MACHINE DRAWING

SYLLABUS

Section A

Introduction graphic language, classification of drawing, principle of drawing, IS codes for machine drawing, lines, scales, section dimensioning, standard abbreviation, – Limits , fits and Tolerance (Dimensional and Geometrical tolerance) , Surface finish,

Gears : Gear terminology, I.S. convention representation of assembly of spur gears, helical gears, bevel gears , worm and worm wheel.

Section B

Orthographic projections: principle of first and third angle projection, orthographic views from isometric views of machine parts / components.

Drawing of sectional views:- Coupling, Crankshaft, Pulley, Piston and Connecting rod, Cotter and Knuckle joint. Riveted Joint and Welded Joint.

SYLLABUS

Free hand sketching: Need for free hand sketching of standard parts and simple machines components.

Section C

Assembly drawing with sectioning and bill of materials from given detailed drawings of assemblies: Lathe Tail stock, Machine vice, Pedestal bearing

Section D

Assembly drawing with sectioning and bill of materials from given detailed drawings of assemblies Steam stop valve, Stuffing box, Drill jigs and Milling fixture.

Introduction- Graphic Language

- Engineering drawing has its origin sometime in 500 BC in the regime of King Pharos of Egypt when symbols were used to convey the ideas among people.
- Irrespective of language barriers, the drawings can be effectively used in other countries, in addition to the country where they are prepared.
- Thus, the engineering drawing is the universal language of all engineers.

Classification of Drawing

- Machine Drawing-
  - Pertaining to machine parts or components.
  - presented through a number of orthographic views.
  - Size & shape of component is fully understood.

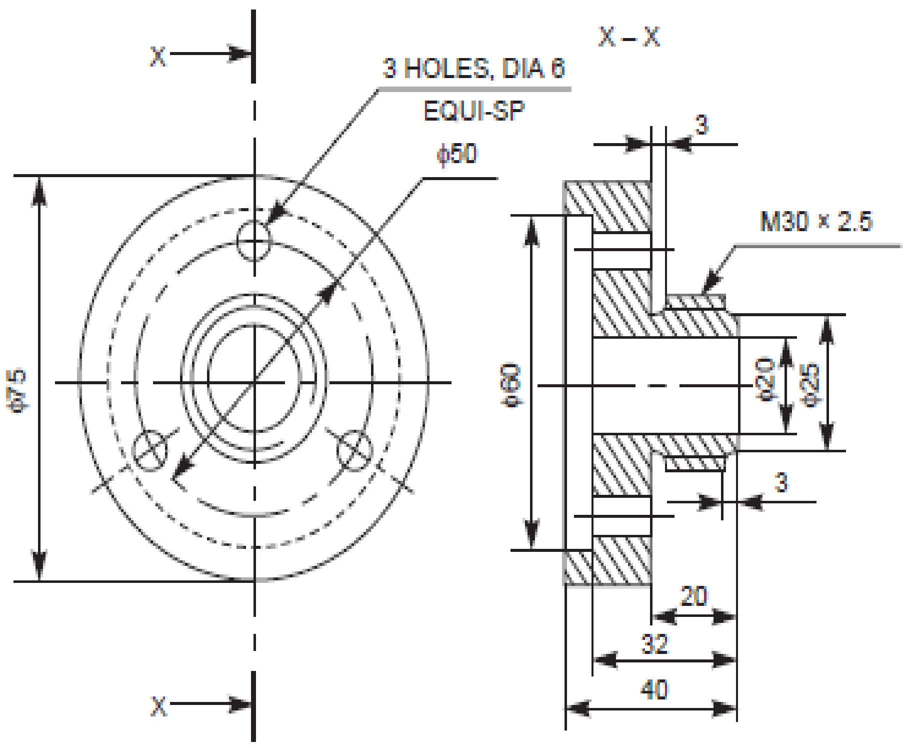


Fig. 1.1 Machine drawing

- Production Drawing –

- Referred as working drawing.
- Should furnish all dimensions, limits & special finishing processes such as heat treatment, honing, lapping, surface finish, etc.
- Title should also mention the material used for the product, number of parts required.

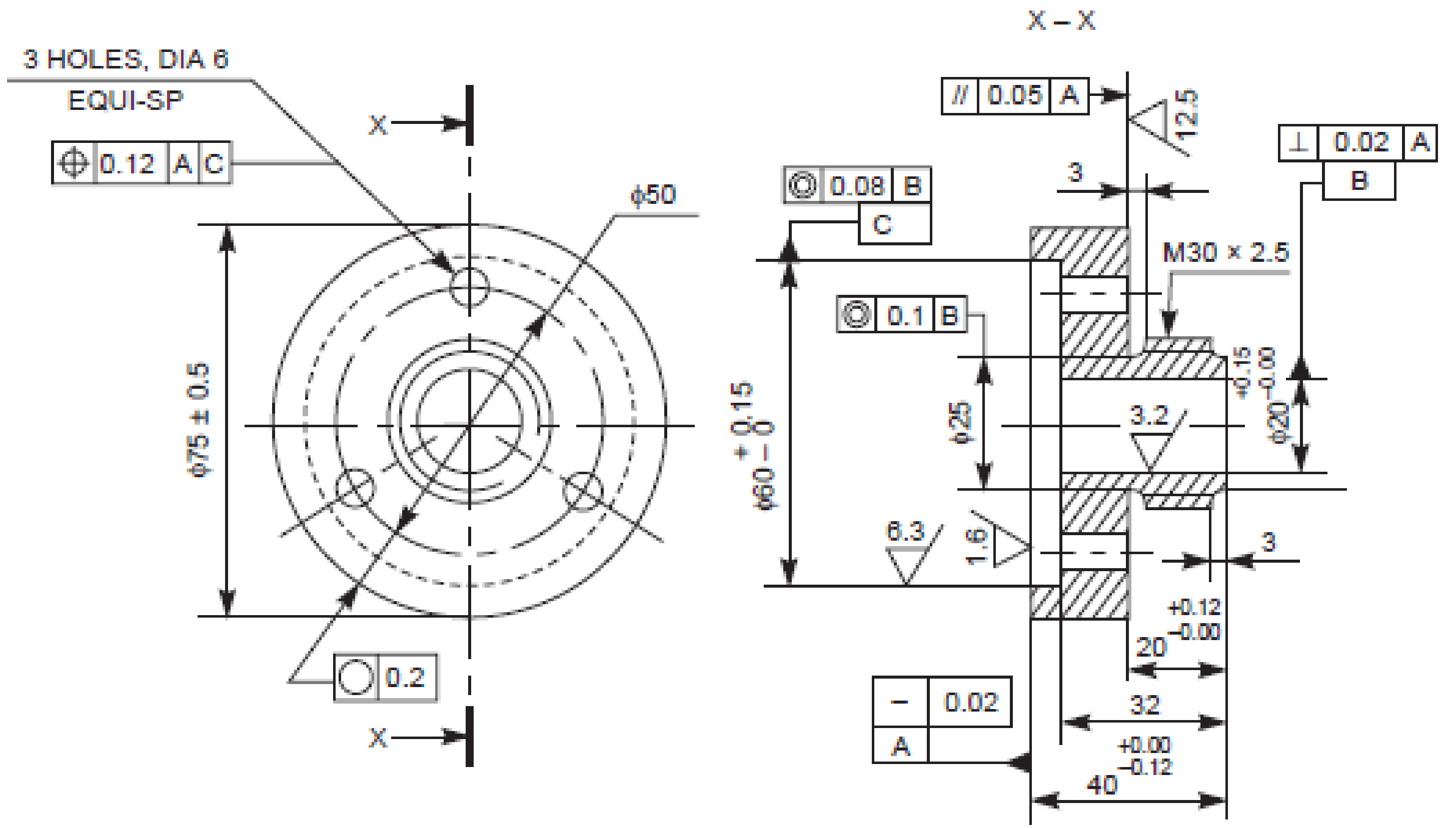
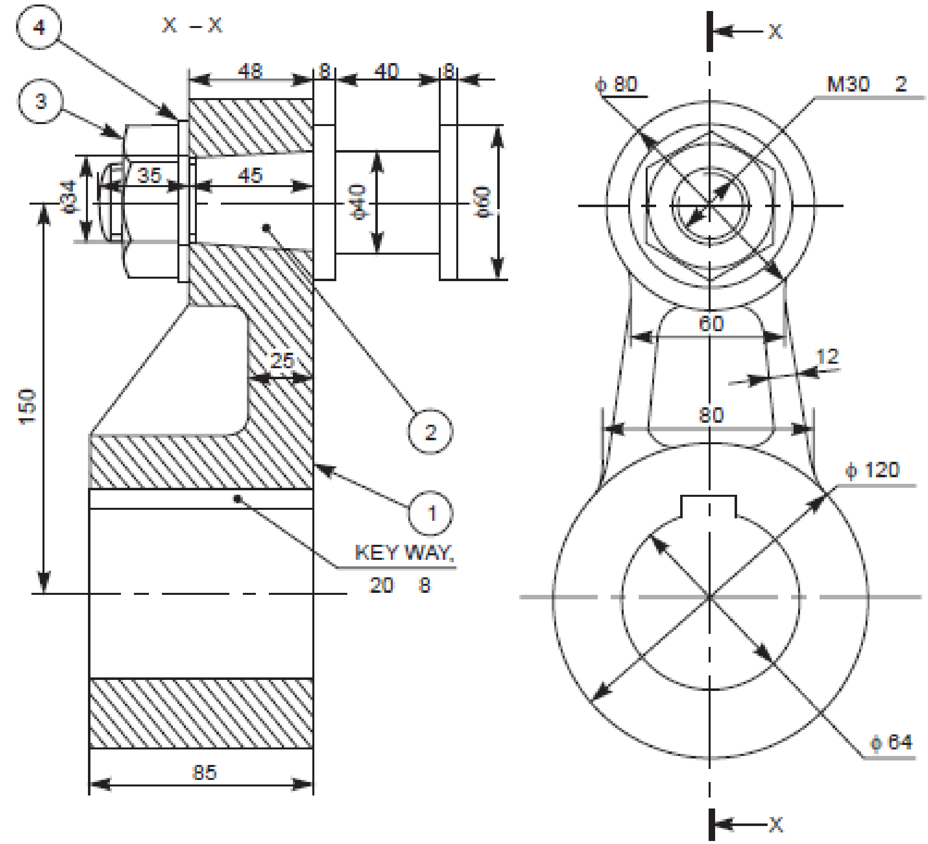


