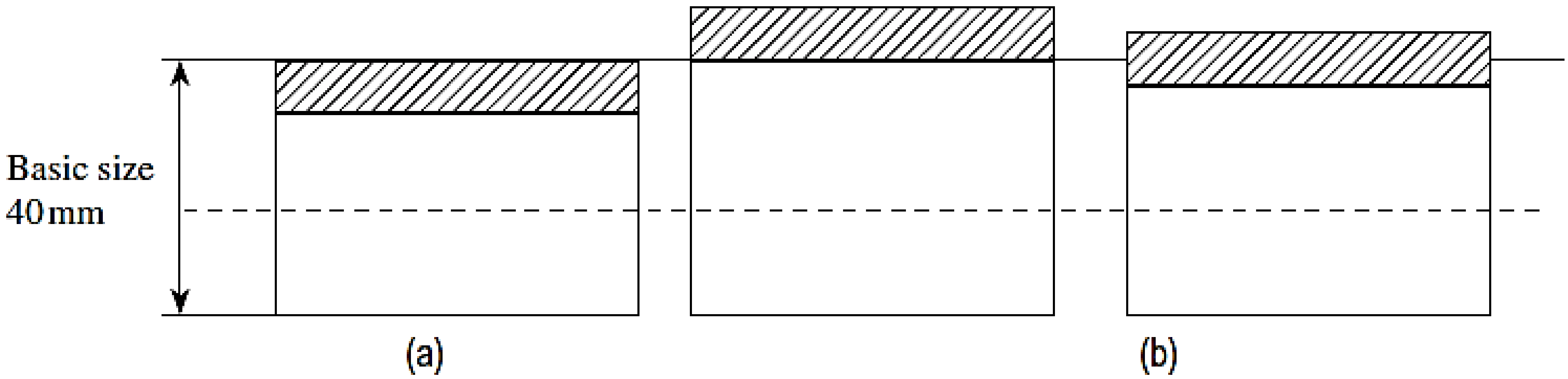
1. Unilateral tolerance
2. Bilateral tolerance
3. Compound tolerance
4. Geometric tolerance

Tolerances

Classification of Tolerance

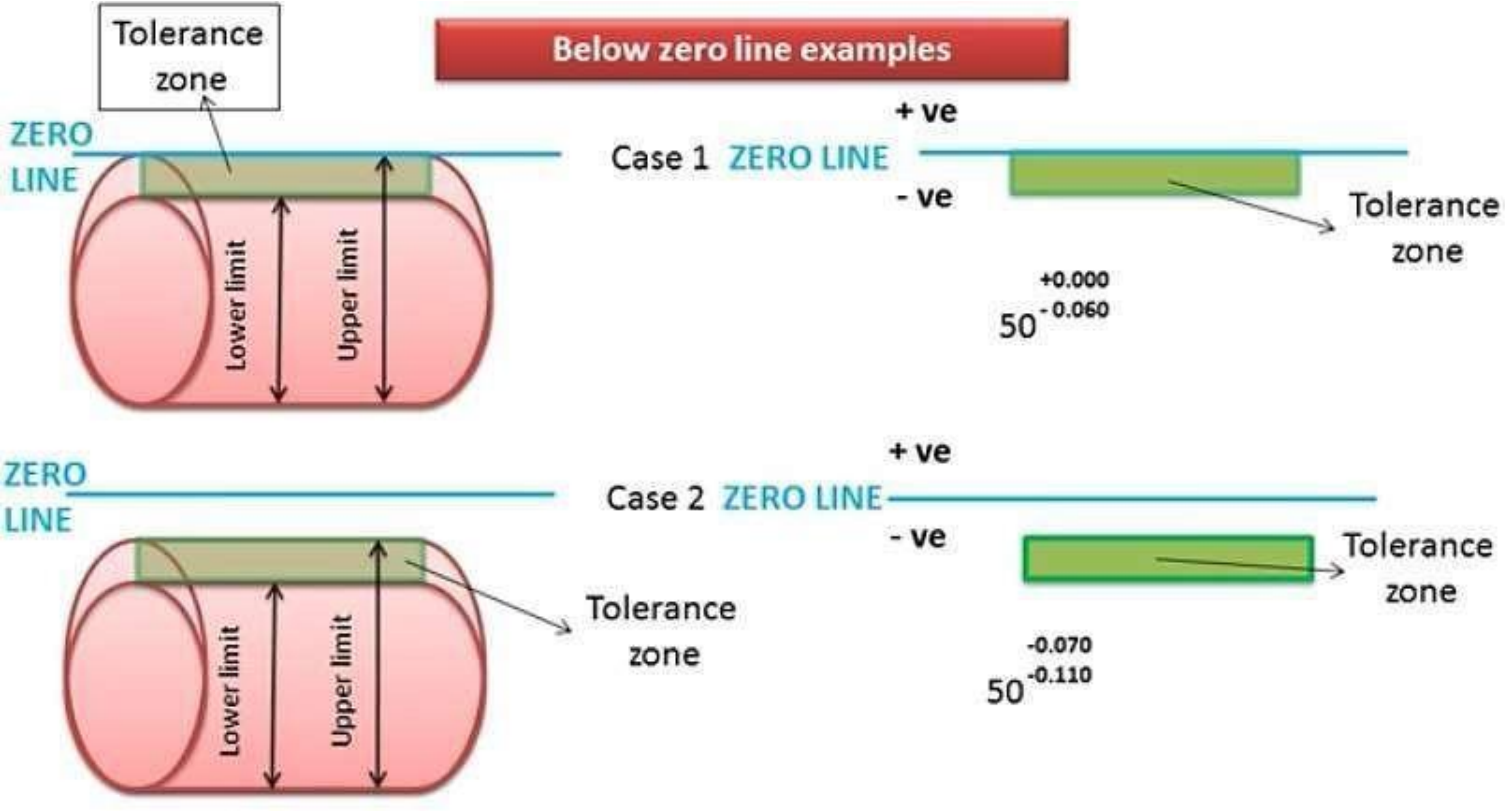
1. Unilateral tolerance

- When the tolerance distribution is only on one side of the basic size. Either positive or negative, but not both.

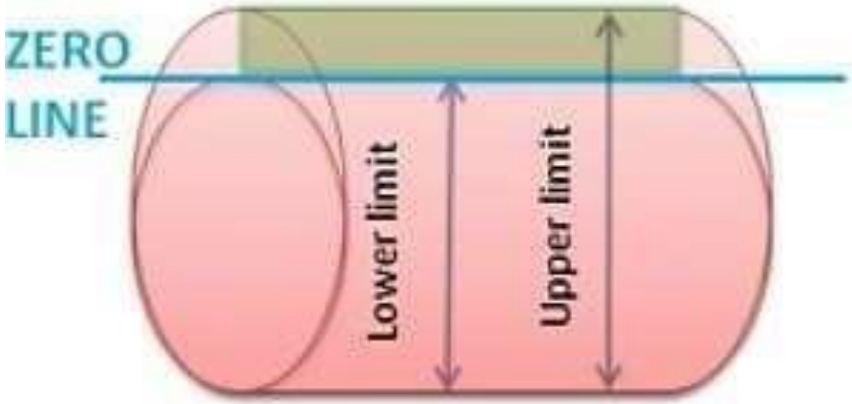


Tolerances (a) Unilateral (b) Bilateral

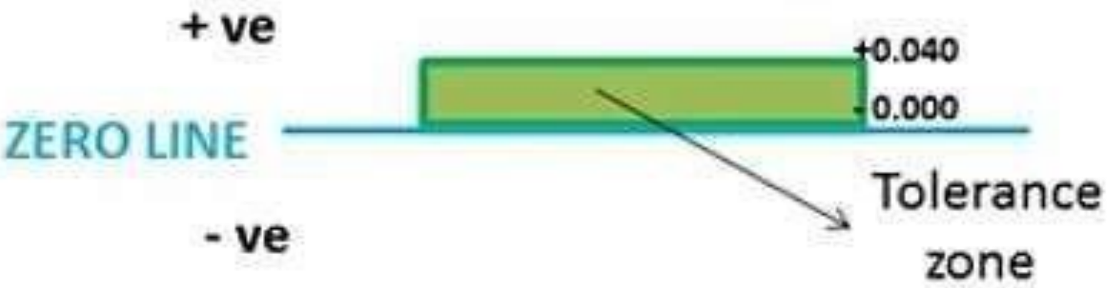
1. Unilateral tolerance: Below zero line: Negative



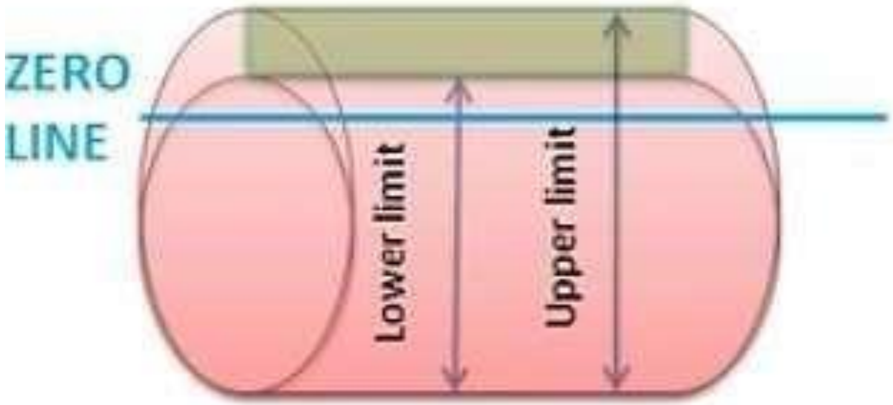
1. Unilateral tolerance: **Above zero line**: Positive



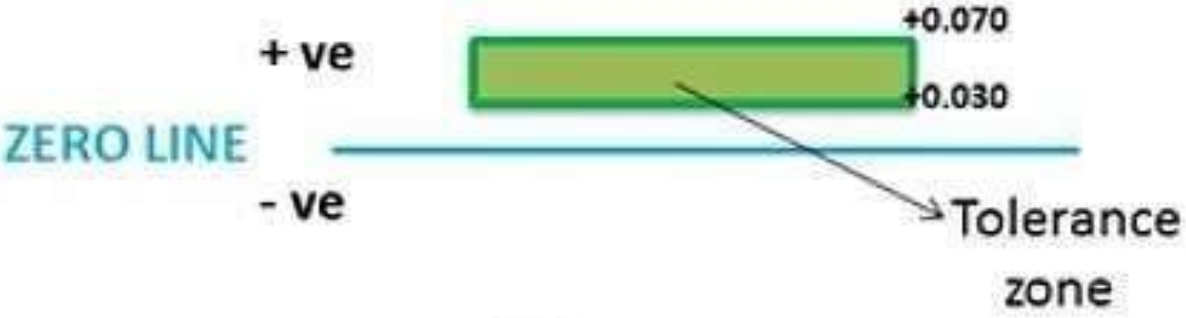
Case 1



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



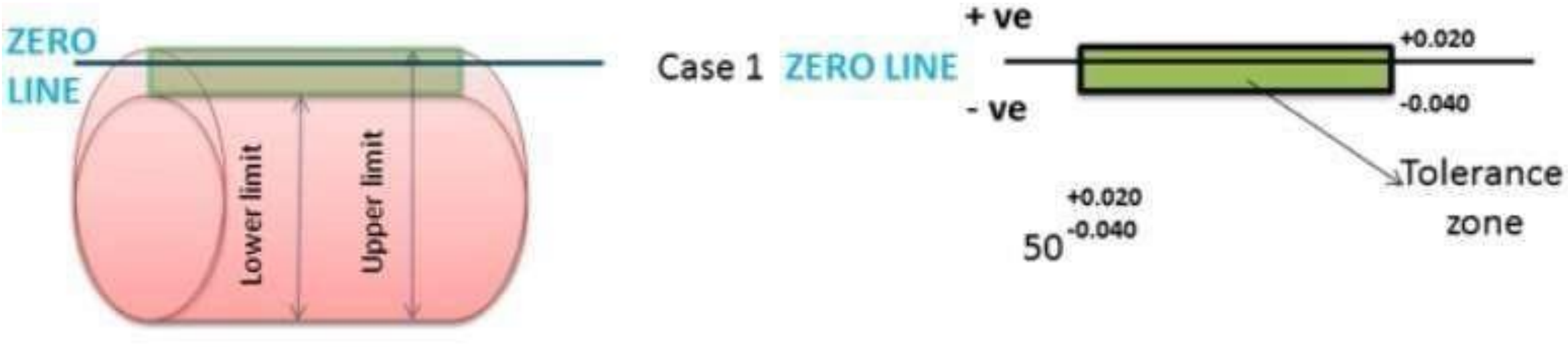
Case 2



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

2. Bilateral tolerance

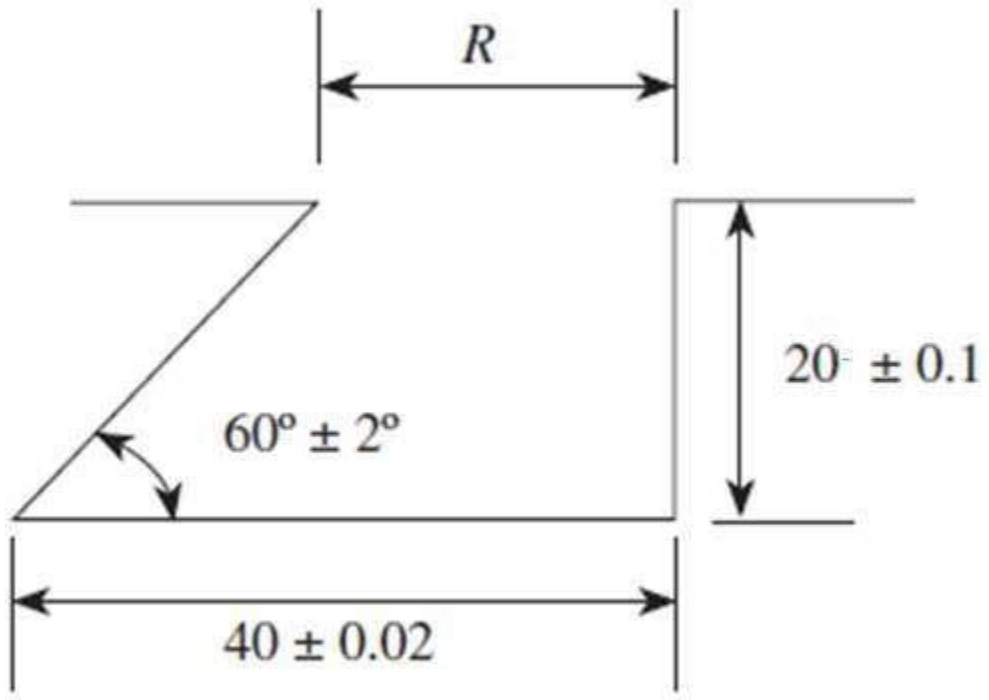
When the tolerance distribution lies on either side of the basic size.



- It is not necessary that Zero line will divide the tolerance zone equally on both sides.
- It may be equal or unequal

Classification of Tolerance

3. Compound tolerance



Tolerance for the dimension *R* is determined by the combined effects of tolerance on 40 mm dimension, on 60°, and on 20 mm dimension

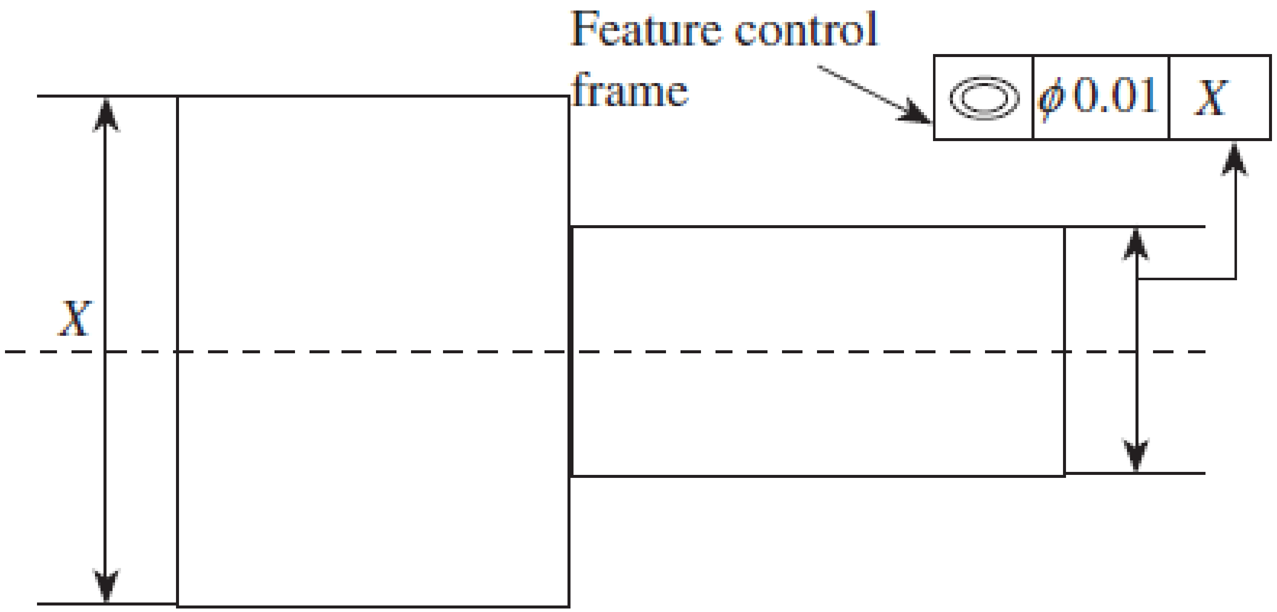
Classification of Tolerance

4. Geometric tolerance

Geometric dimensioning and tolerancing (GD&T) is a method of defining parts based on how they function, using standard symbols.

Classification of Tolerance

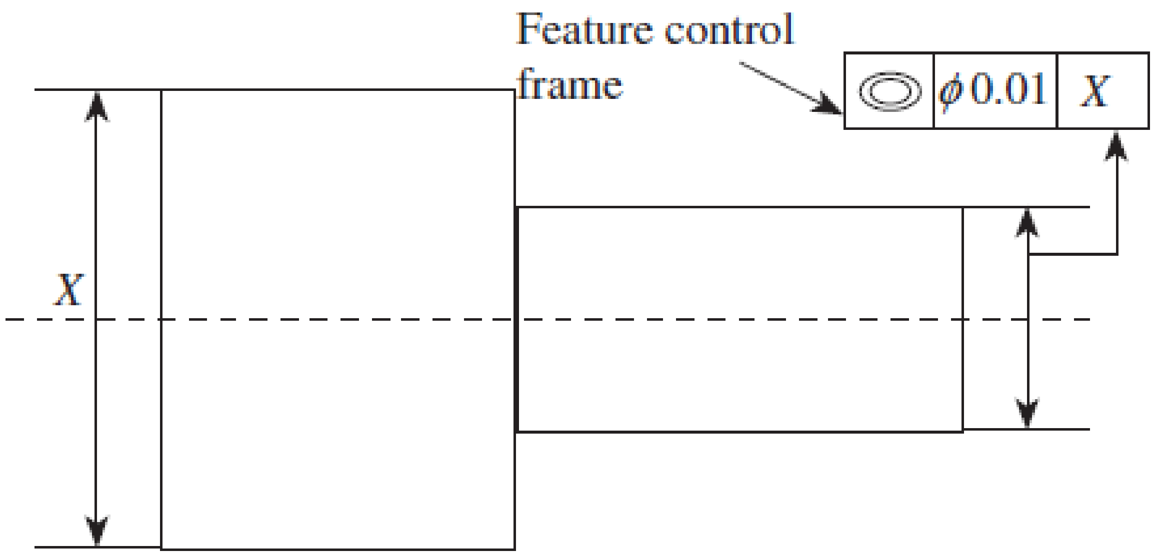
4. Geometric tolerance



- Diameters of the cylinders need be concentric with each other.
- For proper fit between the two cylinders, both the centres to be in line.
- This information is represented in the feature control frame.
- Feature control frame comprises three boxes.

Classification of Tolerance

4. Geometric tolerance



- **First box:** On the left indicates the feature to be controlled, represented symbolically (example: concentricity).
- **Centre box:** indicates distance between the two cylinders, centres cannot be apart by more than 0.01 mm (Tolerance).
- **Third box:** Indicates that the datum is with X.

MAXIMUM AND MINIMUM METAL CONDITIONS

Consider a shaft having a dimension of 40 ± 0.05 mm and Hole having a dimension of 45 ± 0.05 mm.

For Shaft

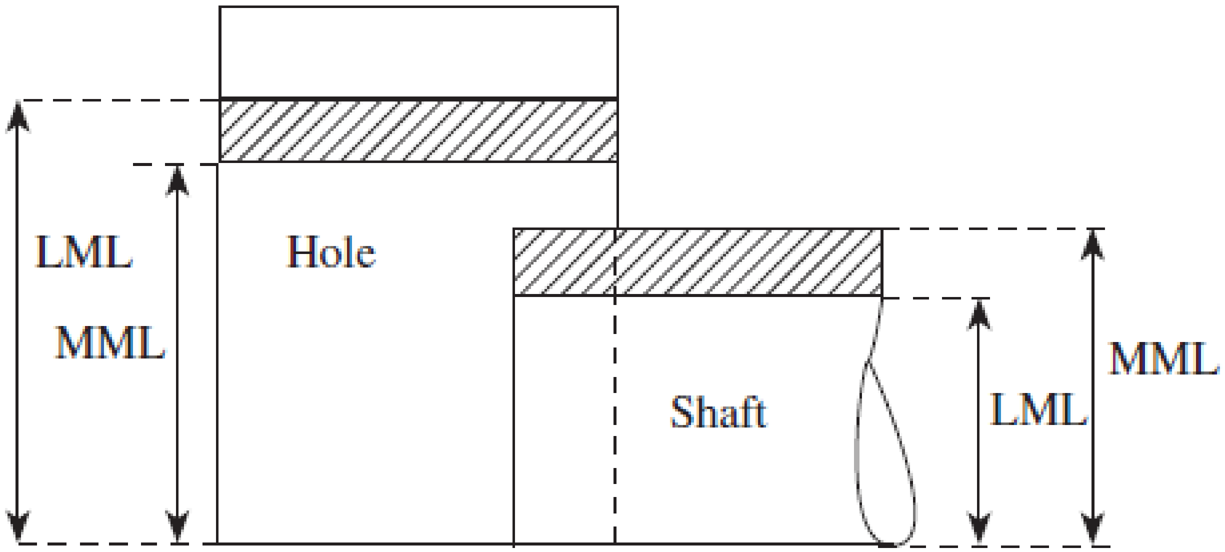
Maximum metal limit (MML) = 40.05 mm

Least metal limit (LML) = 39.95 mm

For Hole

Maximum metal limit (MML) = 44.95 mm

Least metal limit (LML) = 45.05 mm



FITS

The Assembly of Two Mating Parts is called Fit.

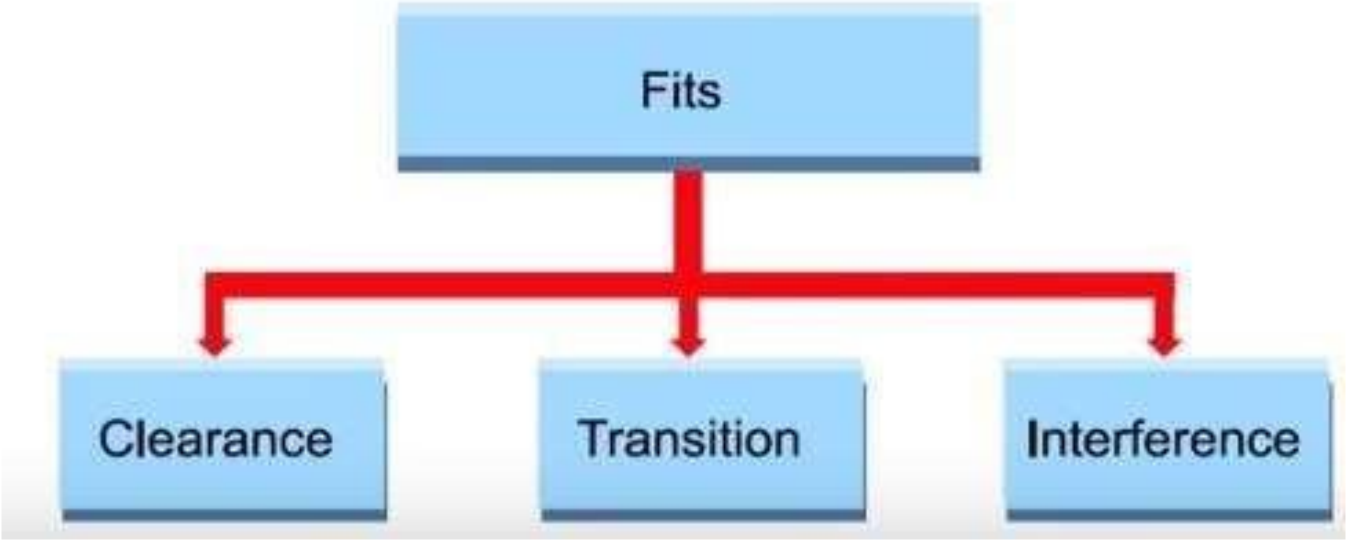
- RUNNING FIT: One part assembled into other so as to allow motion eg. Shaft in bearing
- PUSH FIT : One part is assembled into other with light hand pressure & no clearance to allow shaft to rotate as in locating plugs.
- DRIVING FIT : One part is assembled into other with hand hammer or medium pressure. Eg pulley fitted on shaft with a key
- FORCE FIT: One part is assembled into other with great pressure eg. Cart wheels, railway wheels

FITS

- The degree of tightness and or looseness between the two mating parts.

Three basic types of fits can be identified, depending on the actual limits of the hole or shaft.

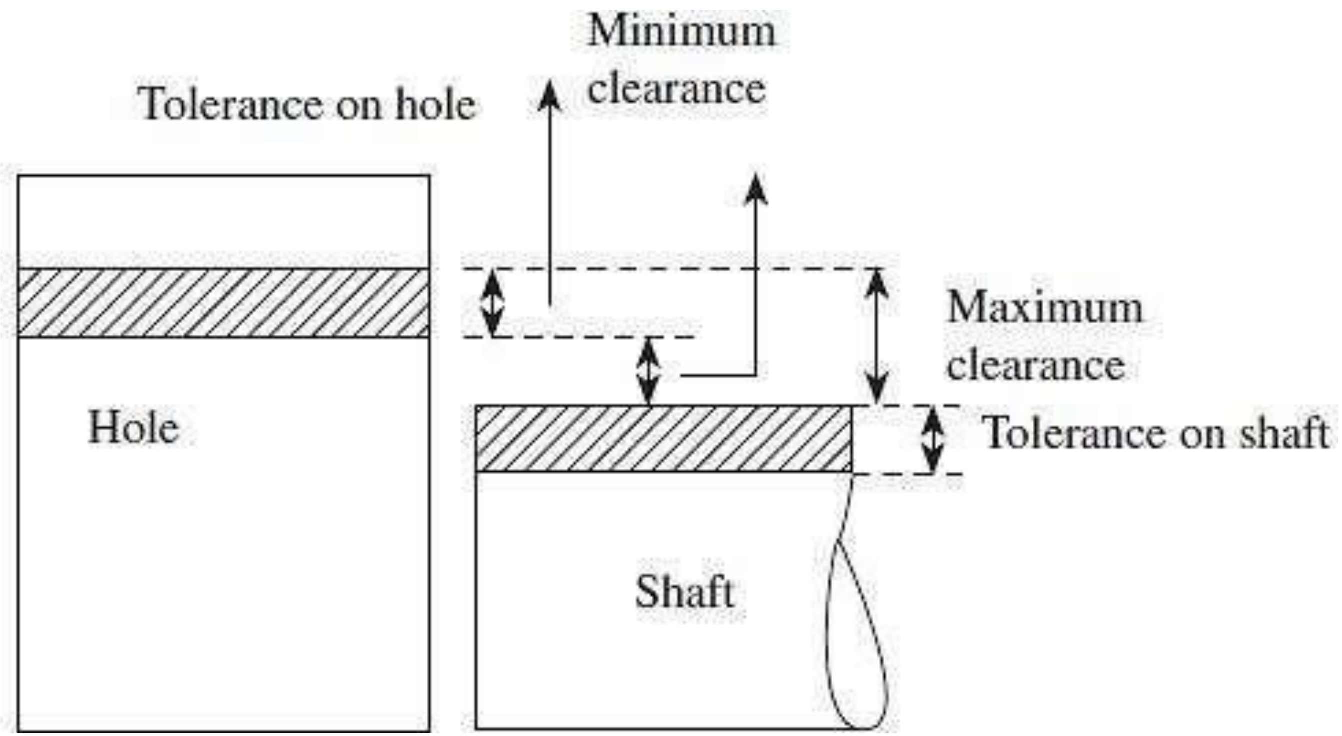
1. Clearance fit
2. Interference fit
3. Transition fit

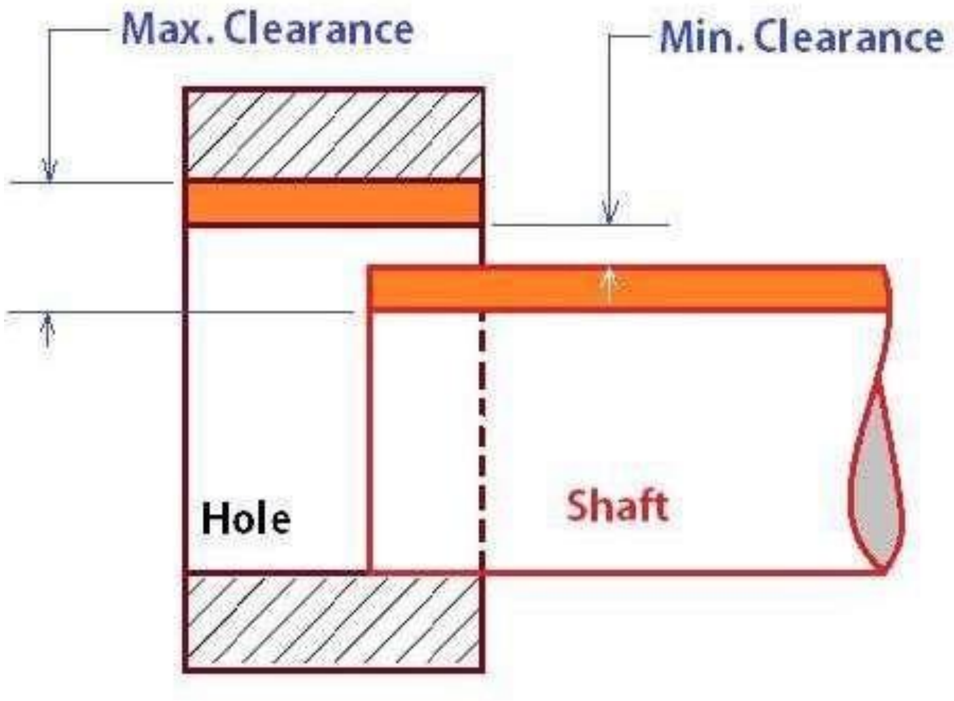


FITS

1. Clearance fit

Upper limit of shaft is less than the lower limit of the hole.





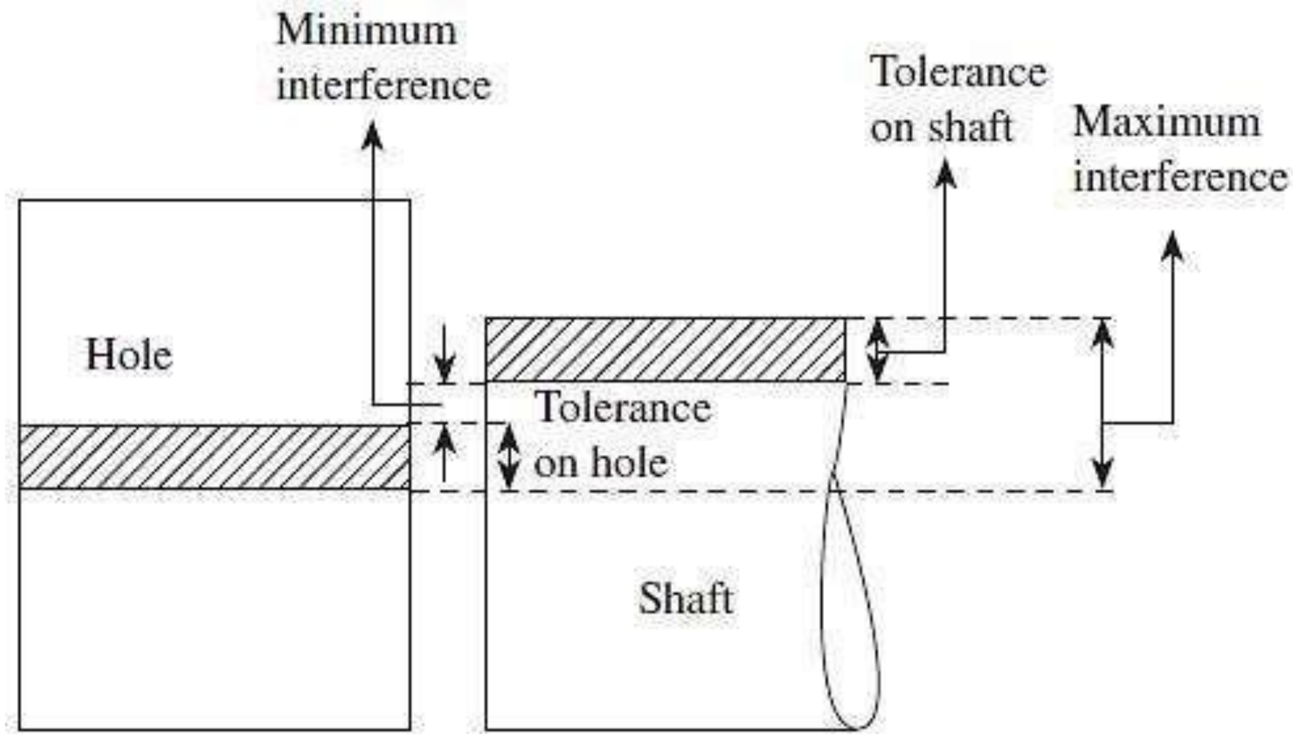
The largest permissible dia. of the shaft is smaller than the dia. of the smallest hole.

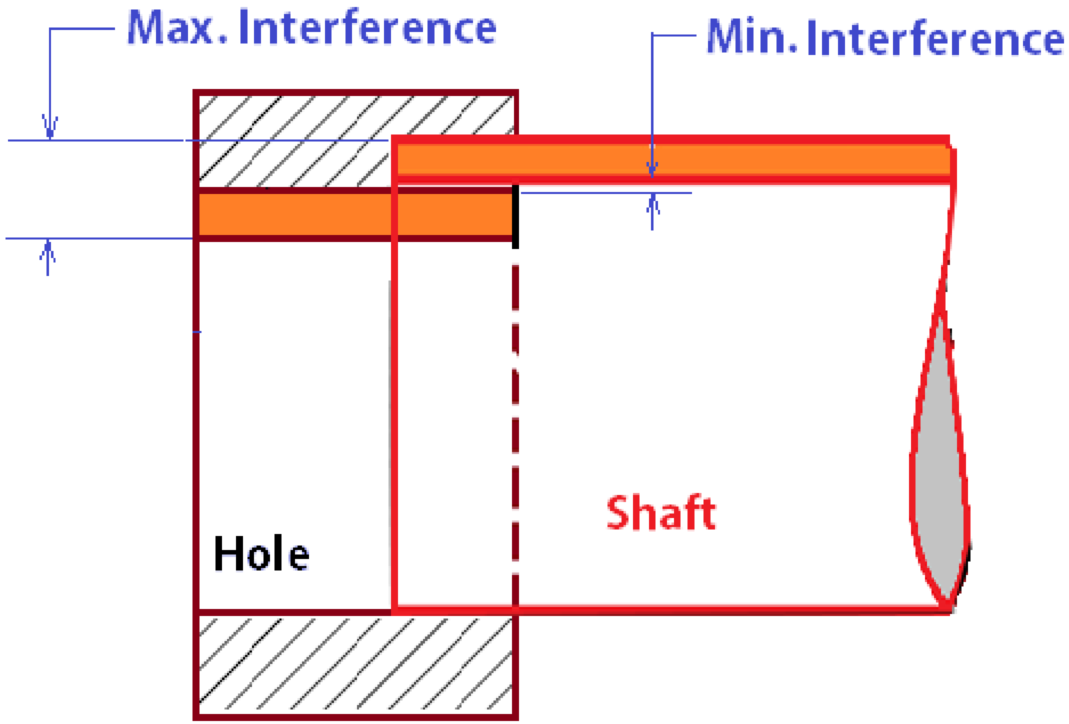
E.g.: Shaft rotating in a bush

FITS

2. Interference fit

Upper limit of the hole is less than the lower limit of shaft.