Fig. 1.2 Production drawing

- **Part Drawing-**
  - Detailed drawing of a component to facilitate its manufacture.
  - Follows principles of orthographic projection

- **Assembly Drawing-**
  - A drawing that shows the various parts of a machine in their correct working locations.



Parts List

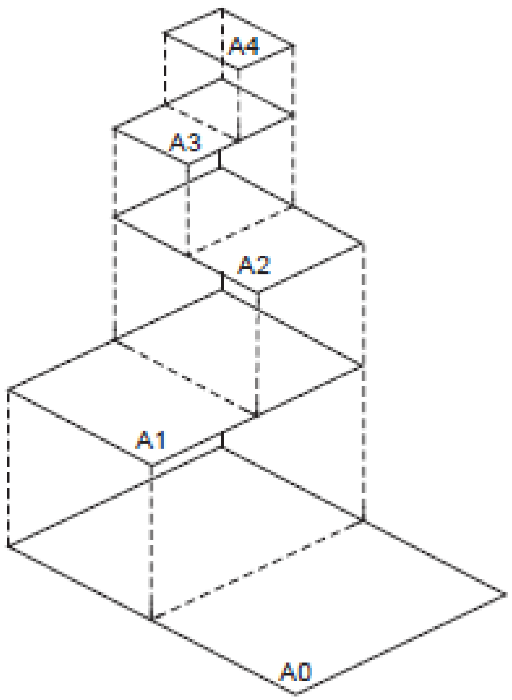
Part No.	Name	Material	Qty
1	Crank	Forged Steel	1
2	Crank Pin	45C	1
3	Nut	MS	1
4	Washer	MS	1

Fig. 1.3 Assembly drawing

Principle of Drawing

To provide the correct information about drawings to all concerned people, the drawing must be prepared, following certain standard practices, as recommended by Bureau of Indian Standards (BIS).

- Sheet Size- For a reference size A0 having a surface area of 1 m^2
  X = 841 mm and Y = 1189 mm.



- Designation of Sizes-

Table Preferred drawing sheet sizes (First choice) ISO-A Series

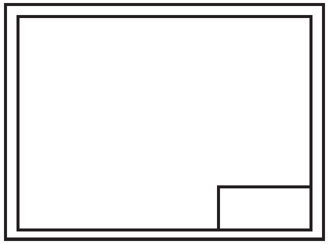
Designation	*Dimensions* (mm)
A0	841 × 1189
A1	594 × 841
A2	420 × 594
A3	297 × 420
A4	210 × 297

Table Special elongated sizes (Second choice)

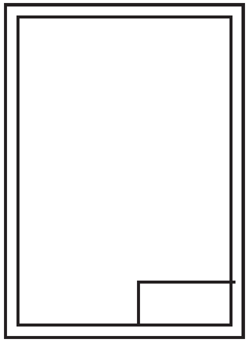
Designation	*Dimensions* (mm)
A3 × 3	420 × 891
A3 × 4	420 × 1188
A4 × 3	297 × 630
A4 × 4	297 × 840
A4 × 5	297 × 1050

- Title Block –

(i) Title of the drawing
(ii) Sheet number
(iii) Scale
(iv) Symbol, denoting the method of projection
(v) Name of the firm / institute
(vi) Initials of staff drawn, checked and approved.



(a)



(b)

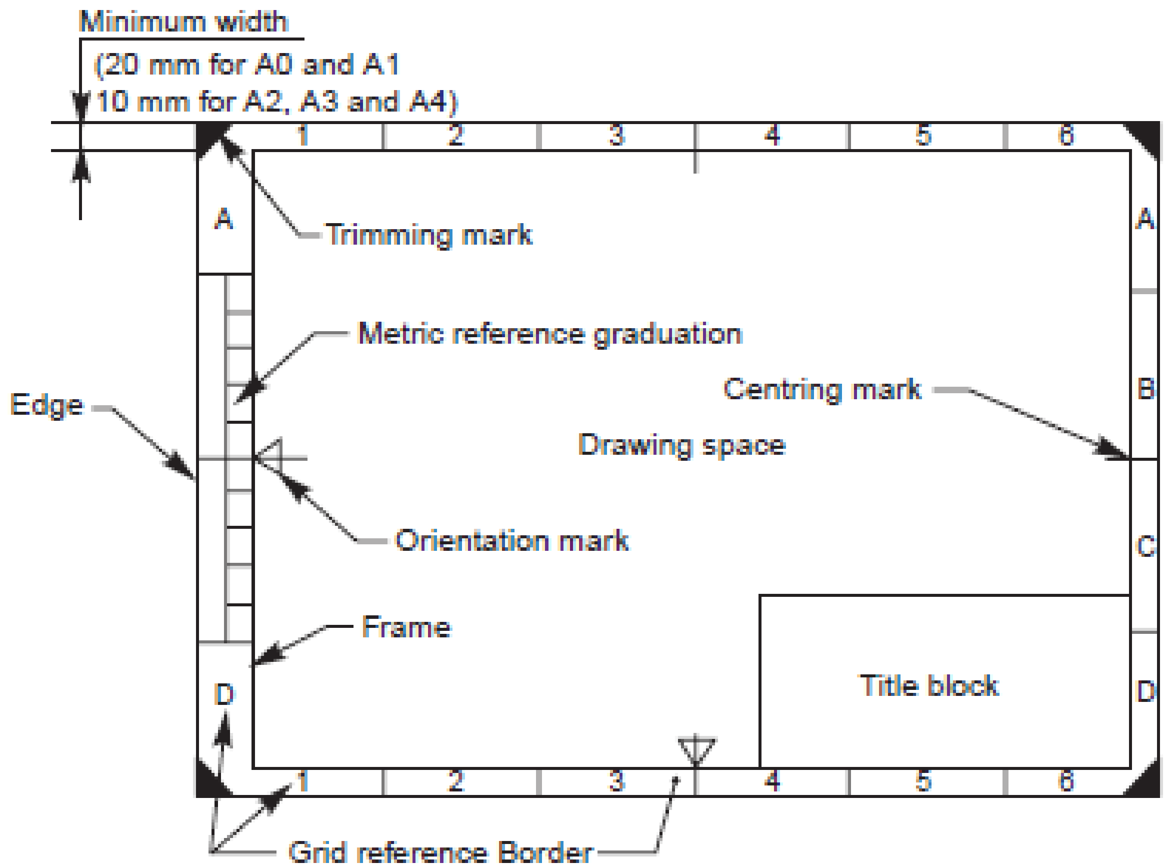
Location of title block

- Borders & Frames –

Minimum 20 mm for size A0 & A1.

Minimum 10 mm for size A2, A3, A4.