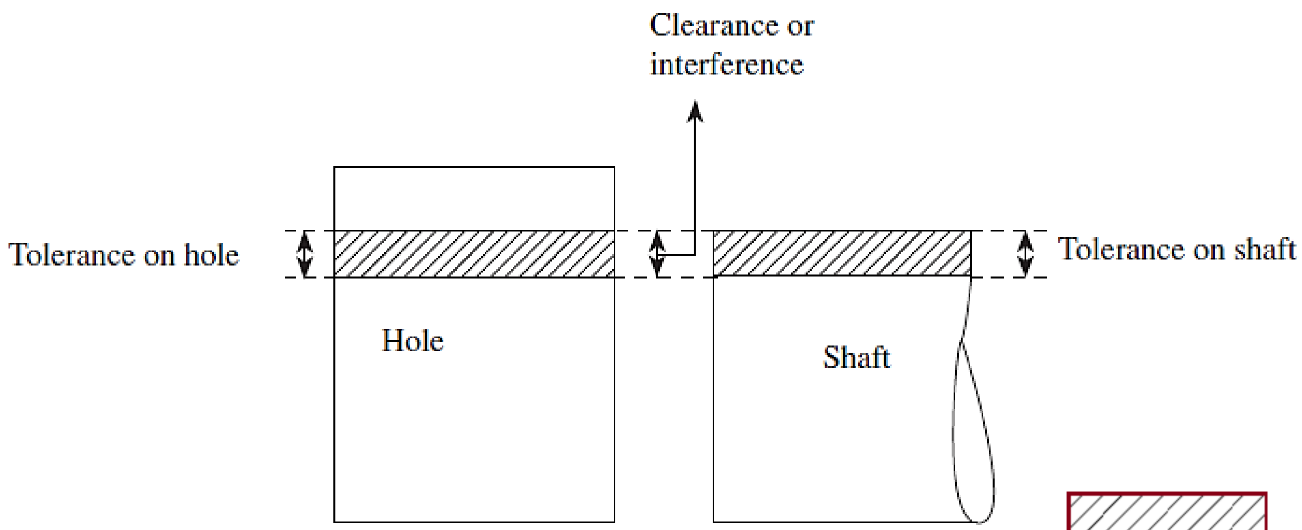


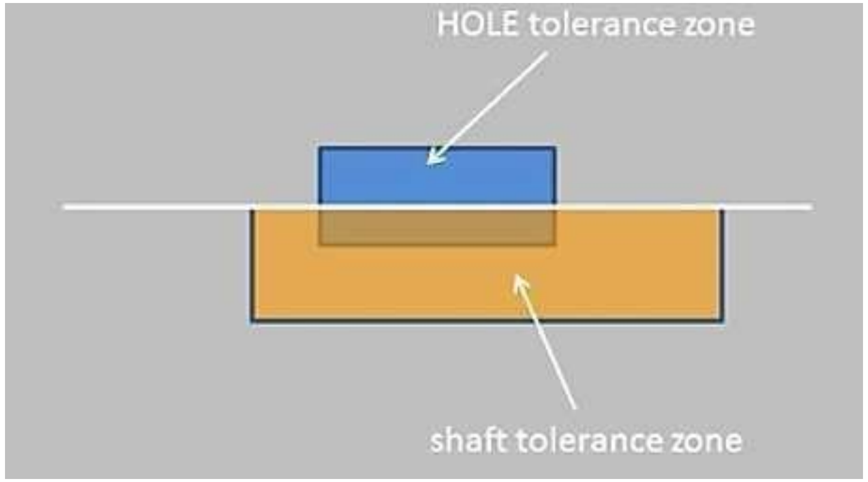


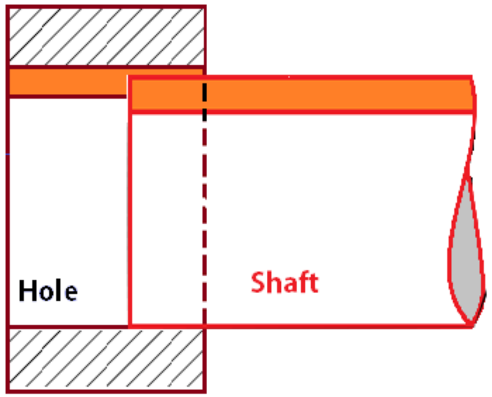
- No gap between the faces and intersecting of material will occur.
- Shaft need additional force to fit into the hole.

3. Transition fit

Dia. of the largest permissible hole is greater than the dia. of the smallest shaft.



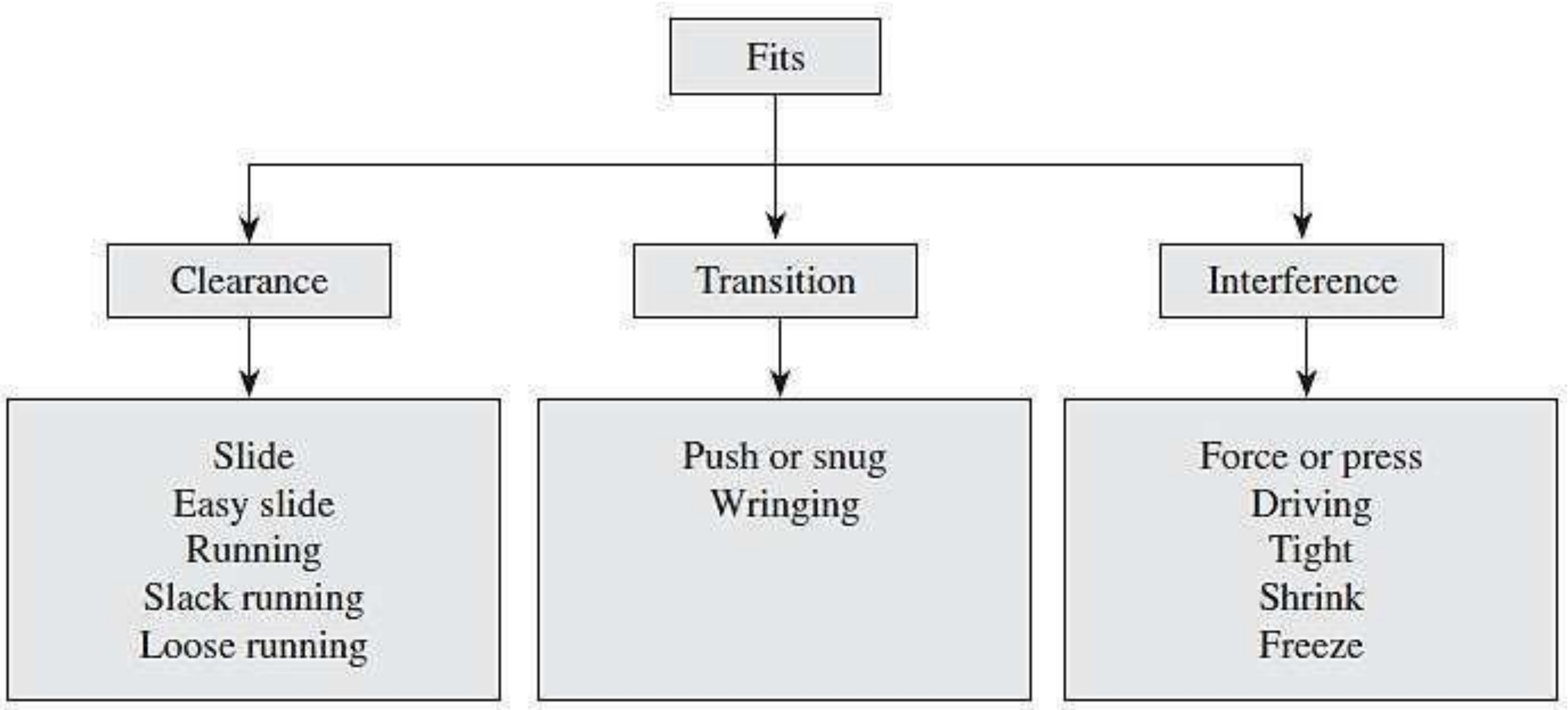




- Neither loose nor tight like clearance fit and interference fit.
- Tolerance zones of the shaft and the hole will be overlapped between the interference and clearance fits.

FITS

Detailed classification of Fits



FITS

Applications

Description of fit	Class of fit	Application area
	Clearance fit	
Slide	H7/h6	Sealing rings, bearing covers, movable gears in change gear trains, clutches, etc.
Easy slide	H7/g7	Lathe spindle, spigots, piston, and slide valves
Running	H8/f8	Lubricated bearings (with oil or grease), pumps and smaller motors, gear boxes, shaft pulleys, etc.
Slack running	H8/c11	Oil seals with metal housings, multi-spline shafts, etc.
Loose running	H8/d9	Loose pulleys, loose bearings with low revolution, etc.

FITS

Applications

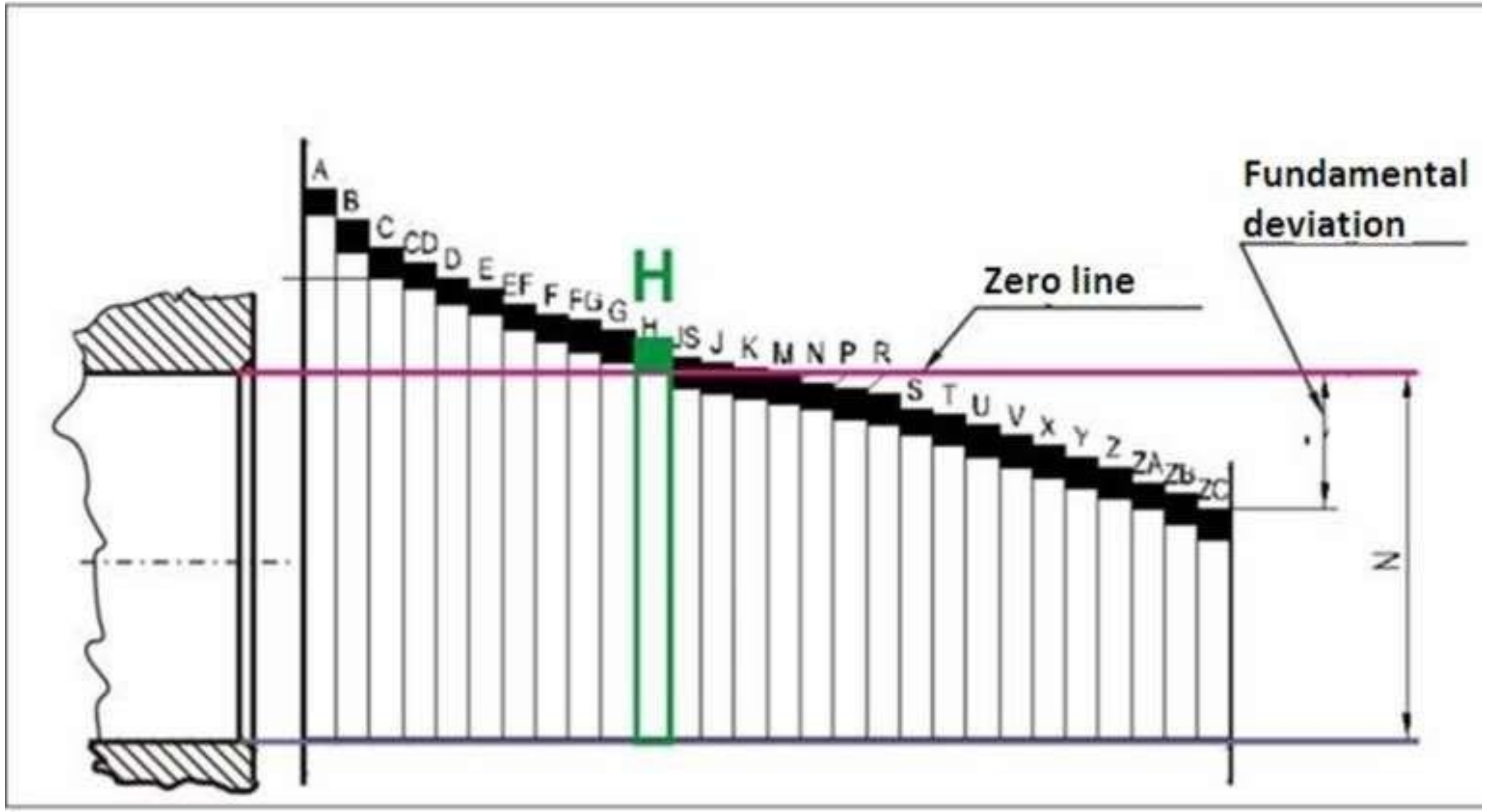
Interference fit		
Force or press	H8/r6	Crankpins, car wheel axles, bearing bushes in castings, etc.
Driving	H7/s6	Plug or shaft slightly larger than the hole
Tight	H7/p6	Stepped pulleys on the drive shaft of a conveyor
Shrink	H7/u6, H8/u7	Bronze crowns on worm wheel hubs, couplings, gear wheels, and assembly of piston pin in IC engine piston
Freeze	H7/u6, H8/u7	Insertion of exhaust valve seat inserts in engine cylinder blocks and insertion of brass bushes in various assemblies

FITS

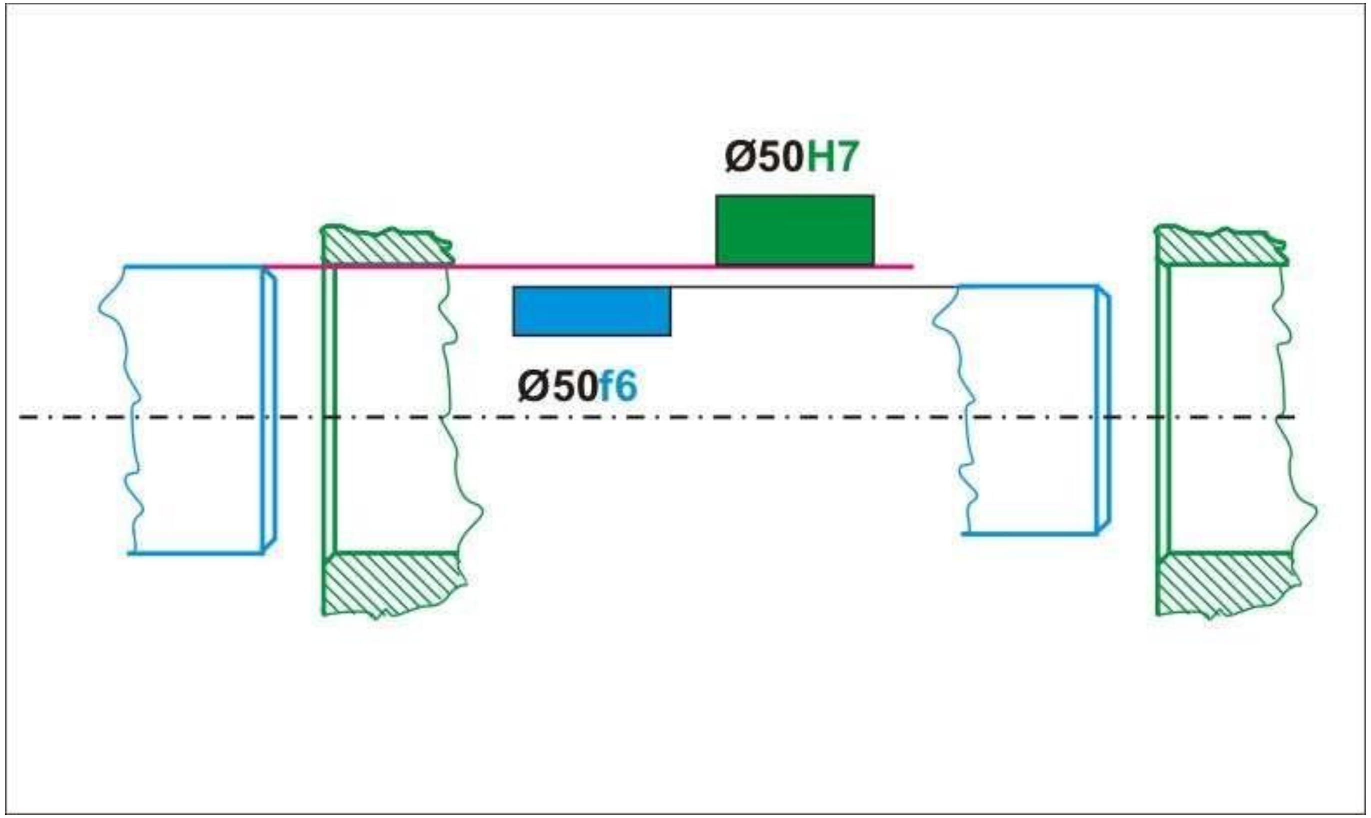
Application of Fits

		Transition fit
Push or snug	H7/k6	Pulleys and inner ring of ball bearings on shafts
Wringing	H7/n6	Gears of machine tools

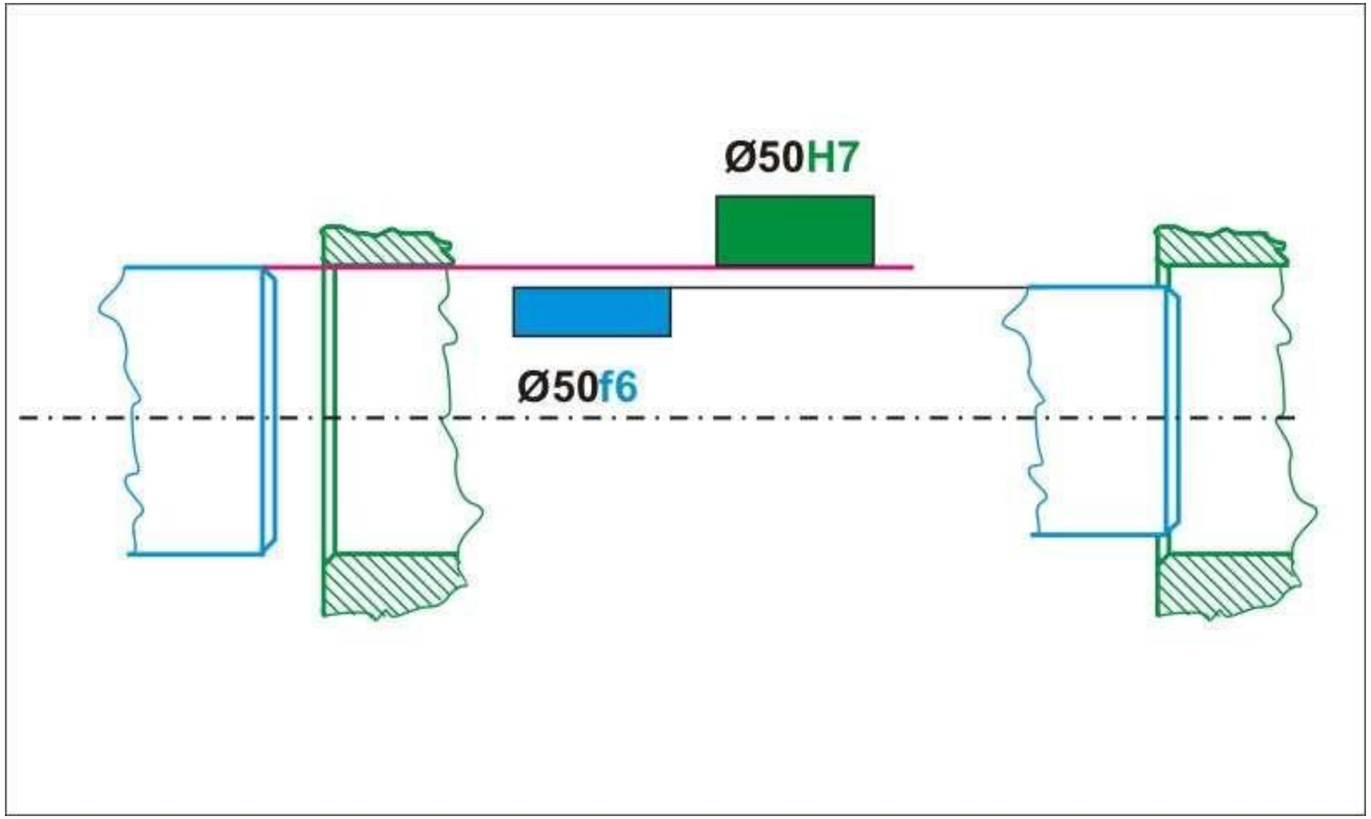
General Terminology in Fits



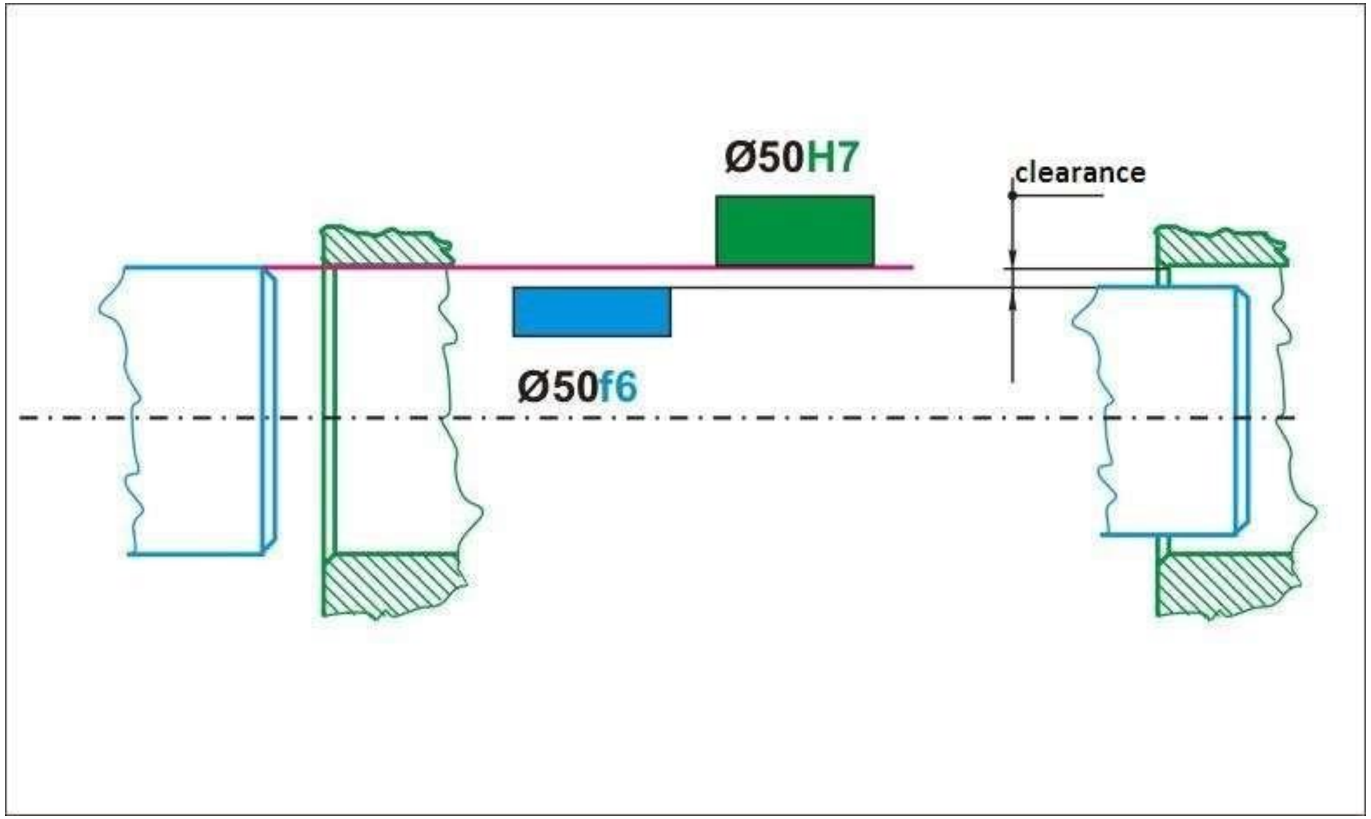
Clearance Fit (e.g.: H7/f6)



Clearance Fit (pl. H7/f6)



Clearance Fit (pl. H7/f6)



Tolerance Grade

- Tolerance grades indicates the degree of accuracy of manufacture.
- IS: 18 grades of fundamental tolerances are available.
- Designated by the letters IT followed by a number.
- The ISO system provides tolerance grades from IT01, IT0, and IT1 to IT16.
- Tolerance values corresponding to grades IT5 - IT16 are determined using the standard tolerance unit (*i*, in μm), which is a function of basic size.

Tolerance Grade

$$i = 0.453\sqrt[3]{D} + 0.001D \text{ microns}$$

- *D* = diameter of the part in mm.
- 0.001*D* = Linear factor counteracts the effect of measuring inaccuracies.
- Value of tolerance unit '*i*' is obtained for sizes up to 500 mm.
- *D* is the geometric mean of the lower and upper diameters.
- D= $\sqrt{D_{max} \times D_{min}}$

Tolerance Grade

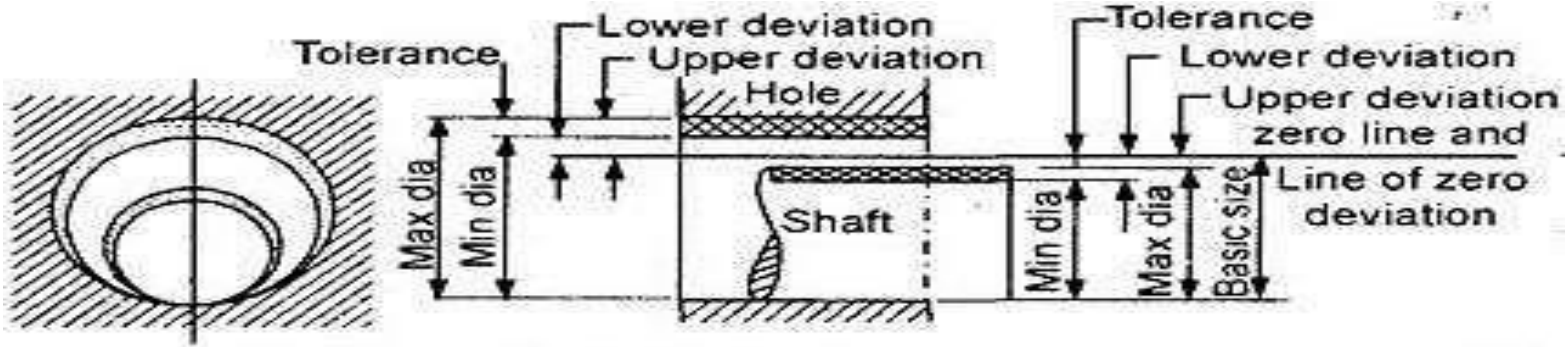
Standard tolerance units

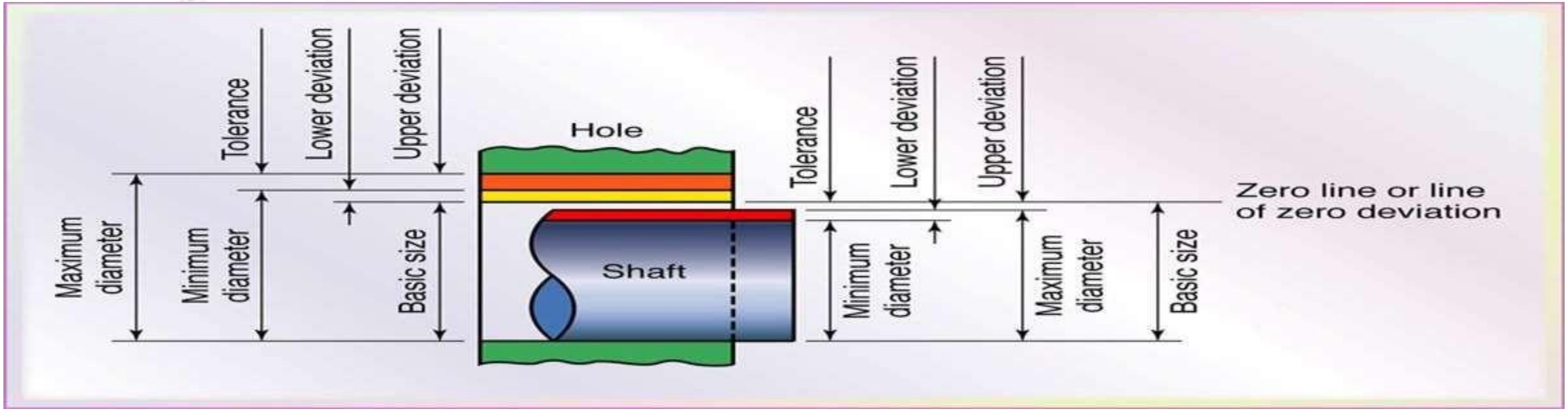
Tolerance grade	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16
Standard tolerance unit (*i*)	10	16	25	40	64	100	160	250	400	640	1000

Tolerances grades for applications

Fundamental tolerance	Applications
IT01–IT4	For production of gauges, plug gauges, and measuring instruments
IT5–IT7	For fits in precision engineering applications such as ball bearings, grinding, fine boring, high-quality turning, and broaching
IT8–IT11	For general engineering, namely turning, boring, milling, planning, rolling, extrusion, drilling, and precision tube drawing
IT12–IT14	For sheet metal working or press working
IT15–IT16	For processes such as casting, stamping, rubber moulding, general cutting work, and flame cutting

General Terminology





General Terminology

- **Basic size:** Exact theoretical size arrived at by design. Also called as nominalsize.
- **Actual size:** Size of a part as found by measurement
- **Zero Line:** Straight line corresponding to the basic size. Deviations are measured from this line.
- **Limits of size:** Maximum and minimum permissible sizes for a specific dimension.
- **Tolerance:** Difference between the maximum and minimum limits of size.
- **Allowance:** LLH -HLS

General Terminology

- **Deviation:** Algebraic difference between a size and its corresponding basic size.

  It may be positive, negative, or zero.

- **Upper deviation:** Algebraic difference between the maximum limit of size and its corresponding basic size.

  Designated as 'ES' for a hole and as 'es' for a shaft.

- **Lower deviation:** Algebraic difference between the minimum limit of size and its corresponding basic size.

  Designated as 'EI' for a hole and as 'ei' for a shaft.

General Terminology

- **Actual deviation:** Algebraic difference between the actual size and its corresponding basic size.
- **Tolerance Zone:** Zone between the maximum and minimum limit size.

Hole Basis and Shaft Basis Systems

- To obtain the desired class of fits, either the size of the hole or the size of the shaft must vary.

Two types of systems are used to represent three basic types of fits, clearance, interference, and transition fits.

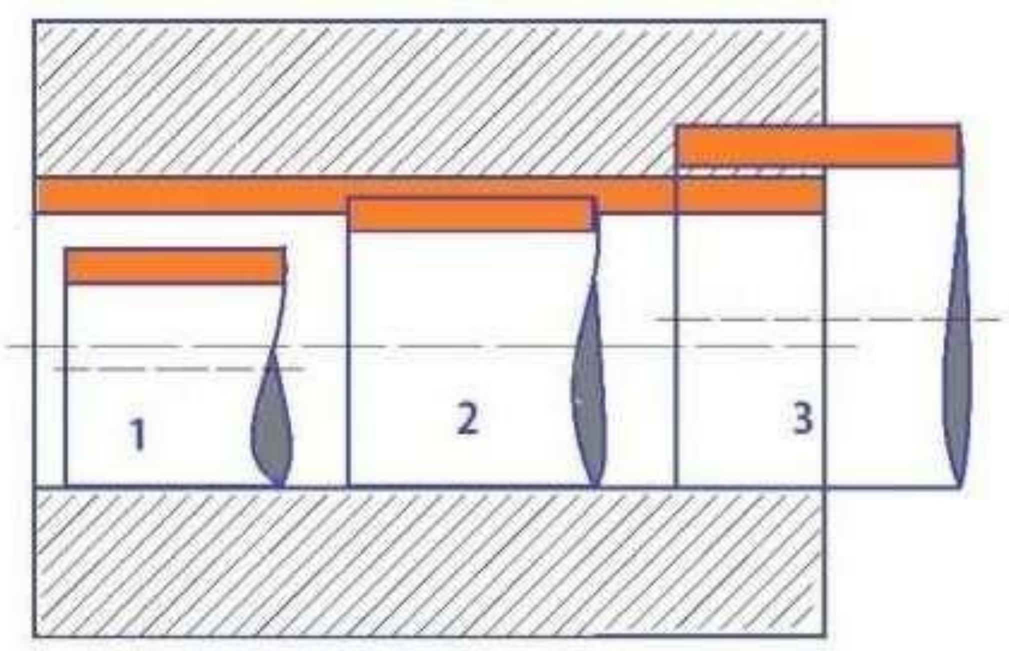
(a) Hole basis system

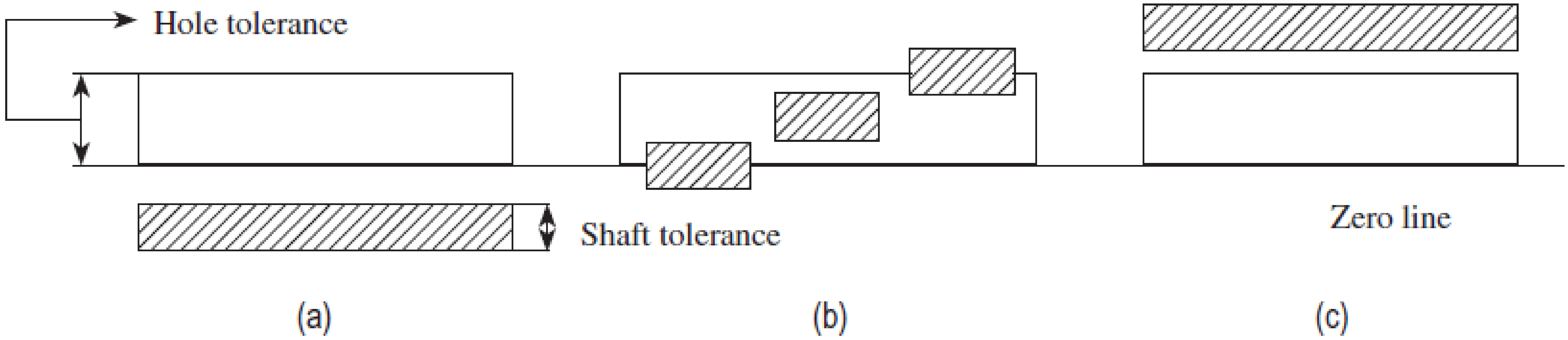
(b) Shaft basis system.

Hole Basis systems

- The size of the hole is kept constant and the shaft size is varied to give various types of fits.
- Lower deviation of the hole is zero, i.e. the lower limit of the hole is same as the basic size.
- Two limits of the shaft and the higher dimension of the hole are varied to obtain the desired type of fit.

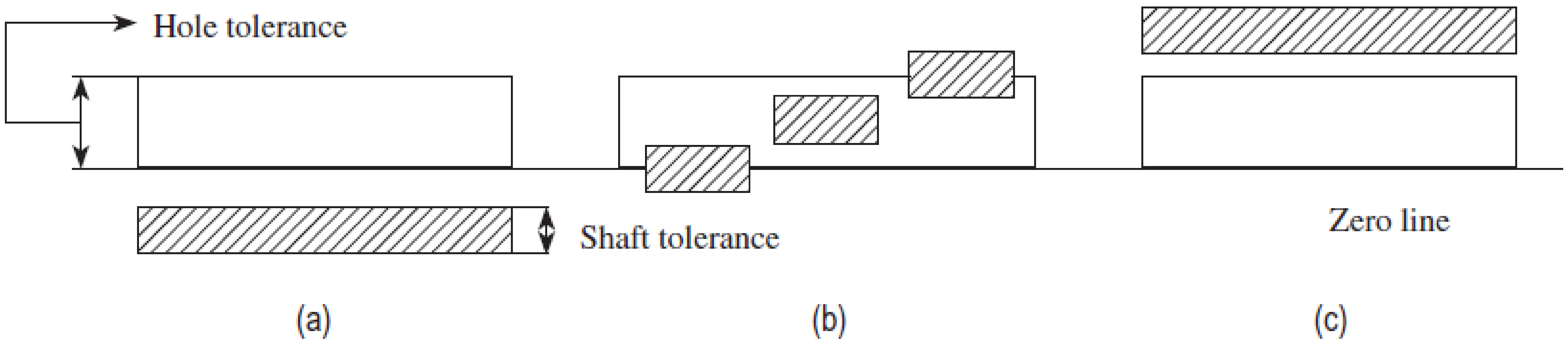
Hole Basis systems





(a) Clearance fit (b) Transition fit (c) Interference fit

Hole Basis systems



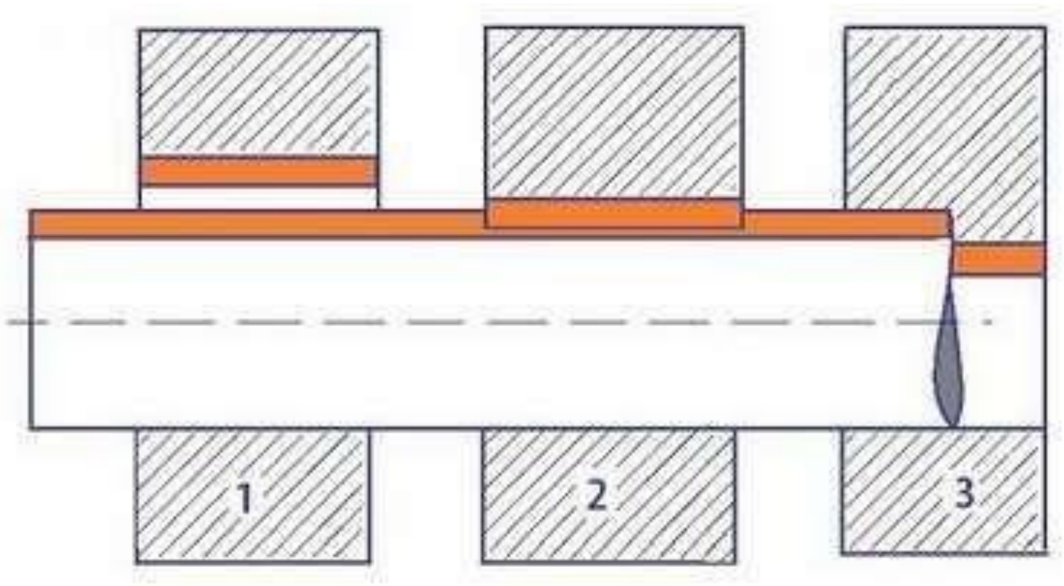
This system is widely adopted in industries, easier to manufacture shafts of varying sizes to the required tolerances.