- Centering Marks
- Metric reference graduation
- Grid reference system
- Trimming mark



Drawing sheet layout

Scales

- The various types of scales used in machine drawing are

  1. Full scale 1:1
  2. Reduced scale 1:X
  3. Enlarged scale X:1

The standard scales are given in Table

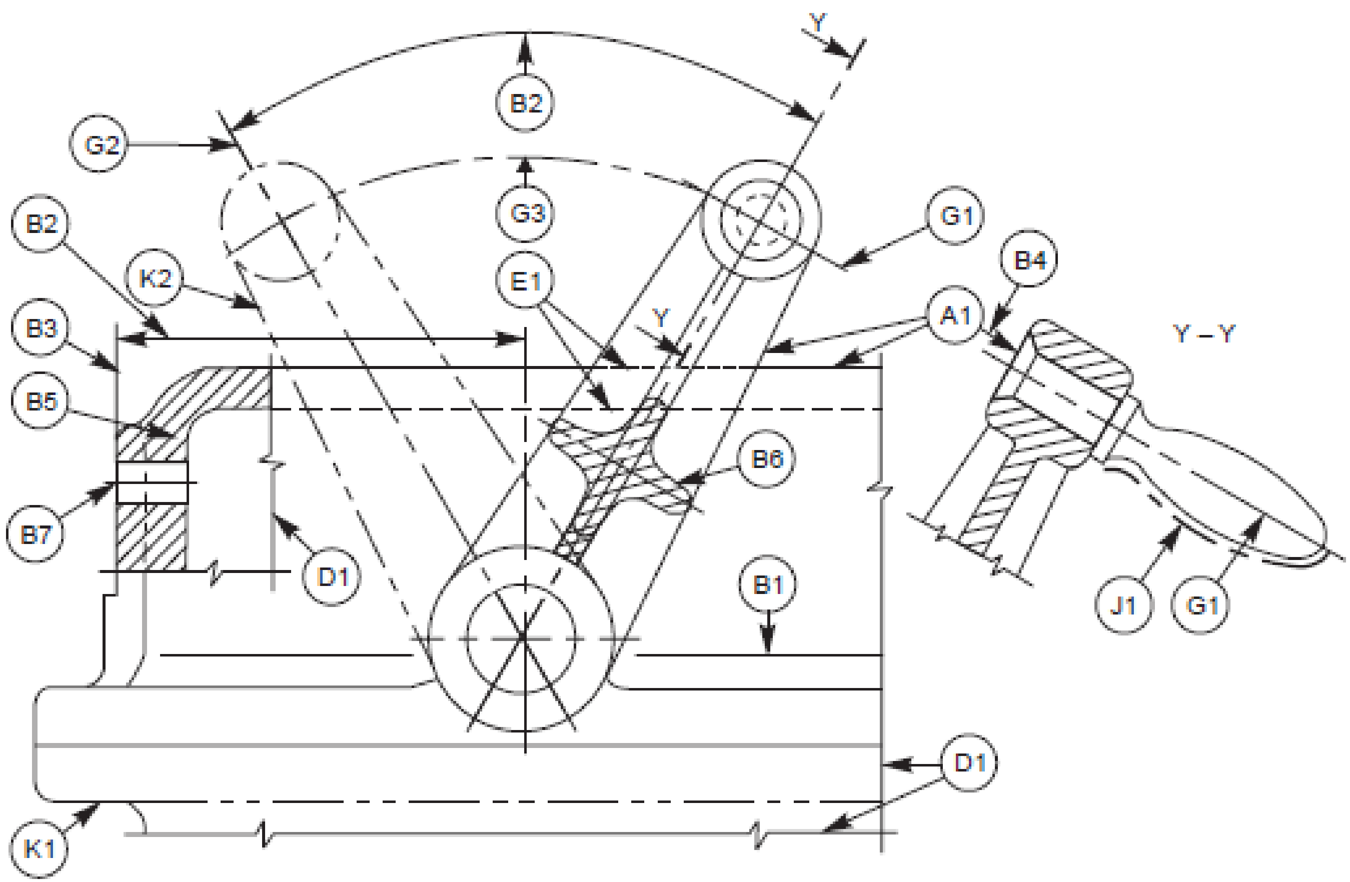
Recommended scales

Category	*Recommended Scales*		
Enlarged scales	50:1	20:1	10:1
	5:1	2:1	
Full size			1:1
Reduced scales	1:2	1:5	1:10
	1:20	1:50	1:100
	1:200	1:500	1:1000
	1:2000	1:5000	1:10000

Types of lines & their applications

Line	*Description*	*General Applications*
A	Continuous thick	A1 Visible outlines
B	Continuous thin (straight or curved)	B1 Imaginary lines of intersection B2 Dimension lines B3 Projection lines B4 Leader lines B5 Hatching lines B6 Outlines of revolved sections in place B7 Short centre lines
C	Continuous thin, free-hand	C1 Limits of partial or interrupted views and sections, if the limit is not a chain thin
D	Continuous thin (straight) with zigzags	D1 Line (see Fig. 2.5)
E	Dashed thick	E1 Hidden outlines
G	Chain thin	G1 Centre lines G2 Lines of symmetry G3 Trajectories
H	Chain thin, thick at ends and changes of direction	H1 Cutting planes
J	Chain thick	J1 Indication of lines or surfaces to which a special requirement applies
K	Chain thin, double-dashed	K1 Outlines of adjacent parts K2 Alternative and extreme positions of movable parts K3 Centroidal lines

Applications of Lines

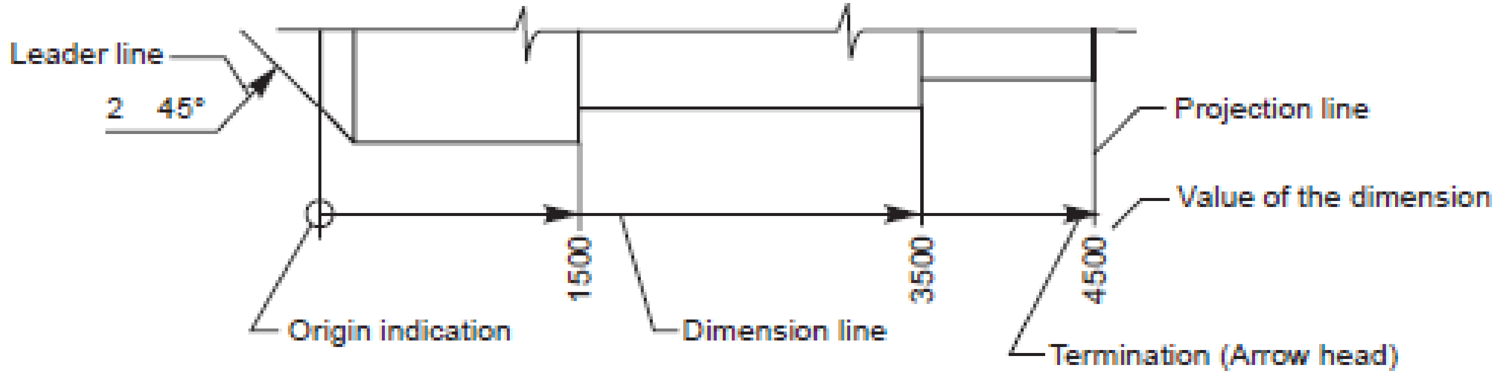


Dimensioning

1. As far as possible, dimensions should be placed outside the view.
2. Should be taken from visible outlines, not from hidden lines.
3. Dimensioning to a centre line should be avoided except when the centre line passes through the centre of a hole.
4. Each feature should be dimensioned only once in a drawing.
5. Placed on the view or section that relates most clearly to the corresponding features.
6. Each drawing should use the same unit for all dimensions, but without showing unit symbol.
7. Minimum dimensions should be placed to define a whole part.
8. No features of a part should be defined by more than one dimension in any one direction.

Elements of Dimensioning

1. Dimension line — It is a thin continuous line terminated by arrowheads touching the outlines, extension lines or centre lines.
2. Extension line (Projection line) — It is a thin line drawn outside and along the outline. There should be a gap of about 1 mm between the extension line and the outline.
3. Leader line —One end of the leader terminates either in an arrowhead or a dot. The arrowhead touches the outline, while the dot is placed within the outline of the object. The other end of the leader is terminated at a horizontal line
4. Arrowhead — An arrowhead is placed at each end of a dimension line. Its pointed end touches an outline, an extension line or a centre line. The length of arrowhead should be about three times its maximum width. The triangle of the arrow should be completely filled in.



Methods of indicating Dimensions

1. Aligned system, and
2. Unidirectional system.

1. Aligned system — In the aligned system, the dimensions are placed above the dimension lines and may be read either from the bottom or from the right side of the drawing

2. Unidirectional system — In the unidirectional system, all dimensions are placed with respect to the bottom of the drawing, irrespective of the disposition of the dimension line. In the system, the dimension lines are broken to insert their dimensions . This system is preferred for big drawings specially when it is not convenient to read the dimension from the right side or any other direction.