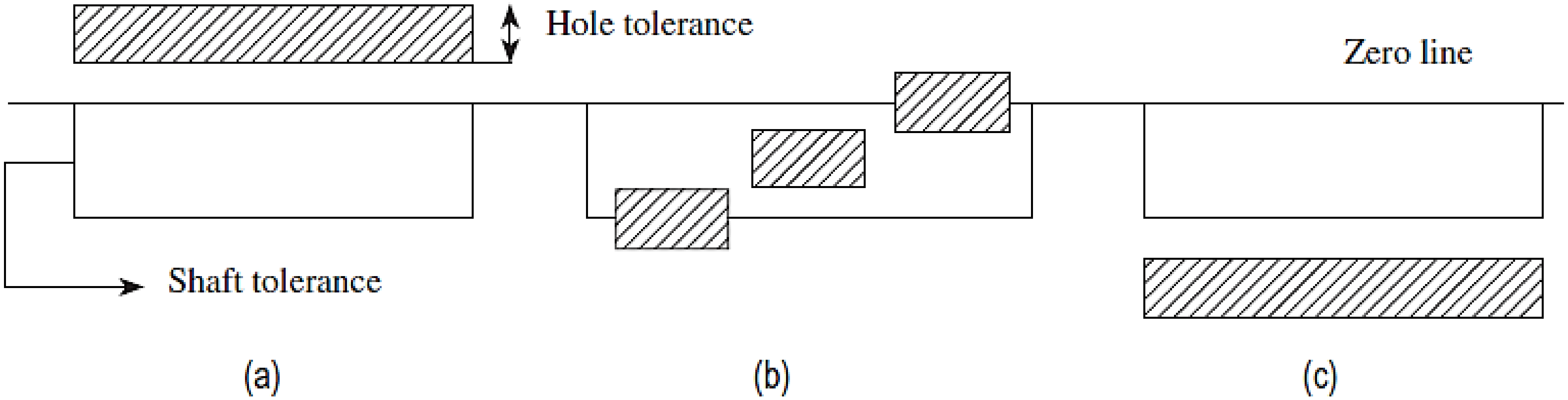
Standard-size plug gauges are used to check hole sizes accurately.

Shaft Basis systems

- The size of the shaft is kept constant and the hole size is varied to obtain various types of fits.
- Fundamental deviation or the upper deviation of the shaft is zero.
- System is not preferred in industries, as it requires more number of standard-size tools, like reamers, broaches, and gauges, increases manufacturing and inspection costs.

Shaft Basis systems





(a) Clearance fit (b) Transition fit (c) Interference fit

Tolerance symbols

Used to specify the tolerance and fits for mating components.

Example: Consider the designation **40 H7/d9**

- Basic size of the shaft and hole = 40 mm.
- Nature of fit for the hole basis system is designated by H
- Fundamental deviation of the hole is zero.
- Tolerance grade: IT7.
- The shaft has a d-type fit, the fundamental deviation has a negative value.
- IT9 tolerance grade.

Tolerance symbols

- First eight designations from A (a) to H (h) for holes (shafts) are used for clearance fit
- Designations, JS (js) to ZC (zc) for holes (shafts), are used for interference or transition fits

Tolerance symbols

- Fundamental Deviation: Deviation either the upper or lower deviation, nearest to the zero line. (provides the position of the tolerance zone).

  It may be positive, negative, or zero.

- Upper deviation: Designated as ‘ES’ for a Hole and as ‘es’ for a shaft.
- Lower deviation: Designated as ‘EI’ for a Hole and as ‘ei’ for a shaft.

- Upper deviation: Designated as ‘ES’ for a Hole and as ‘es’ for a shaft.
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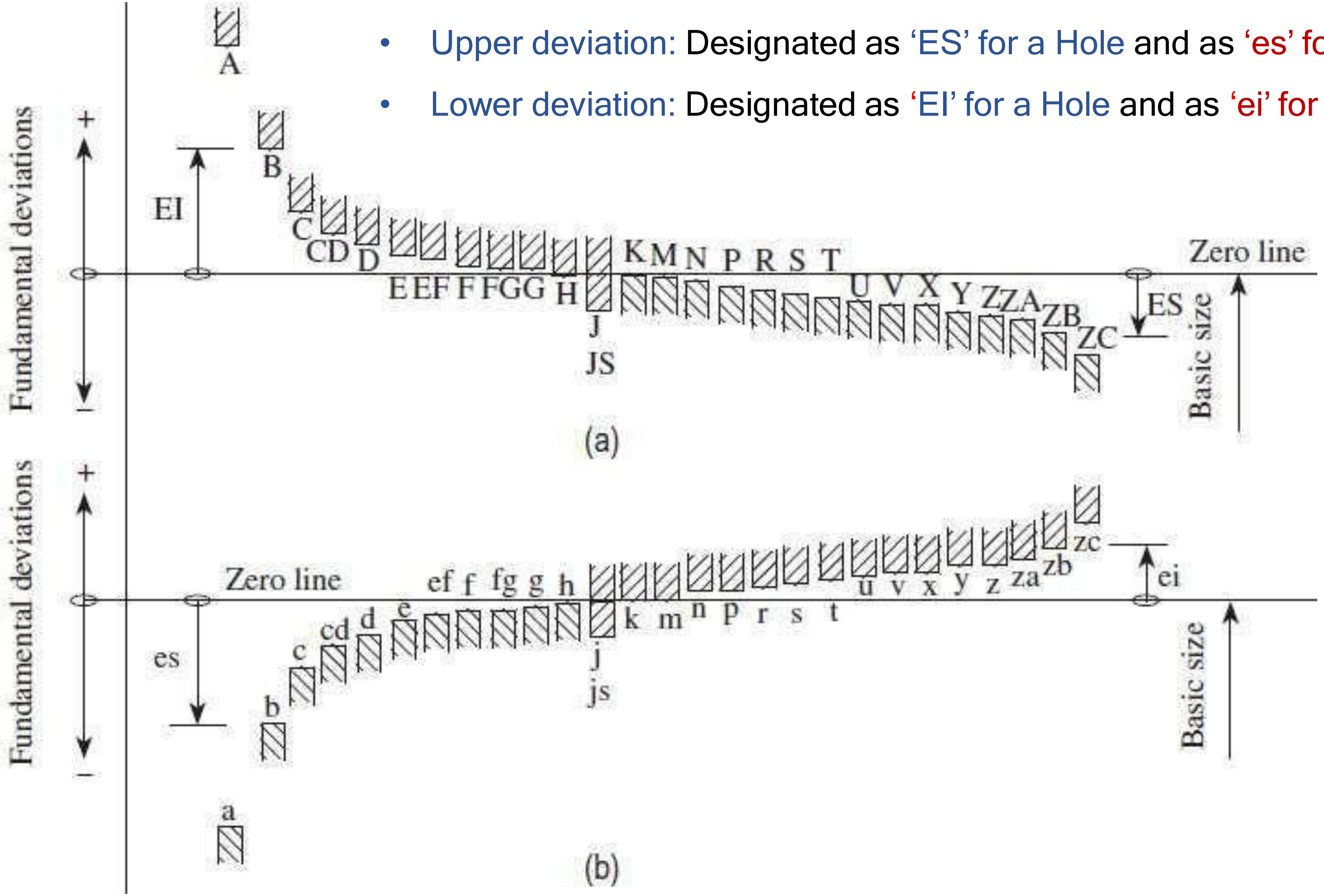


Typical representation of different types of fundamental deviations
(a) Holes (internal features) (b) Shafts (external features)

Fundamental deviation for shafts and holes of sizes from above 500 to 3150 mm

Shafts			Holes			Formula for deviations in µm
Type	Fundamental deviation	Sign	Type	Fundamental deviation	Sign	(for *D* in mm)
d	es	–	D	EI	+	$16D^{0.44}$
e	es	–	E	EI	+	$11D^{0.41}$
f	es	–	F	EI	+	$5.5D^{0.41}$
g	es	–	G	EI	+	$2.5D^{0.34}$
h	es	No sign	H	EI	No sign	0
js	ei	–	JS	ES	+	$0.5IT\pi$
k	ei	–	K	ES	–	0
m	ei	+	M	ES	–	$0.024D + 12.6$
n	ei	+	N	ES	–	$0.04D + 21$
P	ei	+	P	ES	–	$0.072D + 37.8$
r	ei	+	R	ES	–	Geometric mean of the values for p and s or P and S
s	ei	+	S	ES	–	$IT7 + 0.4D$
t	ei	+	T	ES	–	$IT7 + 0.63D$
u	ei	+	U	ES	–	$IT7 + D$

Tolerance Grade

- BIS: 18 grades of fundamental tolerances are available.
- Designated by the letters IT followed by a number.
- ISO/BIS: IT01, IT0, and IT1 to IT16.
- Tolerance values corresponding to grades IT5 - IT16 are determined using the standard tolerance unit (*i*, in µm)

Tolerance Grade

Tolerance unit, $i = 0.453\sqrt[3]{D} + 0.001D$ microns

- *D* = diameter of the part in mm.
- $0.001D$ = Linear factor counteracts the effect of measuring inaccuracies.
- Value of tolerance unit '*i*' is obtained for sizes up to 500 mm.
- *D* is the geometric mean of the lower and upper diameters.
- D= $\sqrt{D_{max} \times D_{min}}$

Tolerance Grade

$$D = \sqrt{D_{max} \times D_{min}}$$

The various steps specified for the diameter steps are as follows:

- 1-3, 3-6, 6-10, 10-18, 18-30, 30-50, 50-80, 80-120
- 120-180, 180-250, 250-315, 315-400, 400-500
- 500-630, 630-800, and 800-1000 mm.

Tolerance Grade

Standard tolerance units

Tolerance grade	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16
Standard tolerance unit (*i*)	10	16	25	40	64	100	160	250	400	640	1000

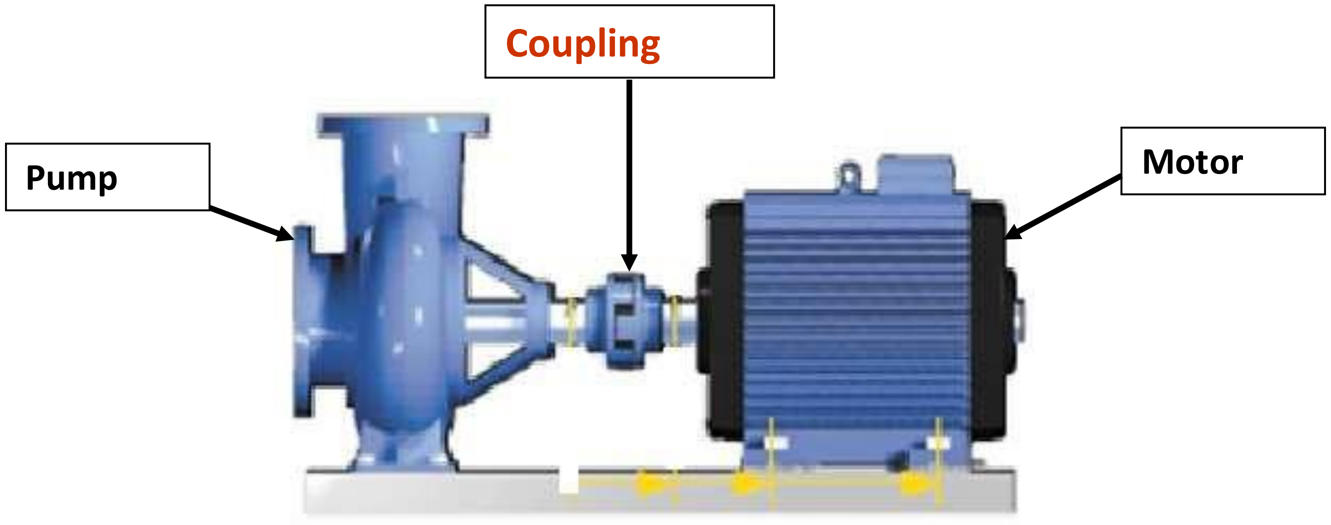
Maximum and Minimum Metal Conditions

- ✓ Let us consider a shaft having a dimension of 40 ± 0.05 mm.
- ✓ The maximum metal limit (MML) of the shaft will have a dimension of 40.05 mm because at this higher limit, the shaft will have the maximum possible amount of metal.
- ✓ The shaft will have the least possible amount of metal at a lower limit of 39.95 mm, and this limit of the shaft is known as minimum or least metal limit (LML).
- ✓ Similarly, consider a hole having a dimension of 45 ± 0.05 mm.
- ✓ The hole will have a maximum possible amount of metal at a lower limit of 44.95 mm and the lower limit of the hole is designated as MML.
- ✓ For example, when a hole is drilled in a component, minimum amount of material is removed at the lower limit size of the hole. This lower limit of the hole is known as MML.
- ✓ The higher limit of the hole will be the LML. At a high limit of 45.05 mm, the hole will have the least possible amount ofmetal.

Chapter 2
Couplings

Couplings

Coupling is a device used to connect two shafts together at their ends for the purpose of transmitting power.



Uses of Coupling

- To provide connection of shafts of units made separately
- To allow misalignment of the shafts or to introduce mechanical flexibility.
- To reduce the transmission of shock loads.
- To introduce protection against overloads.
- To alter the vibration characteristics.

Types of coupling

- Rigid
- Flexible
- Universal

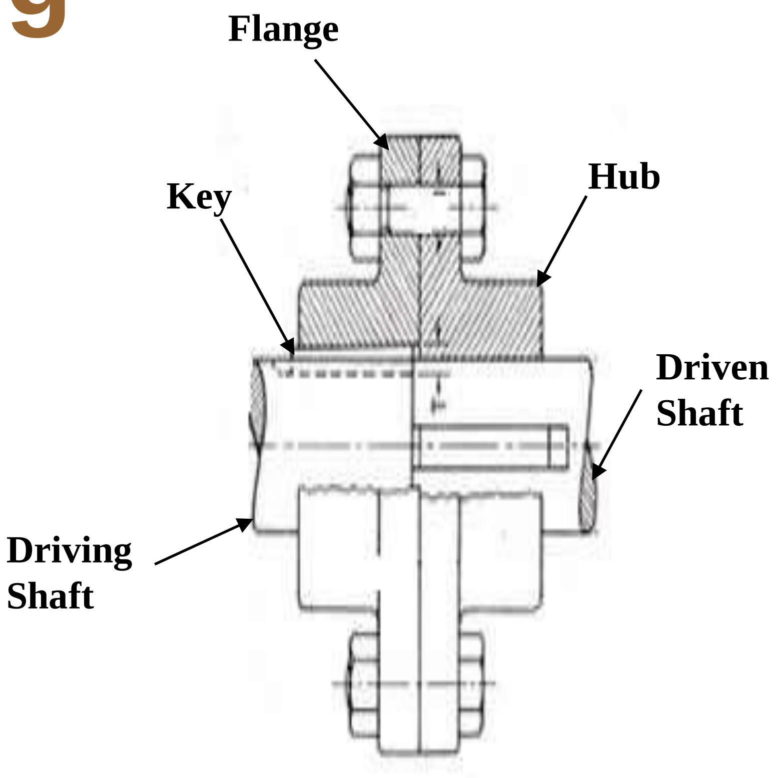
Rigid coupling

Flexible coupling

Universal coupling

Rigid coupling

- Rigid couplings are used when precise shaft alignment is required
- Simple in design and are more rugged
- Generally able to transmit more power than flexible couplings
- Shaft misalignments cannot be compensated

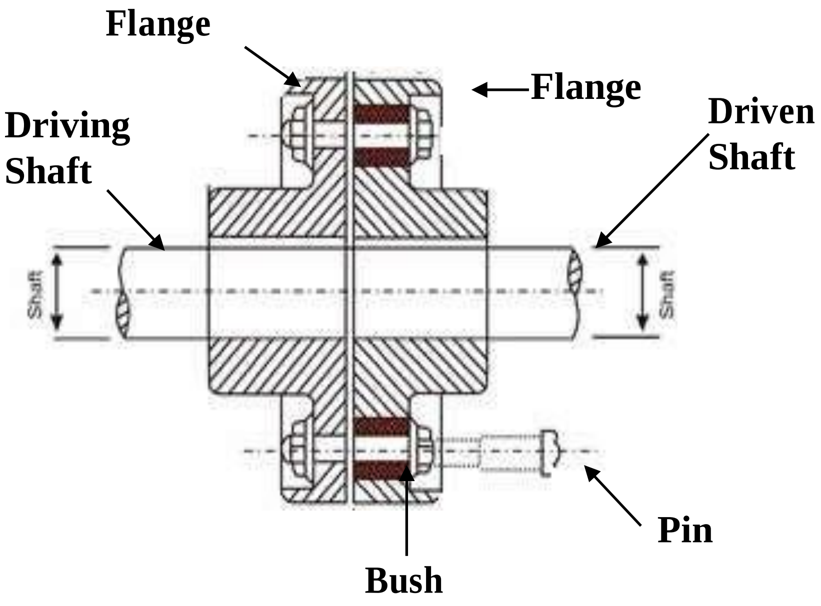


Flanged Coupling

Flexible Coupling

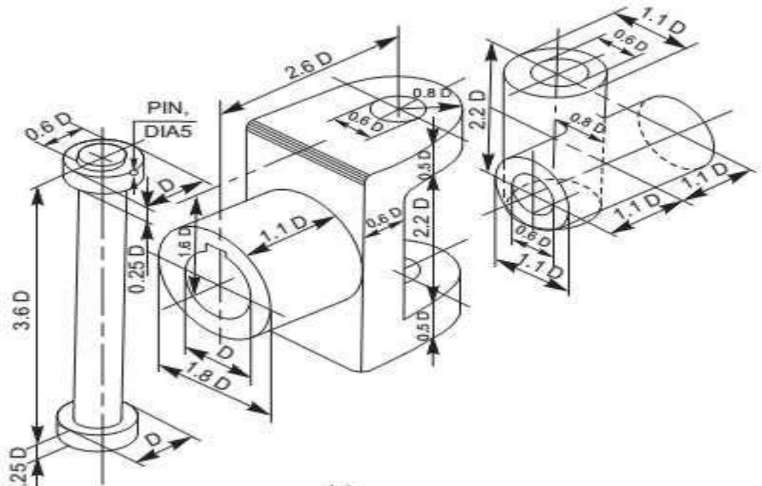
- A flexible coupling permits with in certain limits, relative rotation and
- variation in the alignment of shafts
- Pins (Bolts) covered by rubber washer or bush is used connect flanges with nuts

- The rubber washers or bushes act as a shock absorbers and insulators.

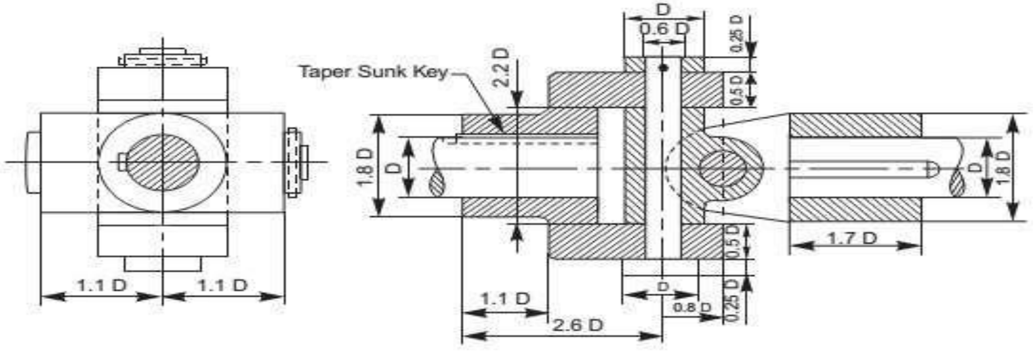


Universal Coupling

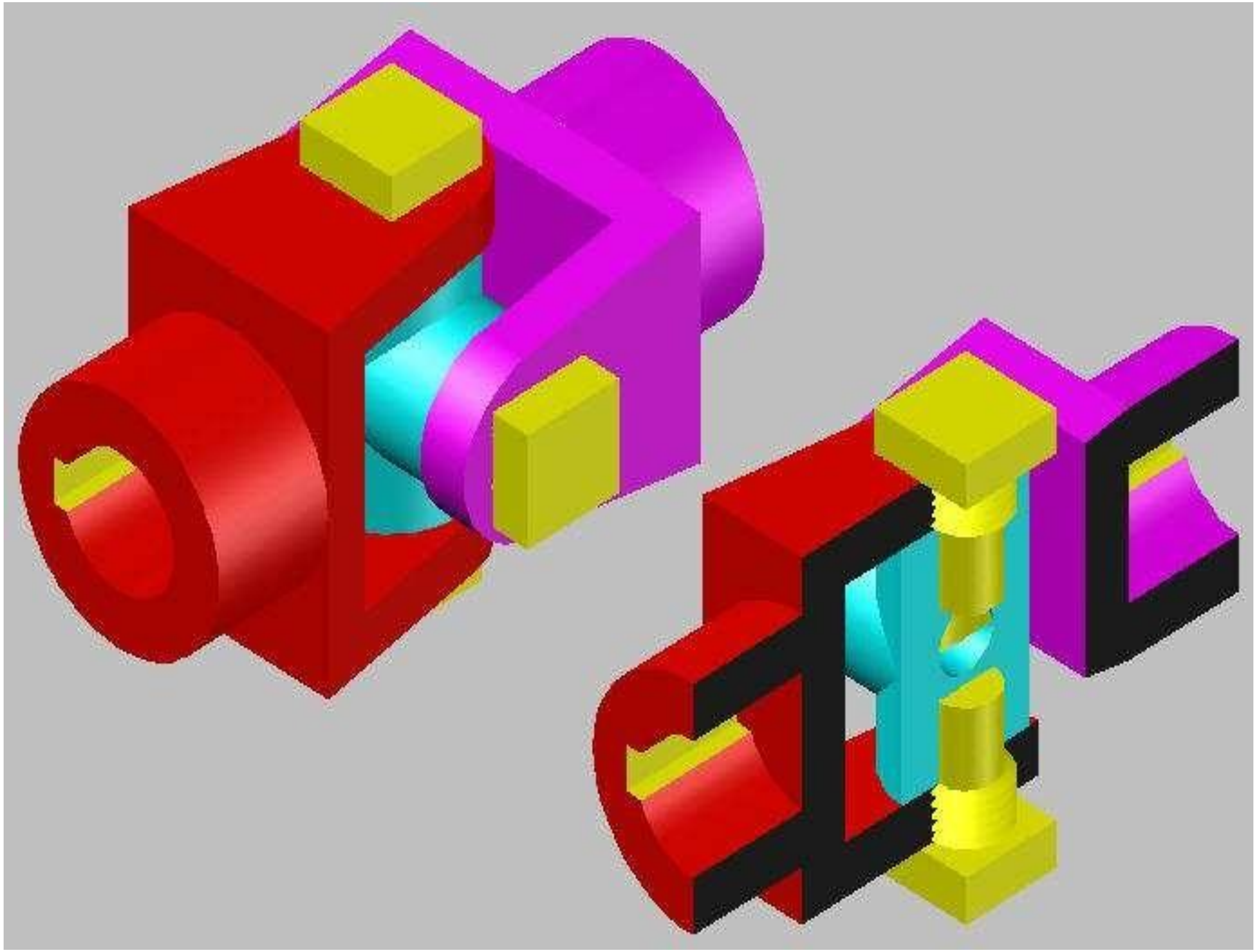
➢ It is a rigid coupling that connects two shafts, whose axes intersect if extended. It consists of two forks which are keyed to the shafts. The two forks are pin joined to a central block, which has two arms at right angle to each other in the form of a cross (Fig.). The angle between the shafts may be varied even while the shafts are rotating.



(a)

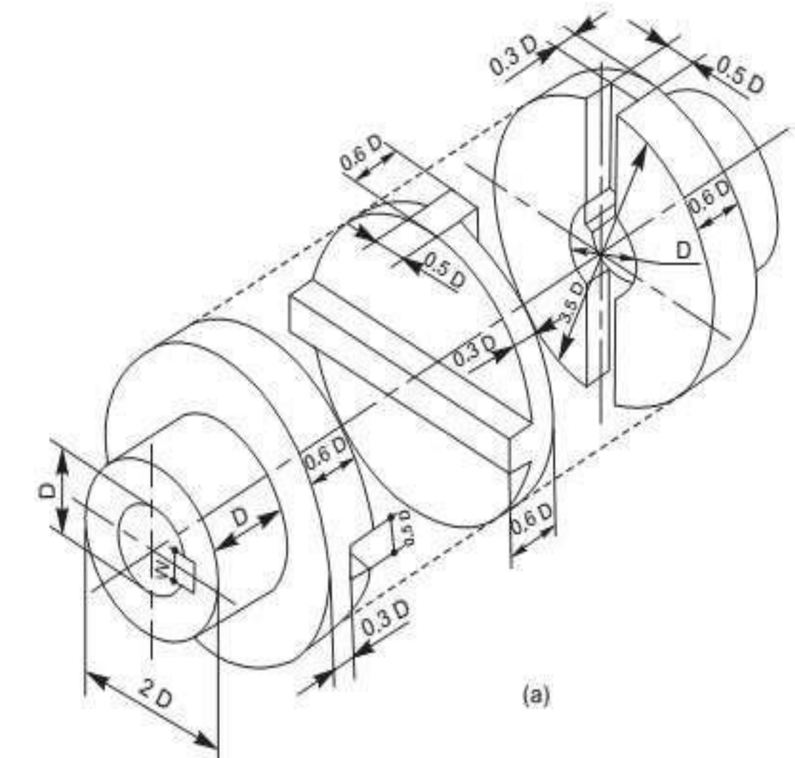


(b)



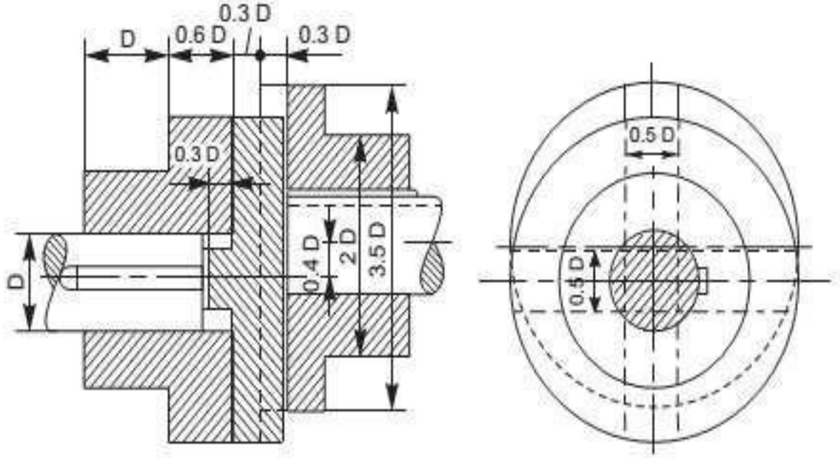
Oldham's Coupling

- It is used to connect two parallel shafts whose axes are at a small distance apart. Two flanges, each having a rectangular slot, are keyed, one on each shaft. The two flanges are positioned such that, the slot in one is at right angle to the slot in the other. To make the coupling, a circular disc with two rectangular projections on either side and at right angle to each other, is placed between the two flanges. During motion, the central disc, while turning, slides in the slots of the flanges. Power transmission takes place between the shafts, because of the positive connection between the flanges and the central disc.



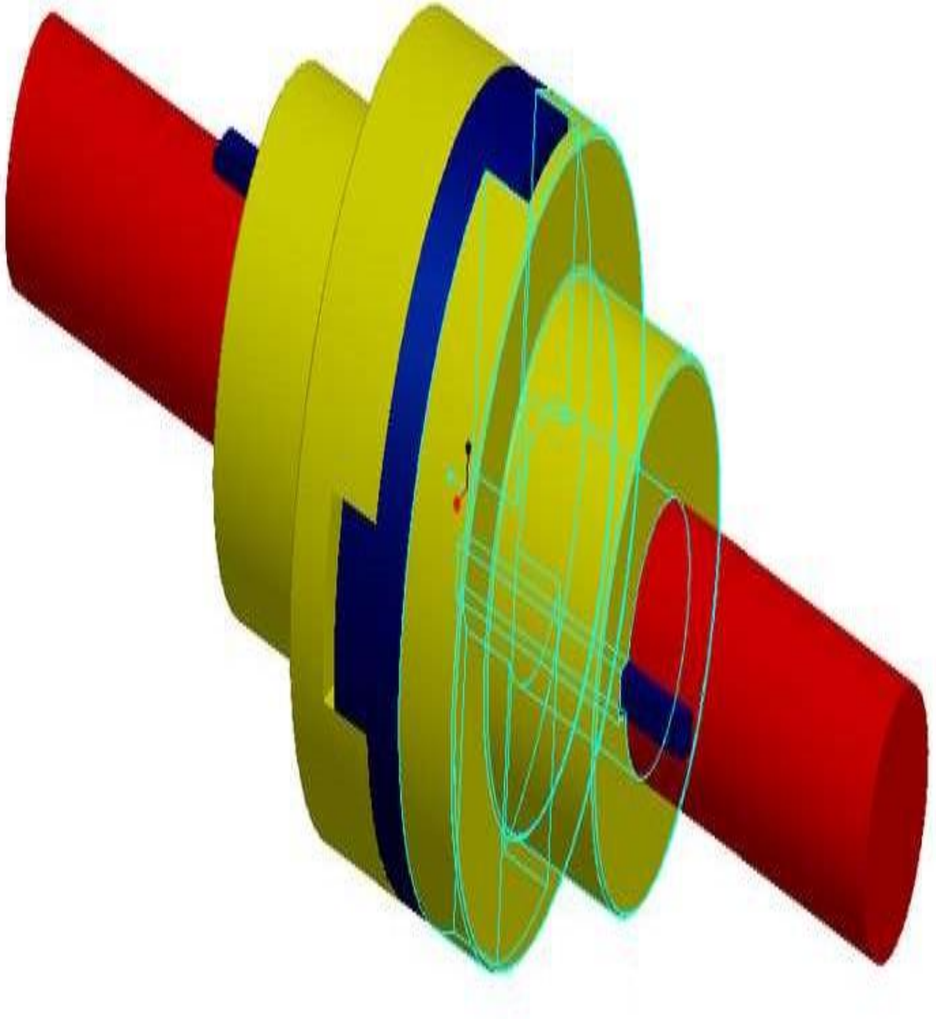
0.3 D
0.5 D
0.6 D
0.5 D
0.6 D
D
3.5 D
0.3 D
0.6 D
D
D
0.5 D
0.6 D
0.3 D
2 D

(a)



D
0.6 D
0.3 D
0.3 D
0.3 D
D
0.4 D
2 D
3.5 D
0.5 D
0.5 D

(b)



Advantages and Limitations

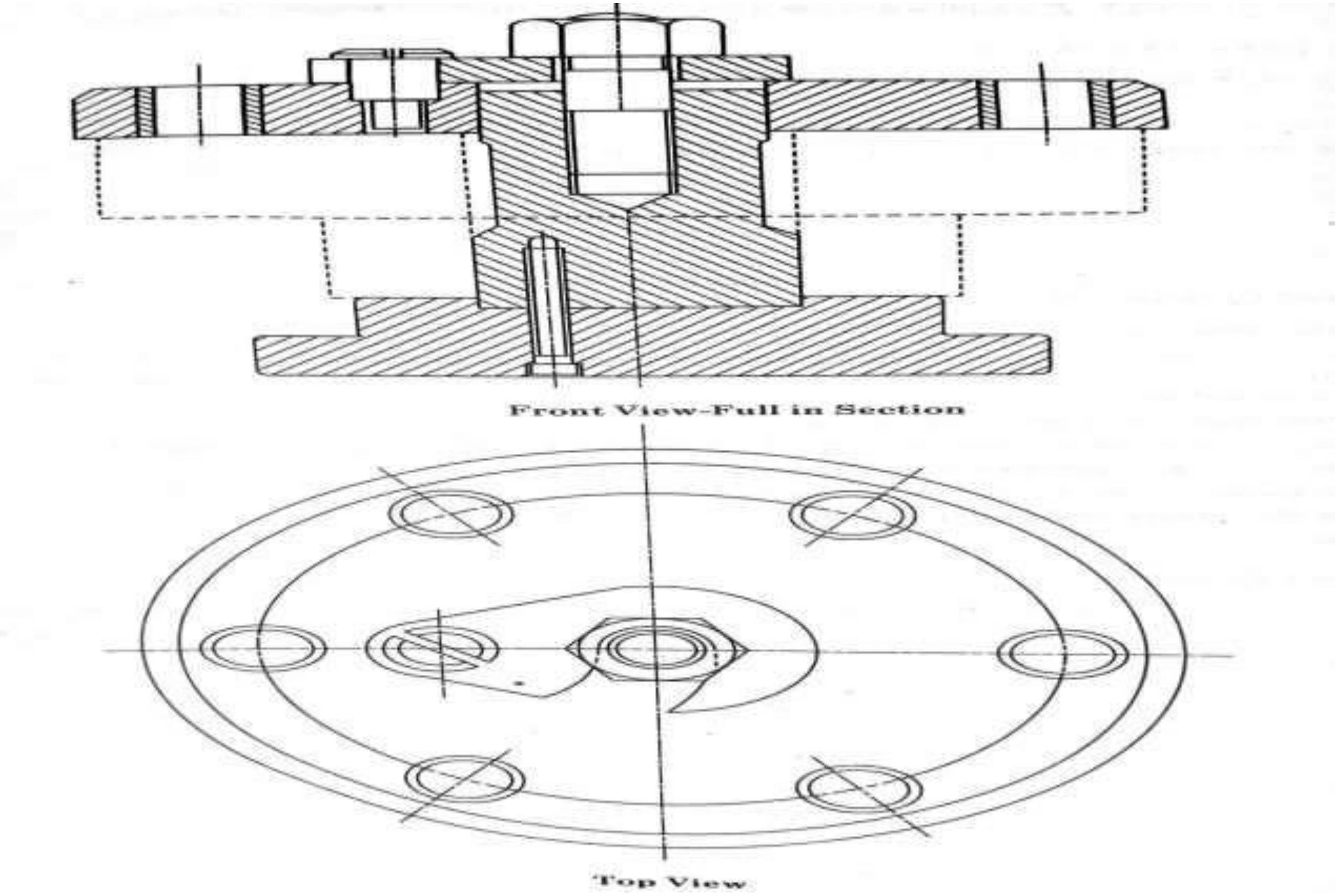
Advantages
Torsionally stiff
No lubrication or maintenance
Good vibration damping and shock absorbing qualities
Less expensive than metallic couplings
More misalignment allowable than most metallic couplings

Limitations
Sensitive to chemicals and high temperatures
Usually not torsionally stiff enough for positive displacement
Larger in outside diameter than metallic coupling
Difficult to balance as an assembly

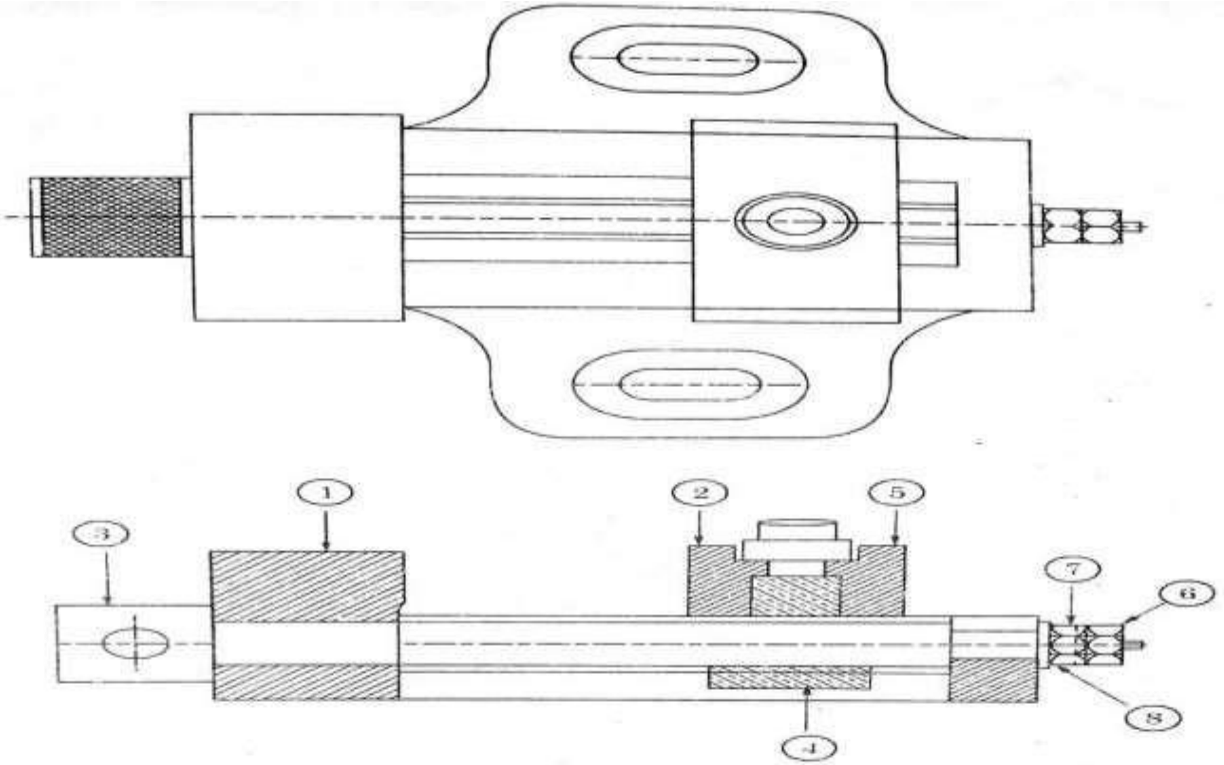
Contents

CHAPTER 3.