Standard Abbreviation

Term	*Abbreviation*	*Term*	*Abbreviation*
Across corners	A/C	Maunfacture	MFG
Across flats	A/F	Material	MATL
Approved	APPD	Maximum	max.
Approximate	APPROX	Metre	m
Assembly	ASSY	Mechanical	MECH
Auxiliary	AUX	Millimetre	mm
Bearing	BRG	Minimum	min.
Centimetre	Cm	Nominal	NOM
Centres	CRS	Not to scale	NTS
Centre line	CL	Number	No.
Centre to centre	C/L	Opposite	OPP
Chamfered	CHMED	Outside diameter	OD
Checked	CHD	Pitch circle	PC
Cheese head	CH HD	Pitch circle diameter	PCD
Circular pitch	CP	Quantity	QTY
Circumference	OCE	Radius	R

Term	*Abbreviation*	*Term*	*Abbreviation*
Continued	CONTD	Radius in a note	RAD
Counterbore	C BORE	Reference	REF
Countersunk	CSK	Required	REQD
Cylinder	CYL	Right hand	RH
Diameter	DIA	Round	RD
Diametral pitch	DP	Screw	SCR
Dimension	DIM	Serial number	Sl. No.
Drawing	DRG	Specification	SPEC
Equi-spaced	EQUI-SP	Sphere/Spherical	SPHERE
External	EXT	Spot face	SF
Figure	FIG.	Square	SQ
General	GNL	Standard	STD
Ground level	GL	Symmetrical	SYM
Ground	GND	Thick	THK
Hexagonal	HEX	Thread	THD
Inspection	INSP	Through	THRU
Inside diameter	ID	Tolerance	TOL
Internal	INT	Typical	TYP
Left hand	LH	Undercut	U/C
Machine	M/C	Weight	WT

Abbreviations for materials

Material	*Abbreviation*
Aluminium	AL
Brass	BRASS
Bronze	BRONZE
Cast iron	CI
Cast steel	CS
Chromium steel	CrS
Copper	Cu
Forged steel	FS
Galvanised iron	GI
Gray iron	FG
Gunmetal	GM
High carbon steel	HCS
High speed steel	HSS
High tensile steel	HTS
Low carbon steel	LCS
Mild steel	MS
Nickel steel	Ni S
Pearlitic malleable iron	PM
Phosphor bronze	PHOS.B
Sheet steel	Sh S
Spring steel	Spring S
Structure steel	St
Tungston carbide steel	TCS
Wrought iron	WI
White metal	WM

Limits , Fits and Tolerance

- The system in which a variation in dimensions is accepted is called the limit system.
- The allowable deviations are called tolerances.
- The relationships between the mating parts are called fits.

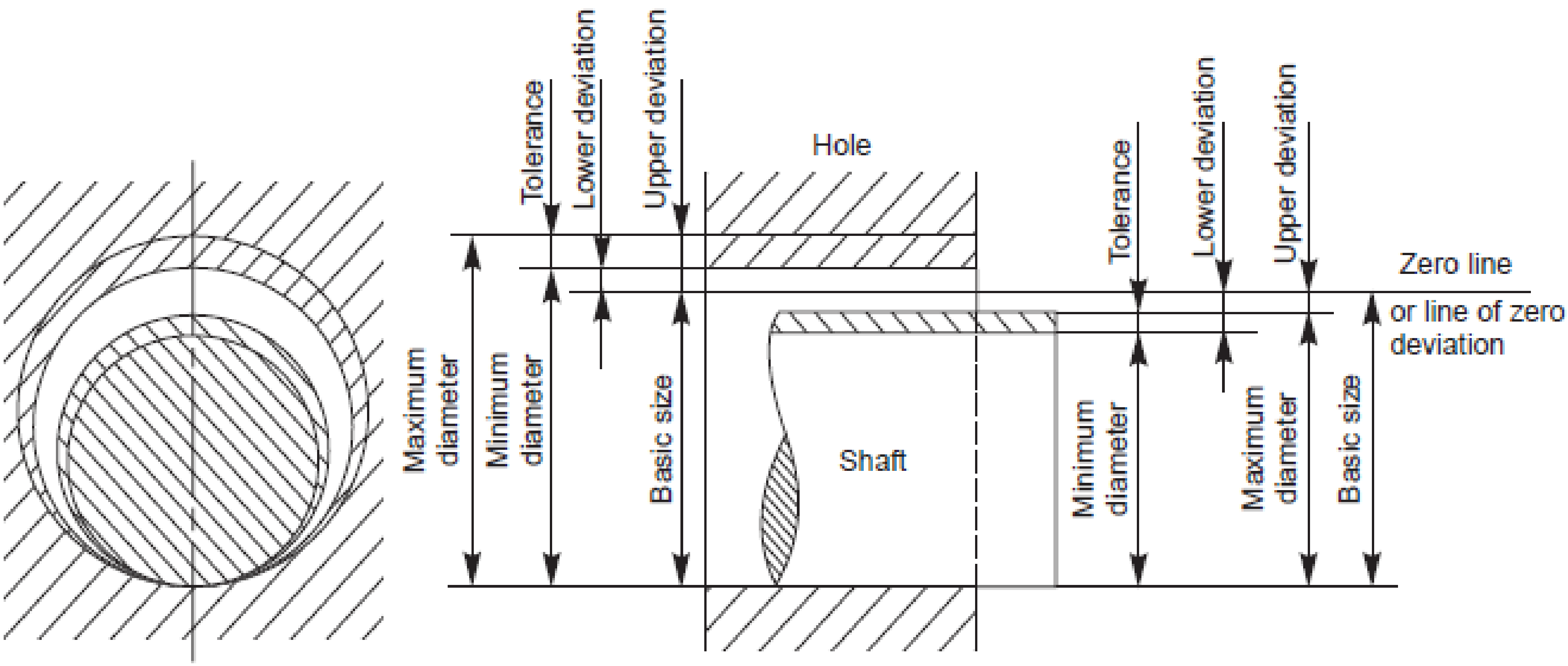


Diagram illustrating basic size deviations and tolerances

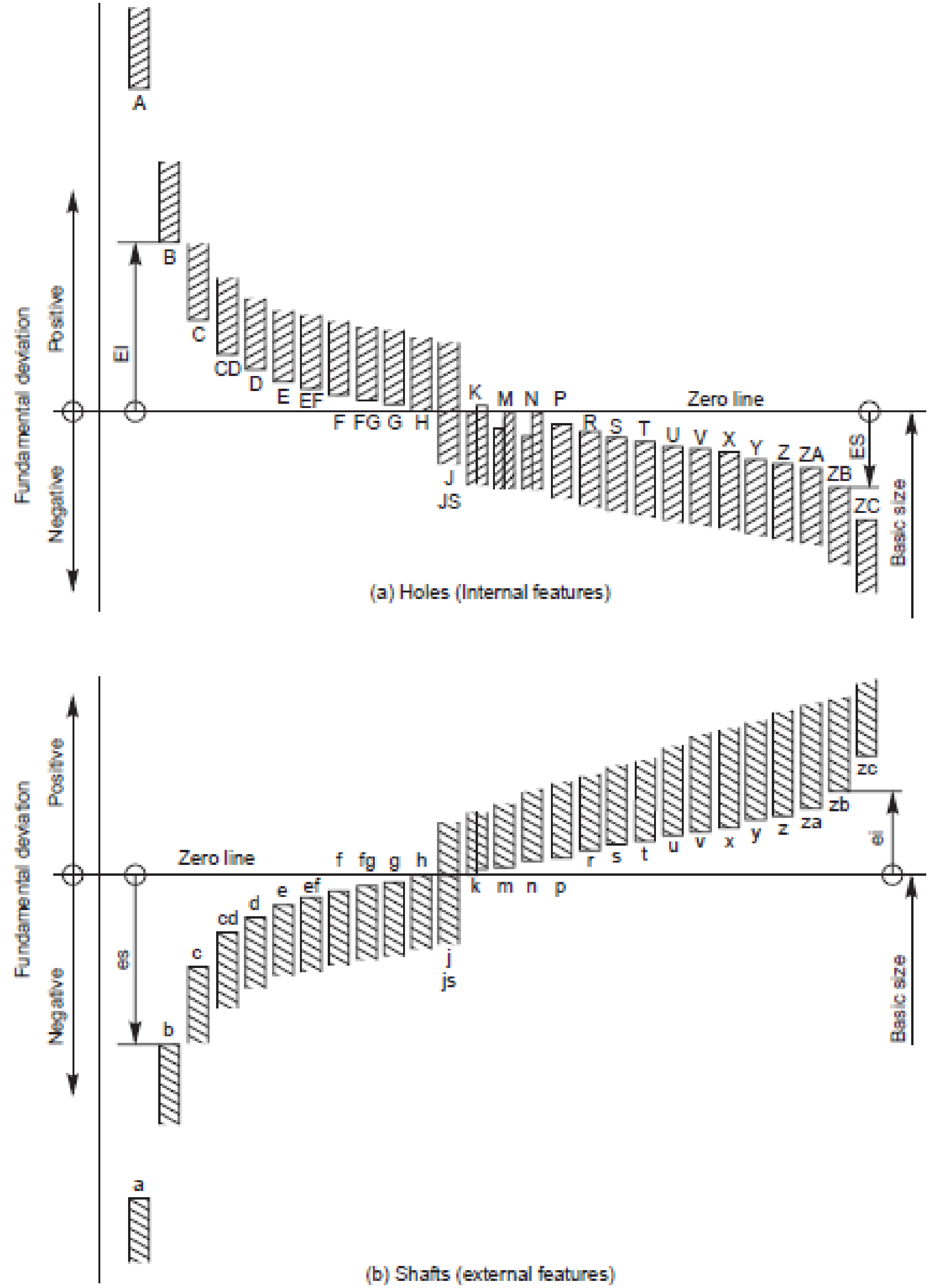
Limits

- The two extreme permissible sizes between which the actual size is contained are called limits.
- The maximum size is called the upper limit and the minimum size is called the lower limit.