Drilling Jig (Assembly Drawing)



CHAPTER 4. Machine Vice



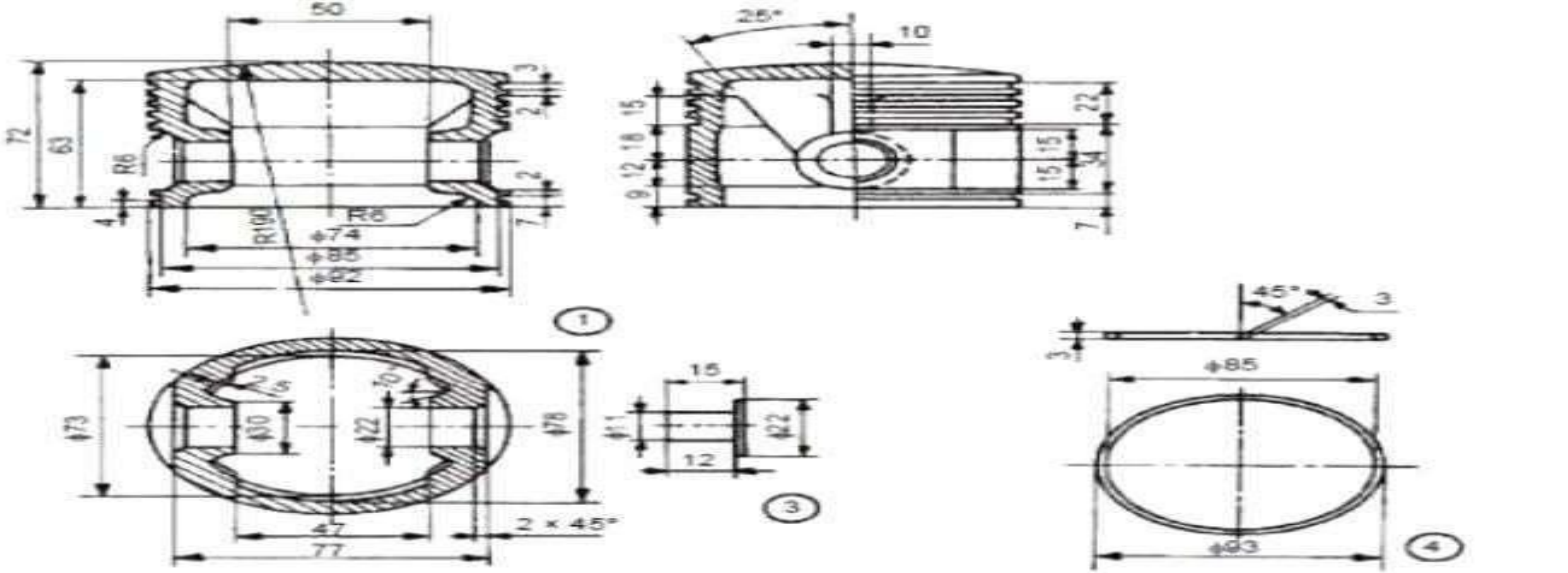
Bill of Materials Machine Vice - Fig. 9.3

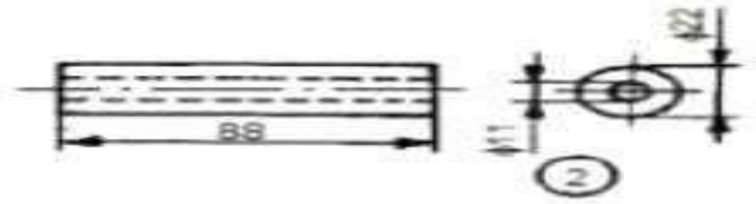
Part No.	Name of Part	Material	No. Off.
1.	Base	C.I.	01
2.	Movable jaw	M.S.	01
3.	Screw	M.S	01
4.	Movable jaw clamping bolt	M.S	01
5.	Circular nut	M.S	01
6.	Hexagonal nut	M.S	01
7.	Lock nut	M.S	01
8.	Washer	M.S	01

CHAPTER 5. I.C. Engine Parts

- Piston
- Connecting Rod
- Crank Shaft and flywheel

Piston (Petrol Engine)

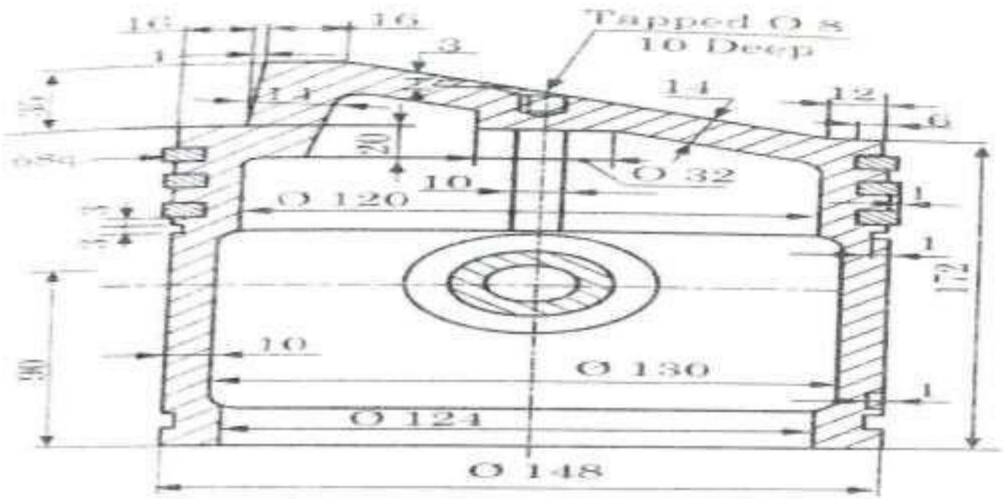




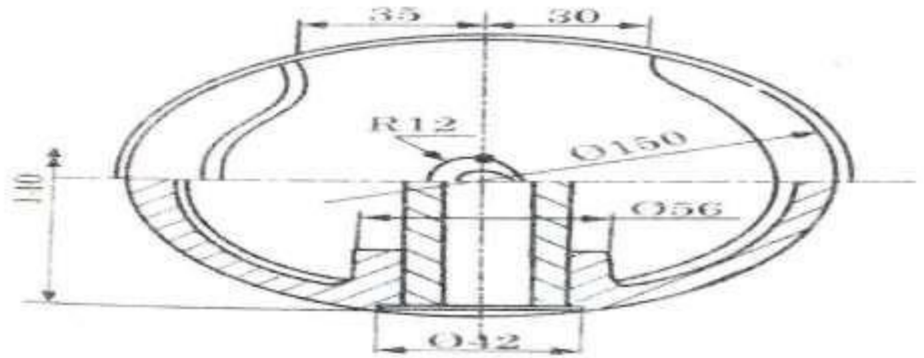
Parts list

No.	Name	Mat'l	Qty
1	Piston	Al-alloy	1
2	Piston pin	HCS	1
3	Piston pin plug	HCS	2
4	Piston ring	CI	5

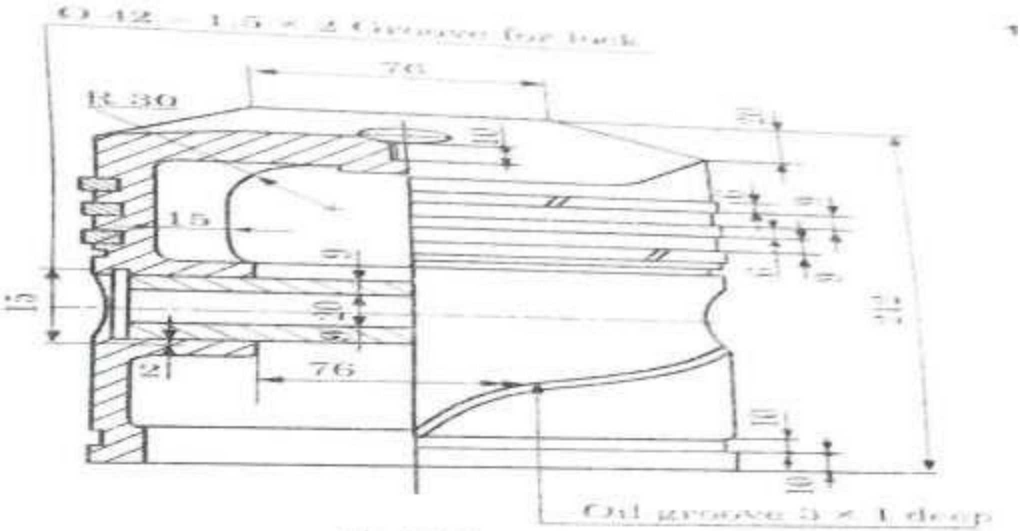
Piston (Diesel Engine)



Sectional Elevation

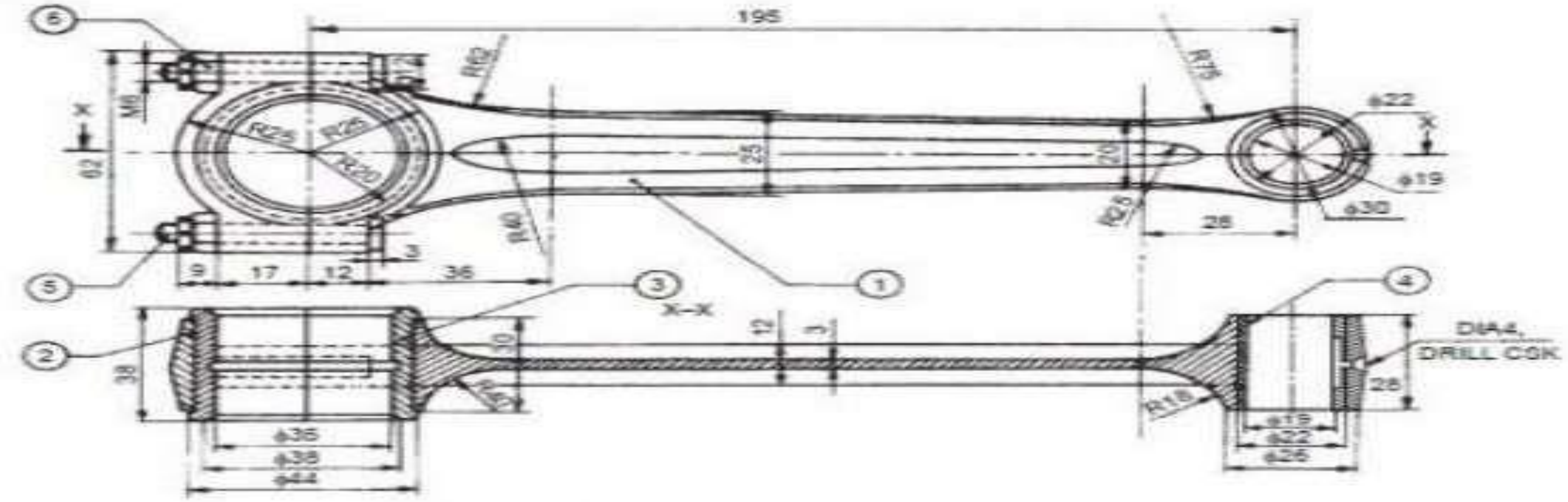


Half Sectional Plan



Half Sectional
Side View

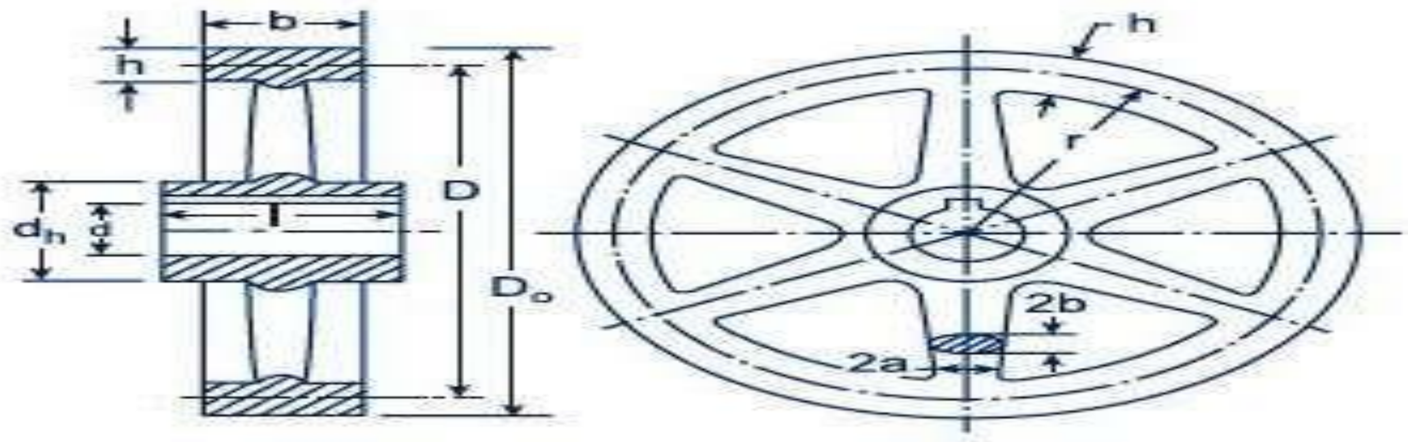
Connecting Rod



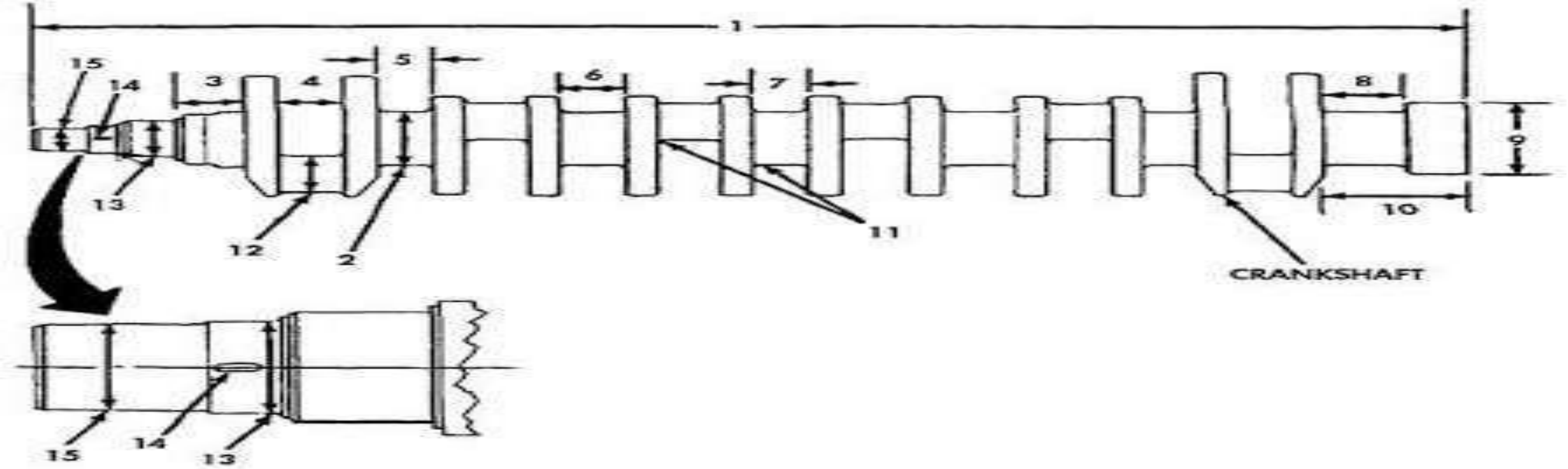
Parts list

Part No.	Name	Matl.	Qty.
1	Rod	FS	1
2	Cap	FS	1
3	Bearing brass	GM	2
4	Bearing bush	P Bronze	1
5	Bolt	MCS	2
6	Nut	MCS	2