Tolerances

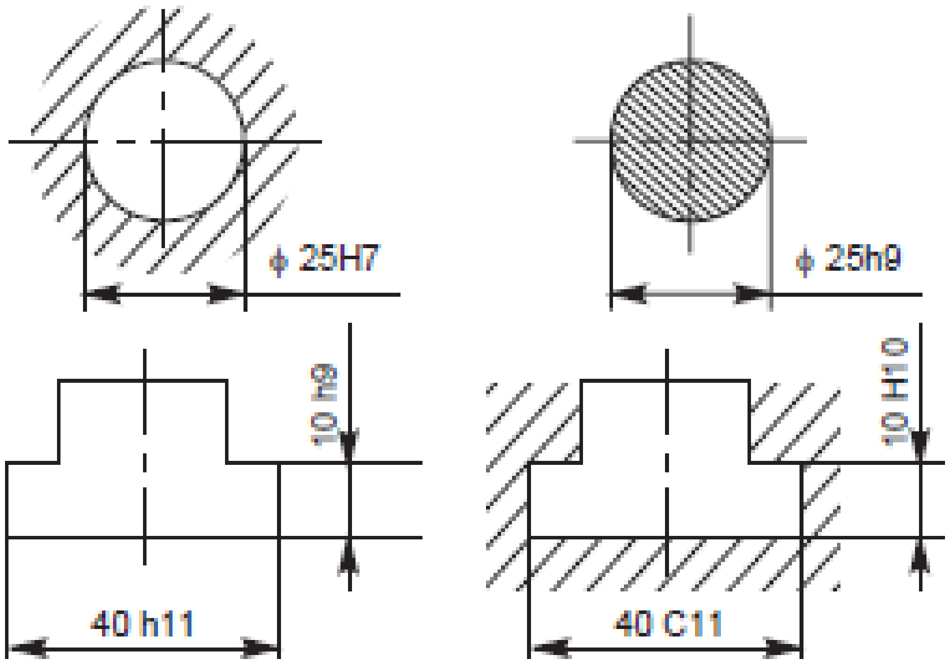
- Tolerance is denoted by two symbols, a letter symbol and a number symbol, called the grade.
- It is the difference between lower and upper deviation.