Crank Shaft and Flywheel



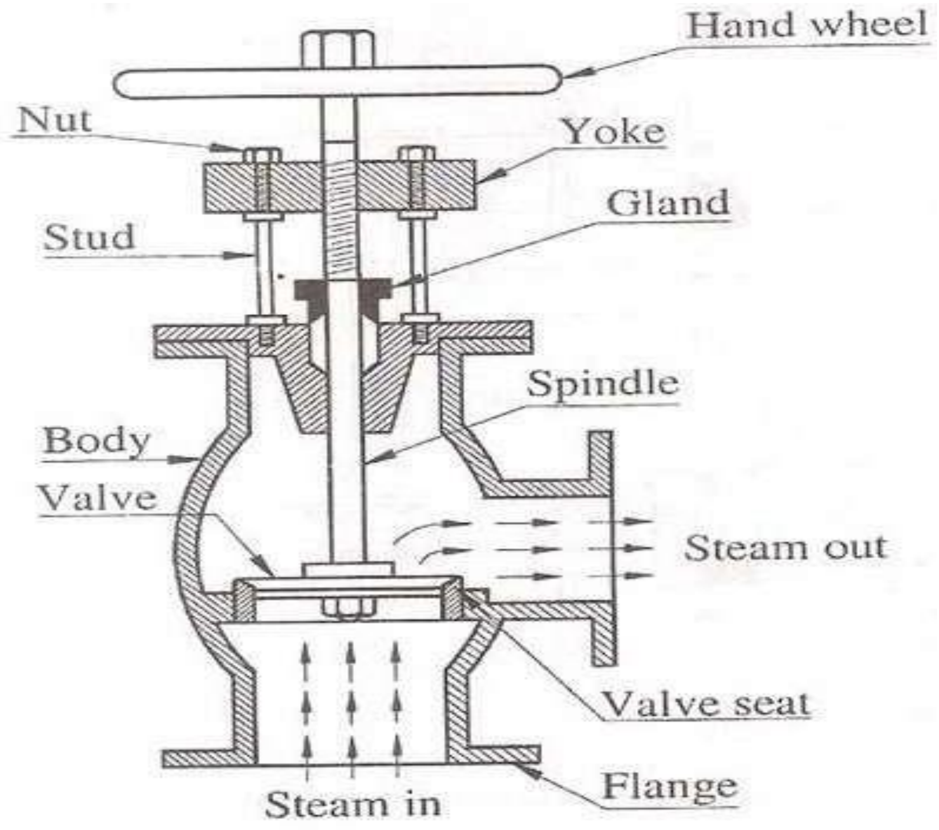
FLYWHEEL



CHAPTER 6

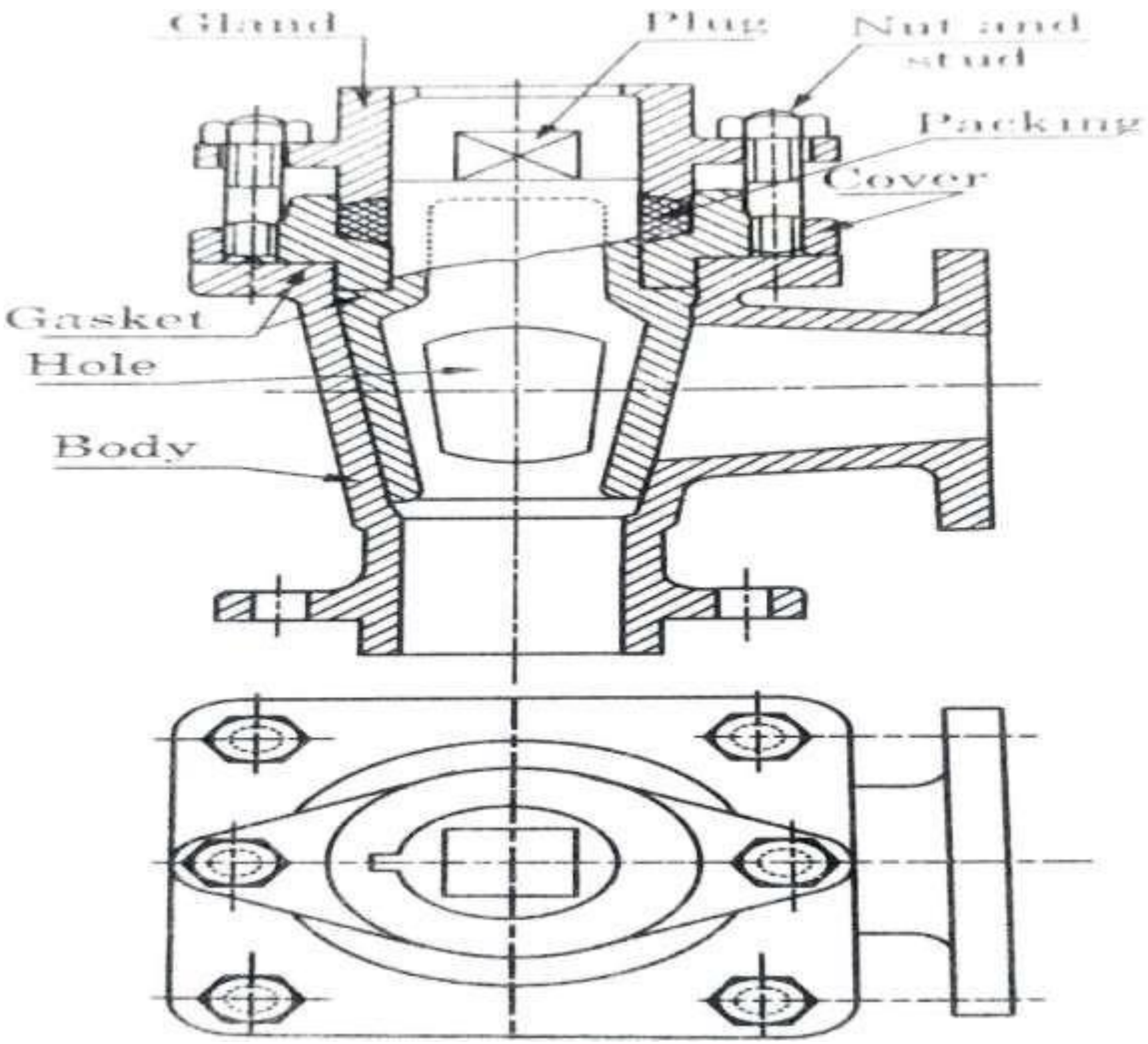
Boiler Parts

Blow Off Cock

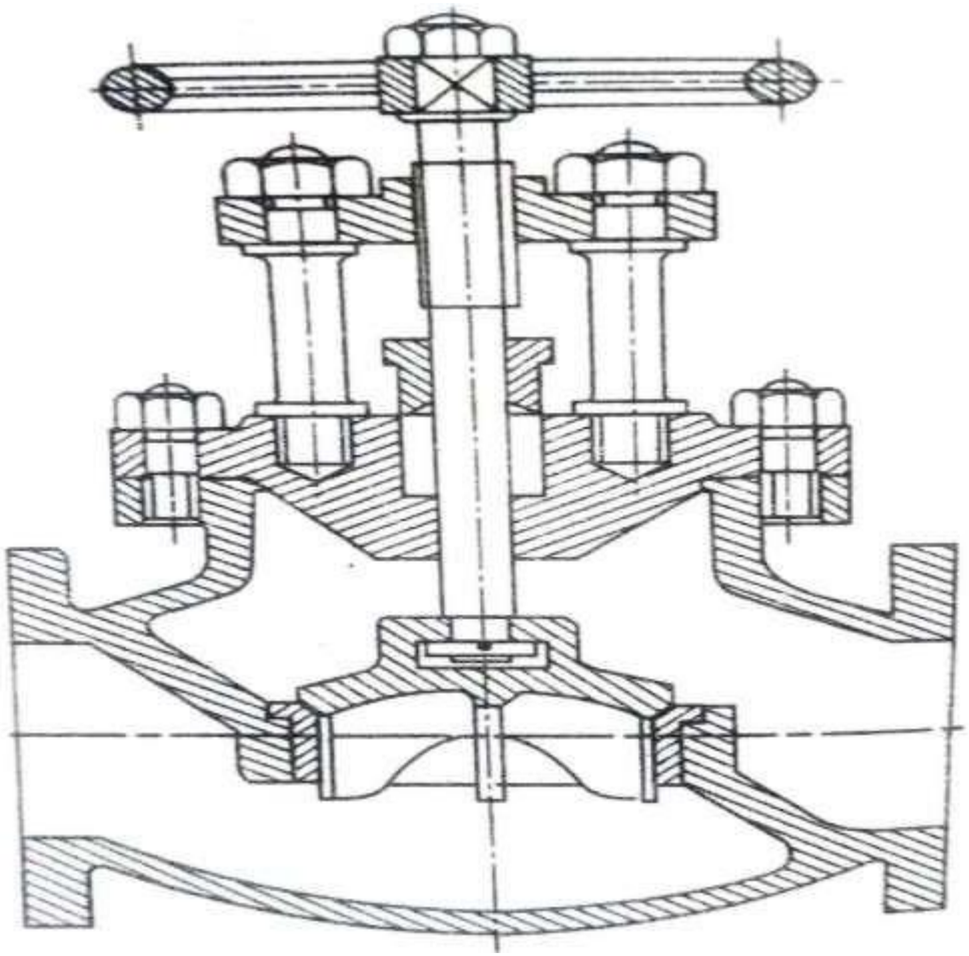


Steam Stop Valve

Blow Off Cock

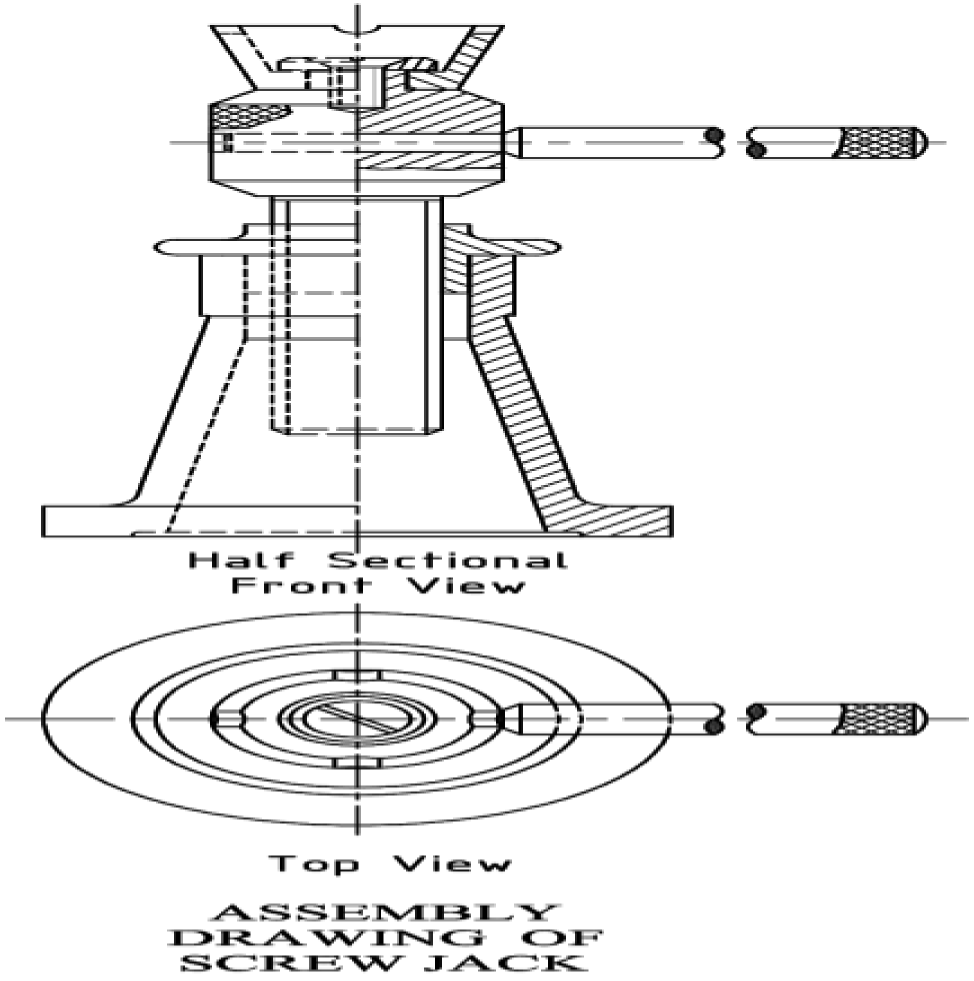


Steam Stop Valve



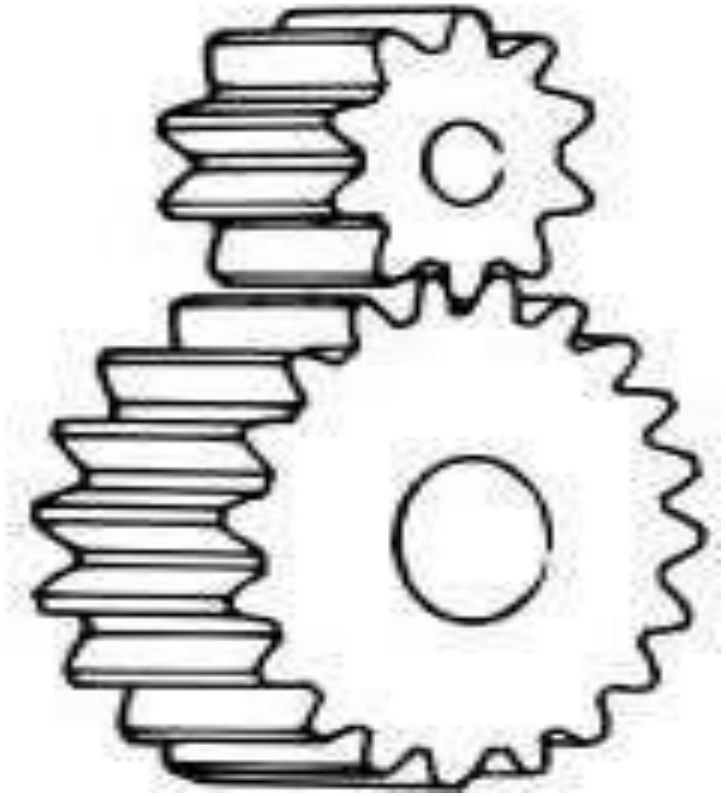
CHAPTER-7

Mechanical Screw Jack (Assembled Drawing)



CHAPTER-8
Gears

A **gear** is a rotating machine part having cut teeth



Classification of Gear

The gears can be classified in the following way:-

1. Depending on the relative position of the geometrical axes of the driving and driven shaft
2. Depending upon the housing design.
3. Depending upon the peripheral Velocity.
4. Depending upon the shape of teeth.

Depending on the relative position of the geometrical axes of the driving and driven shaft

Parallel Shaft 1.Spur Gears 2.Helical Gears 3.Herringbone

Intersecting Shafts

1. Miter Gears
2. Face Gears
3. Zero Bevel Gears
4. Straight Bevel Gears
5. Spiral Bevel Gears

Non-parallel, Non Intersecting Shafts

1. Spiral Gears
2. Hypoid Gears
3. Worm Gears

Depending upon the housing design

- **Open Drives**:- The gear drive is without a casing and is subjected to the action of dust and dirt.
- **Closed Drives**:- The gear Drives are enclosed in special casings and are protected against dirt and dust and are properly lubricated.

Depending upon the peripheral Velocity

1. **Low Velocity:** V is < 3 m/s.
2. **Medium Velocity:** V=3 to 15 m/s.
3. **High Velocity:** V is>15 m/s.

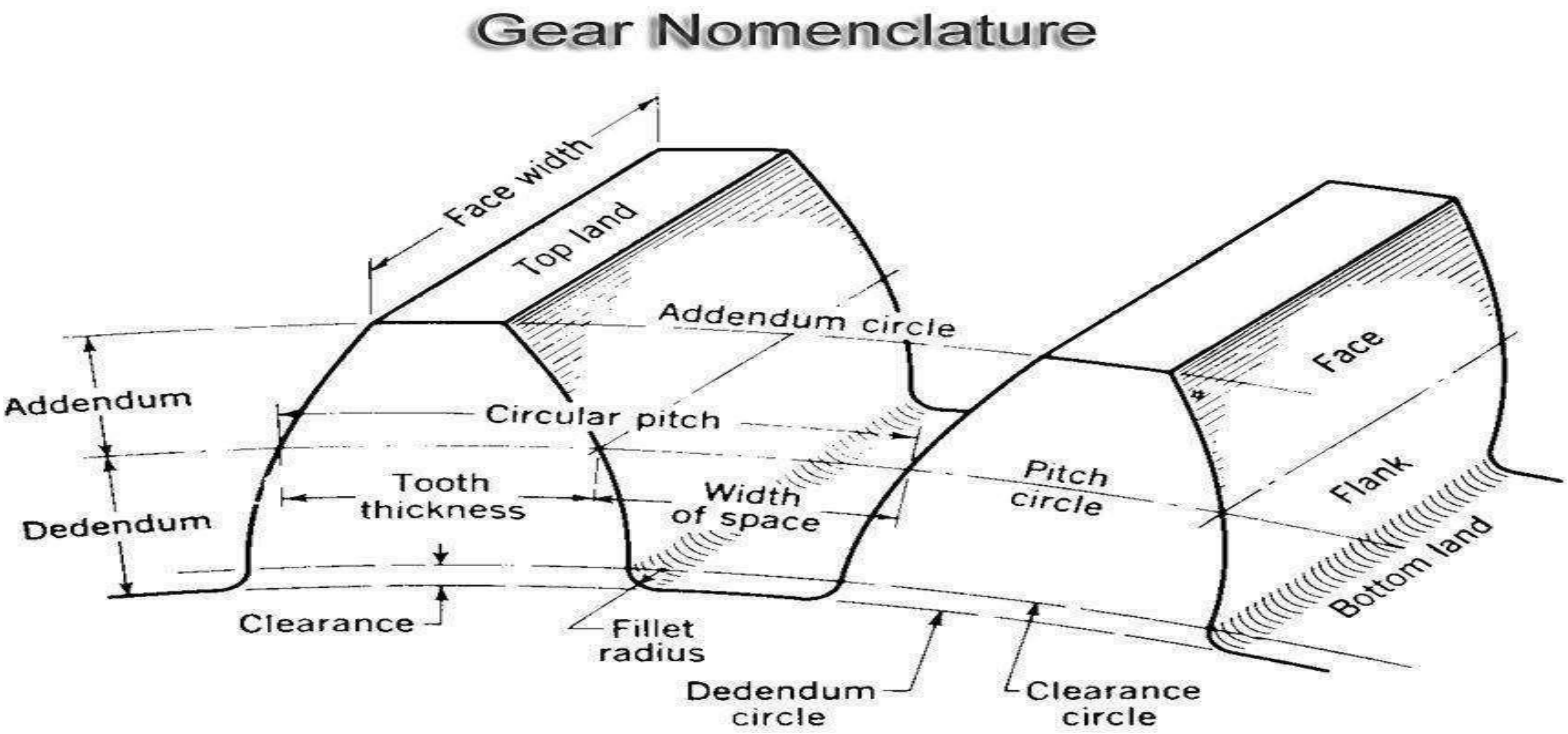
Depending Upon the Type of Gearing

- External Gearing The teeth are provided on the external surfaces
- Internal Gearing The teeth are provided on the internal surfaces
- Rack and Pinion it has infinite Pitch Diameter

Depend upon shape of teeth of the Gear

- Straight teeth Gear it has straight Teeth
- Helical teeth Gear it has helical Teeth
- Herringbone Teeth Gear same as double helical gears but there is no space between the opposite sets of teeth
- Curved Teeth Gear the teeth are Curved

Gear Nomenclature



Gear Nomenclature

1. Pitch circle

Pitch circle is the imaginary circle that rolls without slipping with a pitch circle of a mating gear.

2. Pitch Circle Diameter

The pitch circle diameter is the diameter of the pitch circle. It is also known as pitch diameter.

3. Pressure angle

Pressure angle is the angle between the common normal at the point of tooth contact and the common tangent to the pitch circle. The usual pressure angles are 14½° and 20°.

4. Pitch point

It is a common point of contact between two pitch circles.

5. Pitch surface

It is the surface of the imaginary rolling cylinder that the toothed gear may be considered to replace.

Gear Nomenclature

6. Addendum

The addendum is the radial distance of a tooth from the pitch circle to the top of the tooth.

7. Dedendum

Dedendum is the circle drawn through the bottom of the teeth. It is also called “root circle”.

8. Addendum circle

It is the circle drawn through the top of the teeth and it is concentric with the pitch circle.

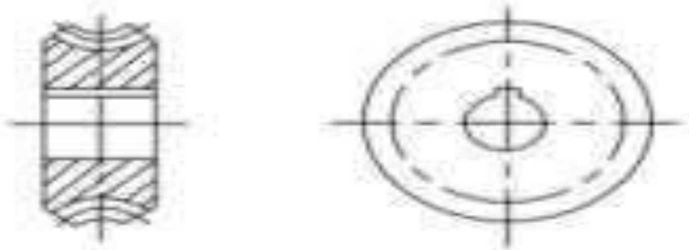
9. Dedendum circle

It is the circle drawn through the bottom of the tooth. It is also called “root circle”.

10. Base Circle

The base circle of involute gear is the circle from which involute tooth profiles are determined.

Convention of Gears

Title	Convention
Spur gear	
Bevel gear	
Worm wheel	
Worm	

Draw the actual profile of involutes teeth of spur gear by different methods

There are two methods given of construction of Spur gear profile

- Tracing Paper Method
- Base Circle Method

Draw the actual profile of involutes teeth of spur gear by different methods

Problem 13.1. Draw the profile of involute teeth for a gear having 22 teeth and diametral pitch 0.1 tooth/mm. Assume pressure angle = 20°. Use tracing paper method.

Solution. Given, $T = 22$, $P_d = 0.1$ tooth/mm, $\phi = 20°$

$$\text{Module, } m = \frac{1}{P_d} = \frac{1}{0.1} = 10 \text{ mm}$$

Pitch circle diameter, $d = m \times T$

$= 10 \times 22 = 220$ mm

Circular pitch, $P_c = \pi \times m$

$= \pi \times 10 = 31.4$ mm

Addendum $= 1\text{ m} = 10$ mm

Addendum circle diameter $= d + 2 \times \text{Addendum}$

$= 220 + 2 \times 20 = 240$ mm

Clearance $= 0.157\text{ m} = 0.157 \times 10 = 1.57$ mm

Dedendum $= \text{Addendum} + \text{Clearance} = 10 + 1.57 = 11.57$ mm

Dedendum circle diameter $= d - 2 \times \text{Dedendum} = 220 - 2 \times 11.57 = 196.86$ mm

$$\text{Tooth thickness} = \frac{P_c}{2} = \frac{31.4}{2} = 15.7 \text{ mm}$$

$$\text{Fillet radius} = \frac{P_c}{8} = \frac{31.4}{8} = 3.9 \text{ mm}$$

Draw the actual profile of involutes teeth of spur gear by different methods

Problem 13.1. Draw the profile of involute teeth for a gear having 22 teeth and diametral pitch 0.1 tooth/mm. Assume pressure angle = 20°. Use tracing paper method.