- Graphical illustration of tolerance zones



Method of placing limit dimensions

Method 1



Toleranced dimensions for internal and external features

$$\phi\, 25H7 = \phi\, 25^{+0.021}_{+0.000}$$

$$10H10 = 10^{+0.058}_{+0.000}$$

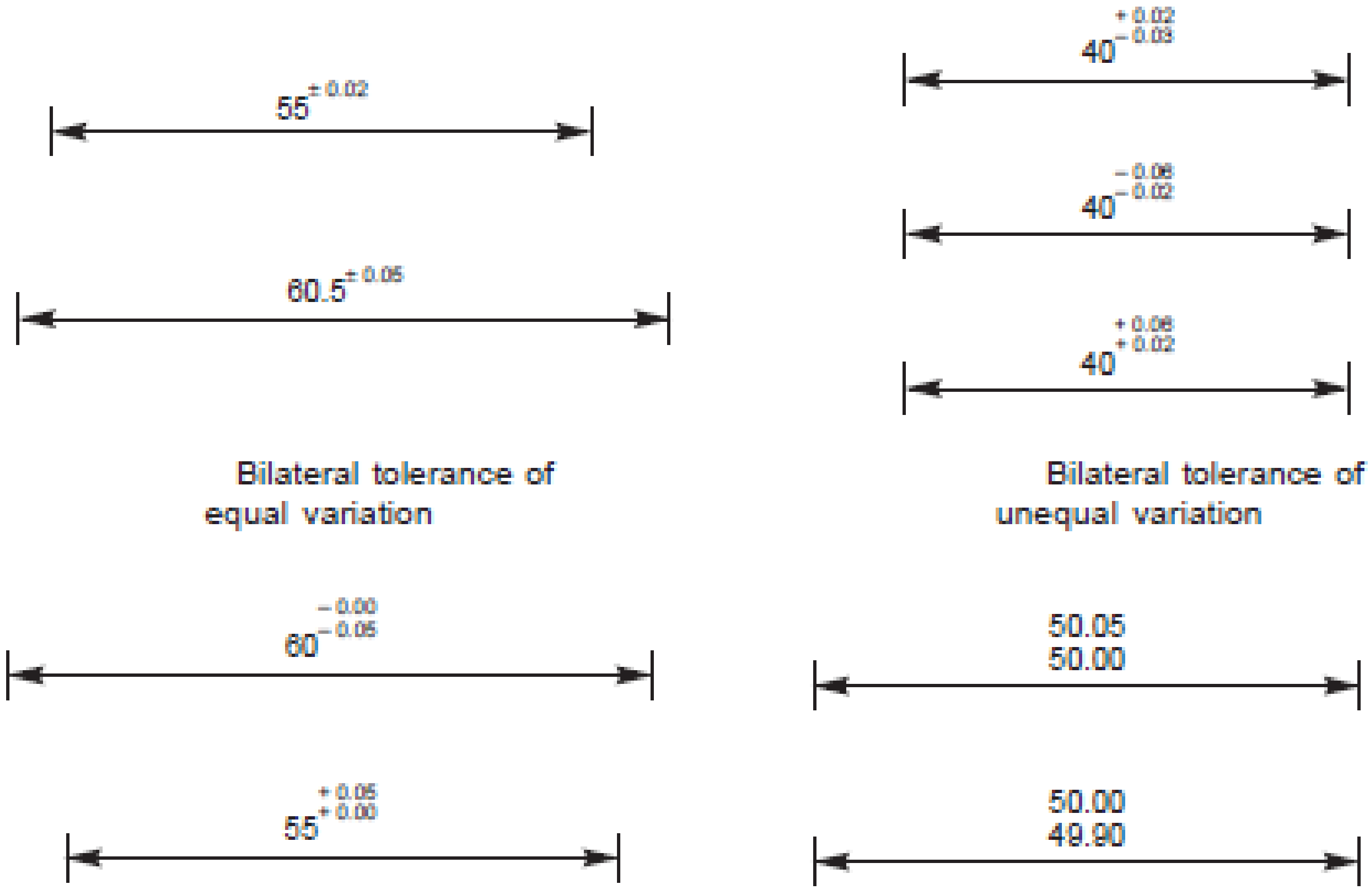
$$40C11 = 40^{+0.280}_{+0.120}$$

$$10h9 = 10^{-0.000}_{-0.036}$$

$$\phi\, 25h9 = \phi\, 25^{-0.000}_{-0.052}$$

$$\phi\, 40h11 = \phi\, 40^{-0.000}_{-0.160}$$

Method 2



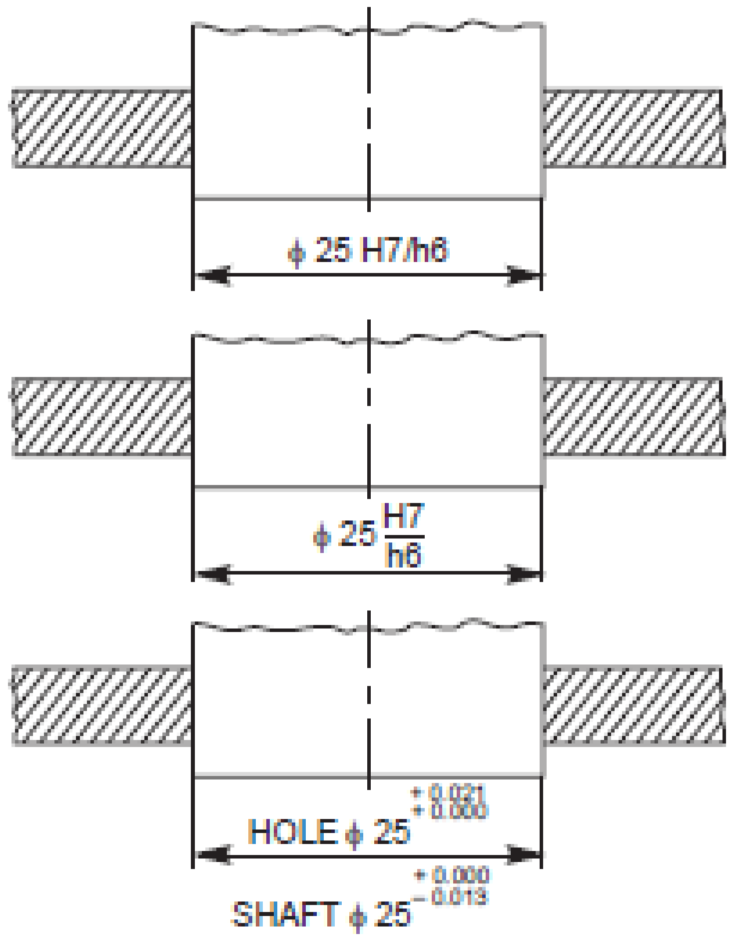
Bilateral tolerance of equal variation

Bilateral tolerance of unequal variation

Unilateral tolerance with zero variation in one direction

Maximum and minimum size directly indicated

Method 3

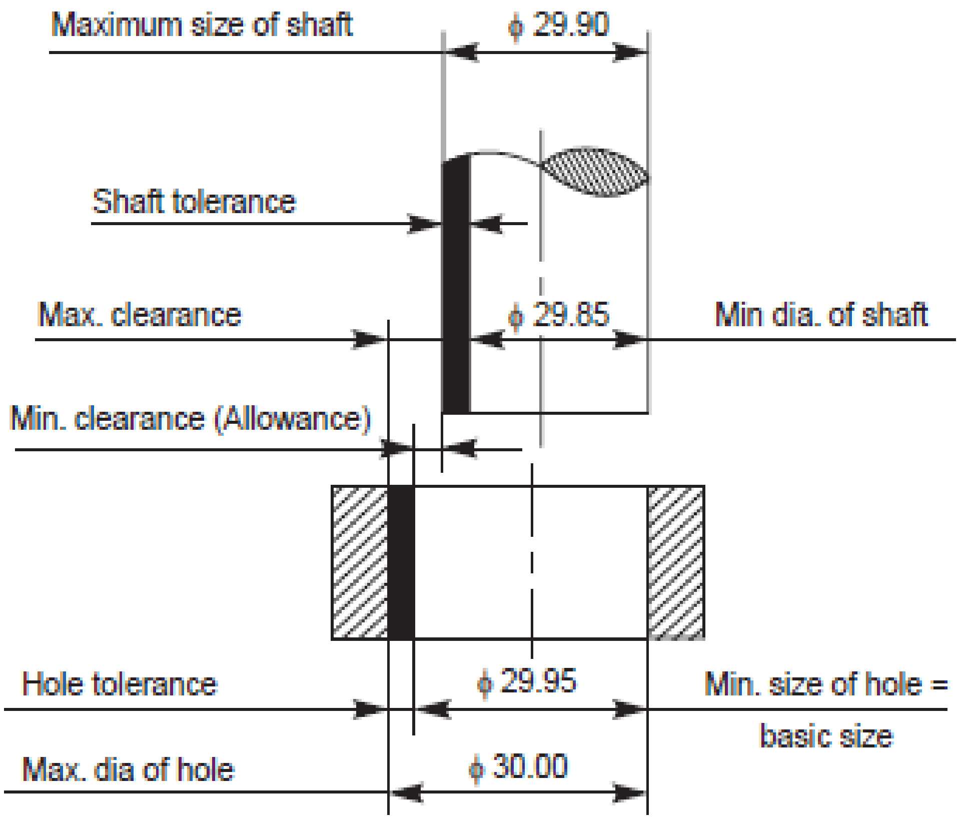


Toleranced dimensioning of assembled parts

Types of Fits

1. Clearance Fit –

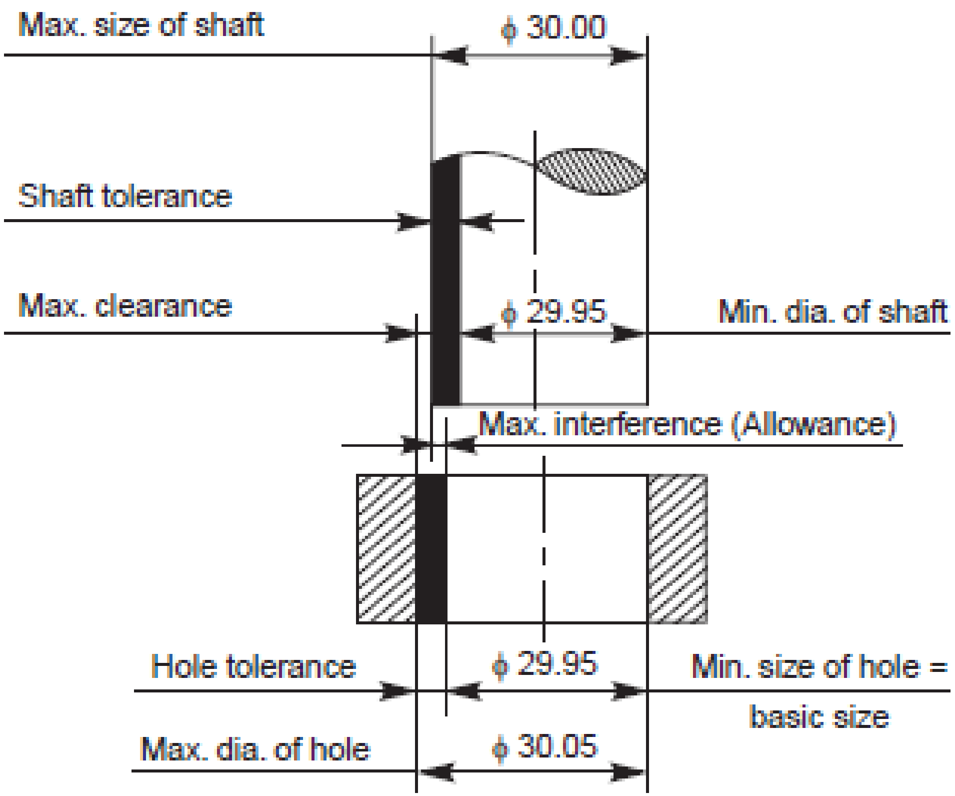
It is a fit that gives a clearance between the two mating parts.



Types of Fits

2. Transition Fit –

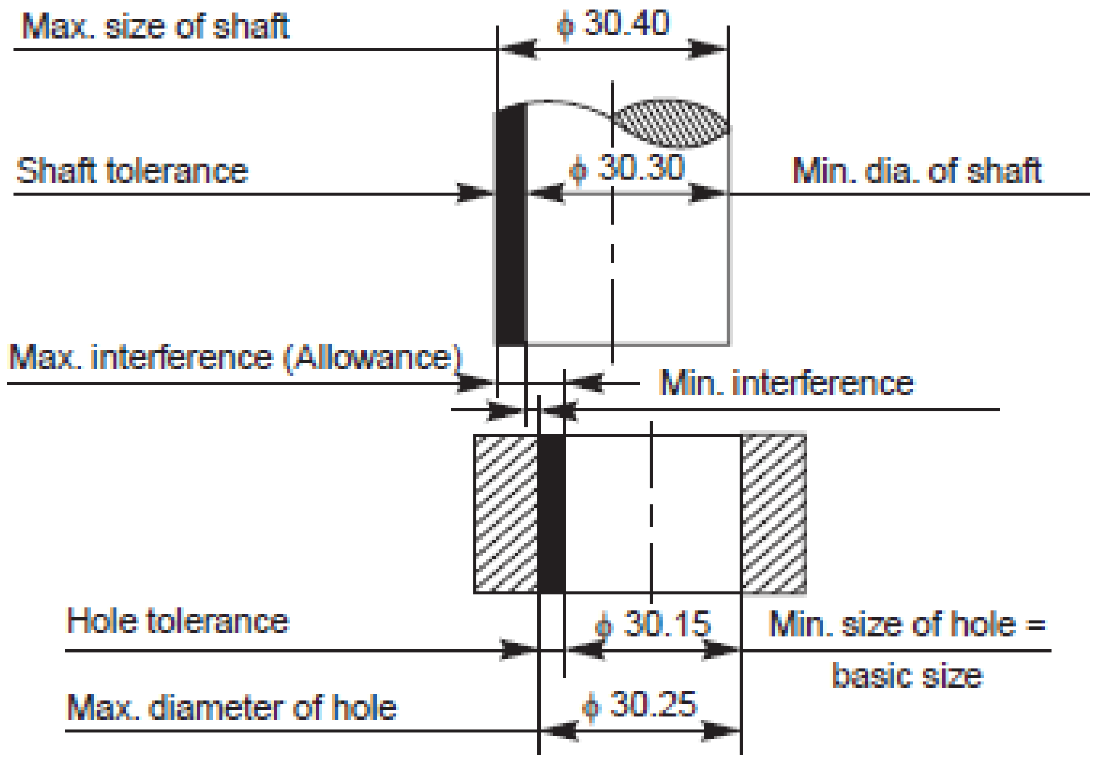
This fit may result in either an interference or a clearance, depending upon the actual values of the tolerance of individual parts.



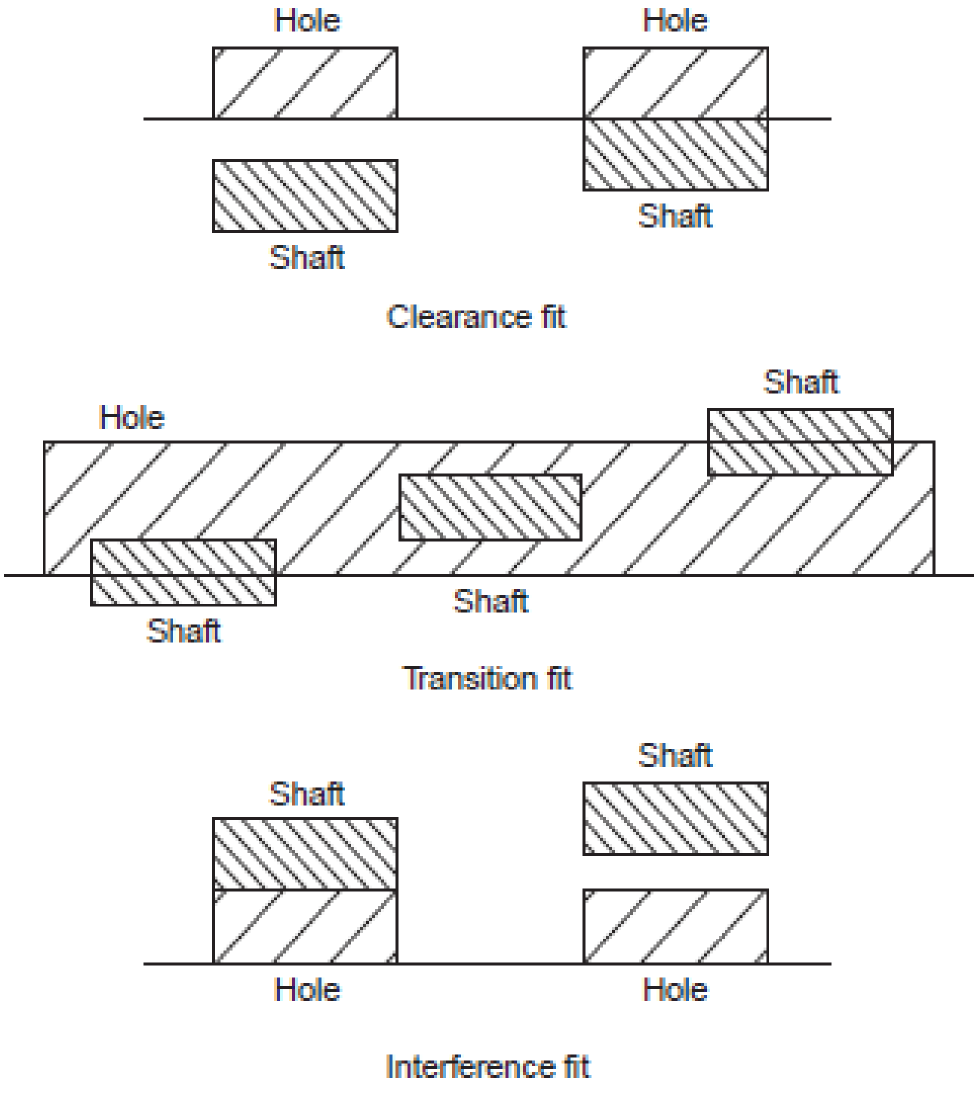
Types of Fits

3. Interference Fit -

   If the difference between the hole and shaft sizes is negative before assembly; an interference fit is obtained.



Schematic Representation of Fits

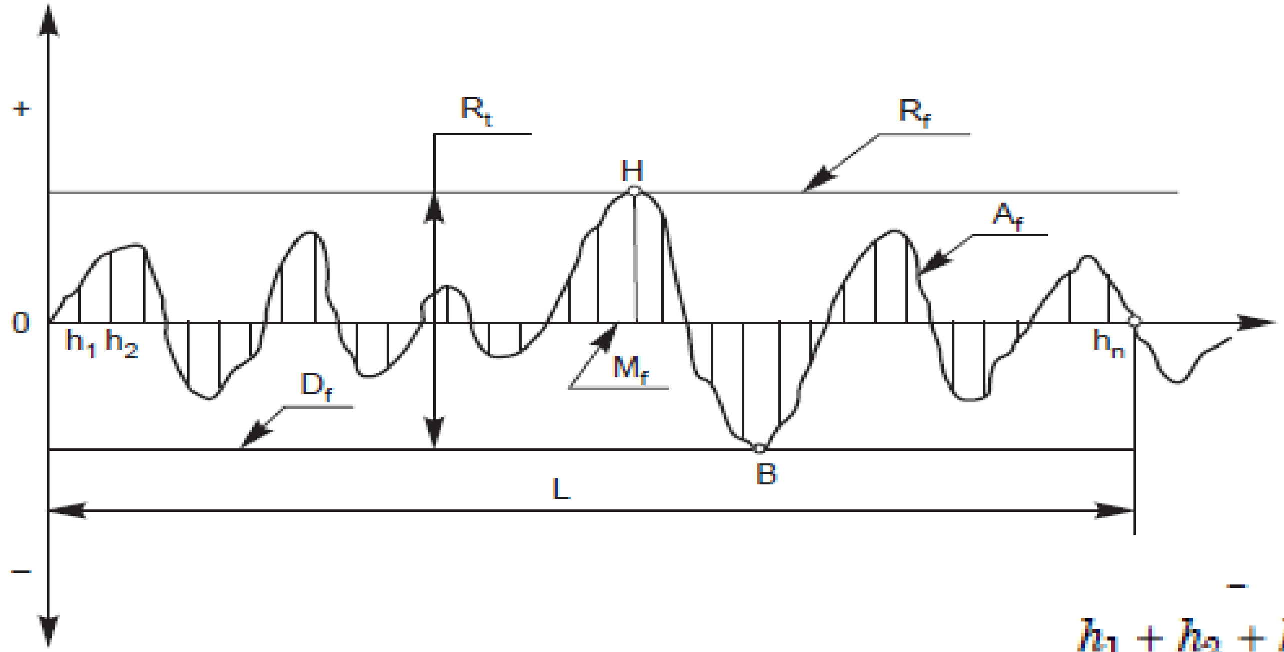


Surface finish

The geometrical characteristics of a surface include,

1. Macro-deviations,
2. Surface waviness, and
3. Micro-irregularities.

The surface roughness is evaluated by the height, *Rt and mean roughness index Ra of* the micro-irregularities.

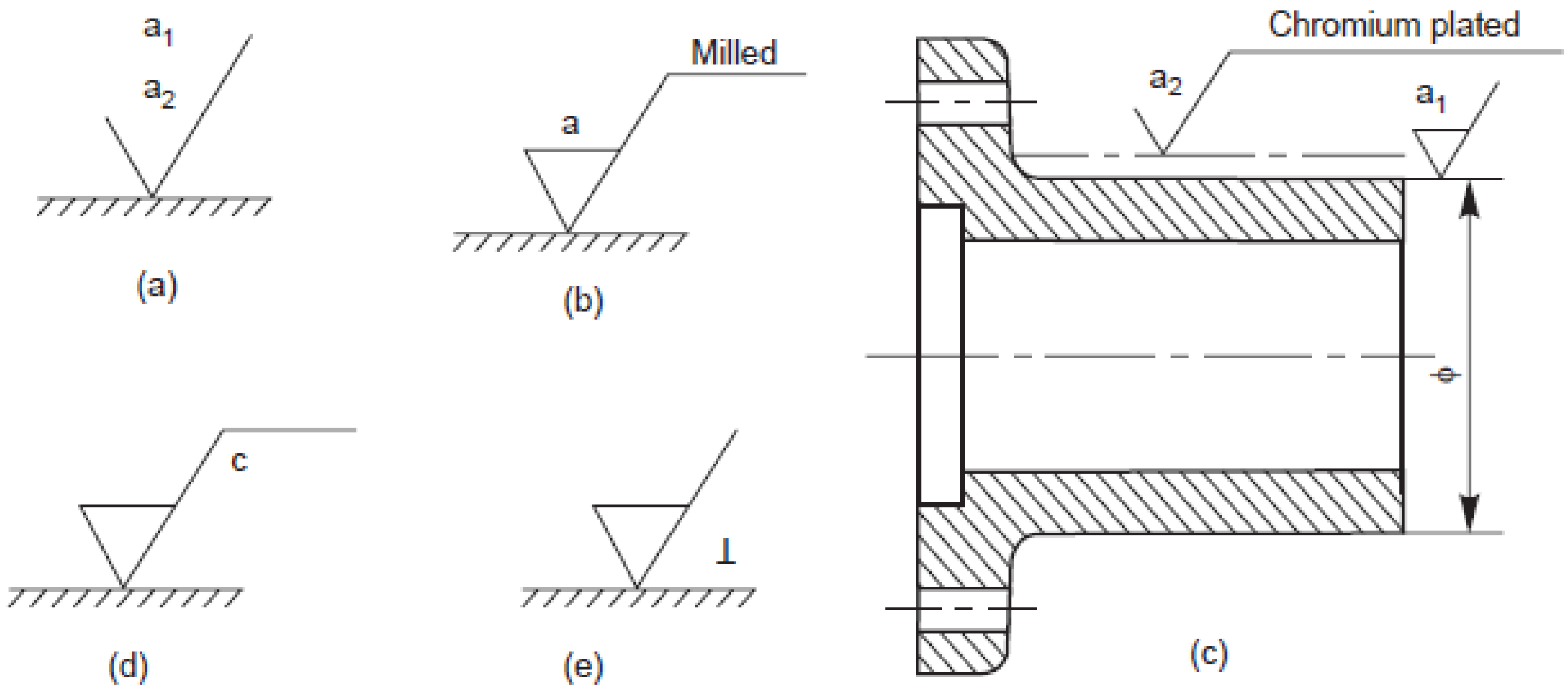


$$R_a = \frac{h_1 + h_2 + h_3 + \ldots + h_n}{n}$$

Equivalent Surface Roughness Symbols

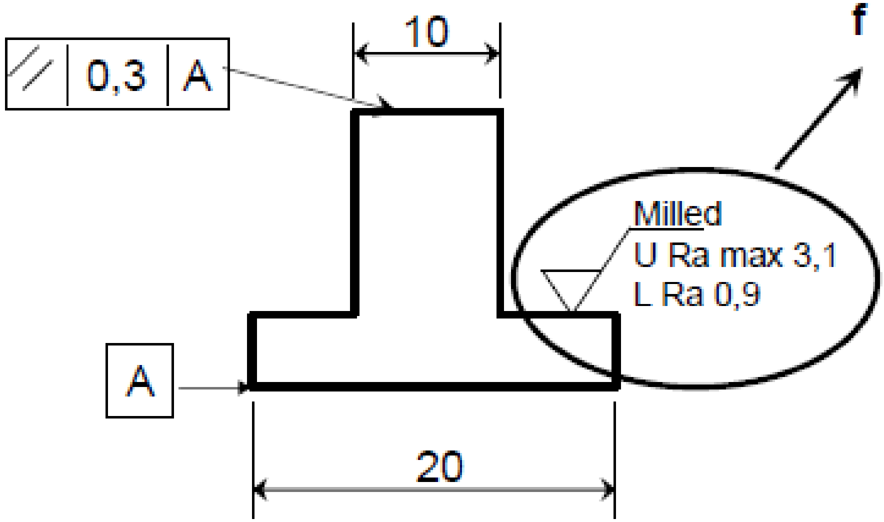
Roughness values R_a *µm*	*Roughness grade number*	*Roughness grade symbol*
50	N12	∼
25	N11	▽
12.5	N10	
6.3	N9	▽▽
3.2	N8	
1.6	N7	
0.8	N6	▽▽▽
0.4	N5	
0.2	N4	
0.1	N3	▽▽▽▽
0.05	N2	
0.025	N1	

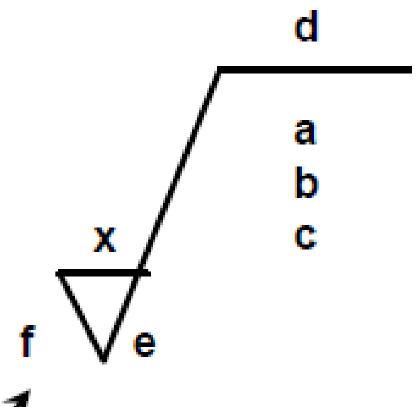
Indication of Surface Roughness



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

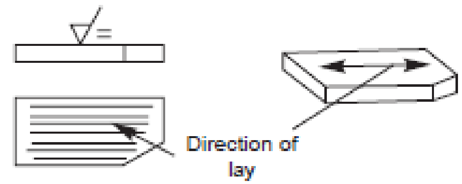
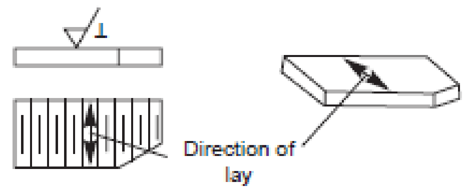
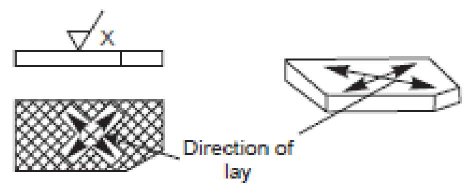
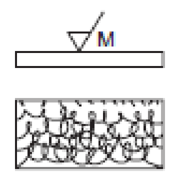
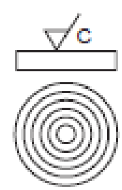
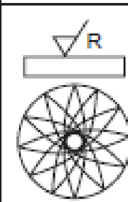
Surface roughness expected from various manufacturing processes

Sl. No.	Manufacturing Process	R_a in µm (from)	R_a in µm (to)
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

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

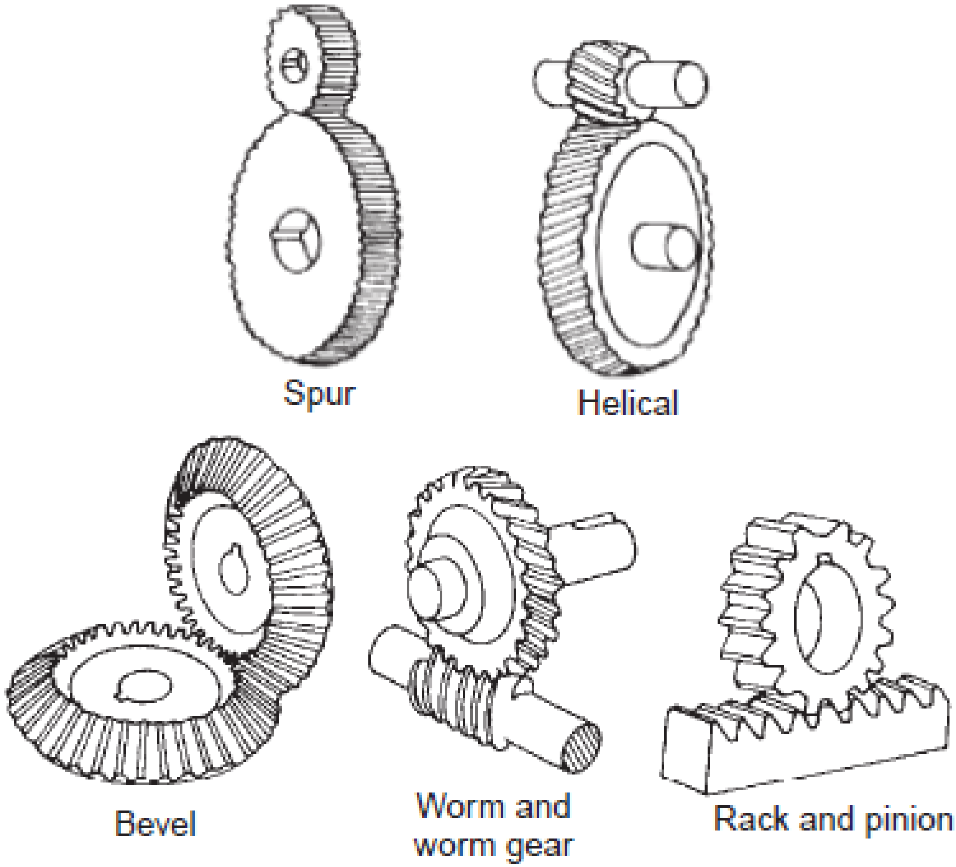
12	Filing	0.25	25
13	Planing	1.6	50
14	Shaping	1.6	25
15	Drilling	1.6	20
16	Turning & Milling	0.32	25
17	Boring	0.4	6.3
18	Reaming	0.4	3.2
19	Broaching	0.4	3.2
20	Hobbing	0.4	3.2
21	Surface grinding	0.063	5
22	Cylindrical grinding	0.063	5
23	Honing	0.025	0.4
24	Lapping	0.012	0.16
25	Polishing	0.04	0.16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

Symbols specifying the directions of lay

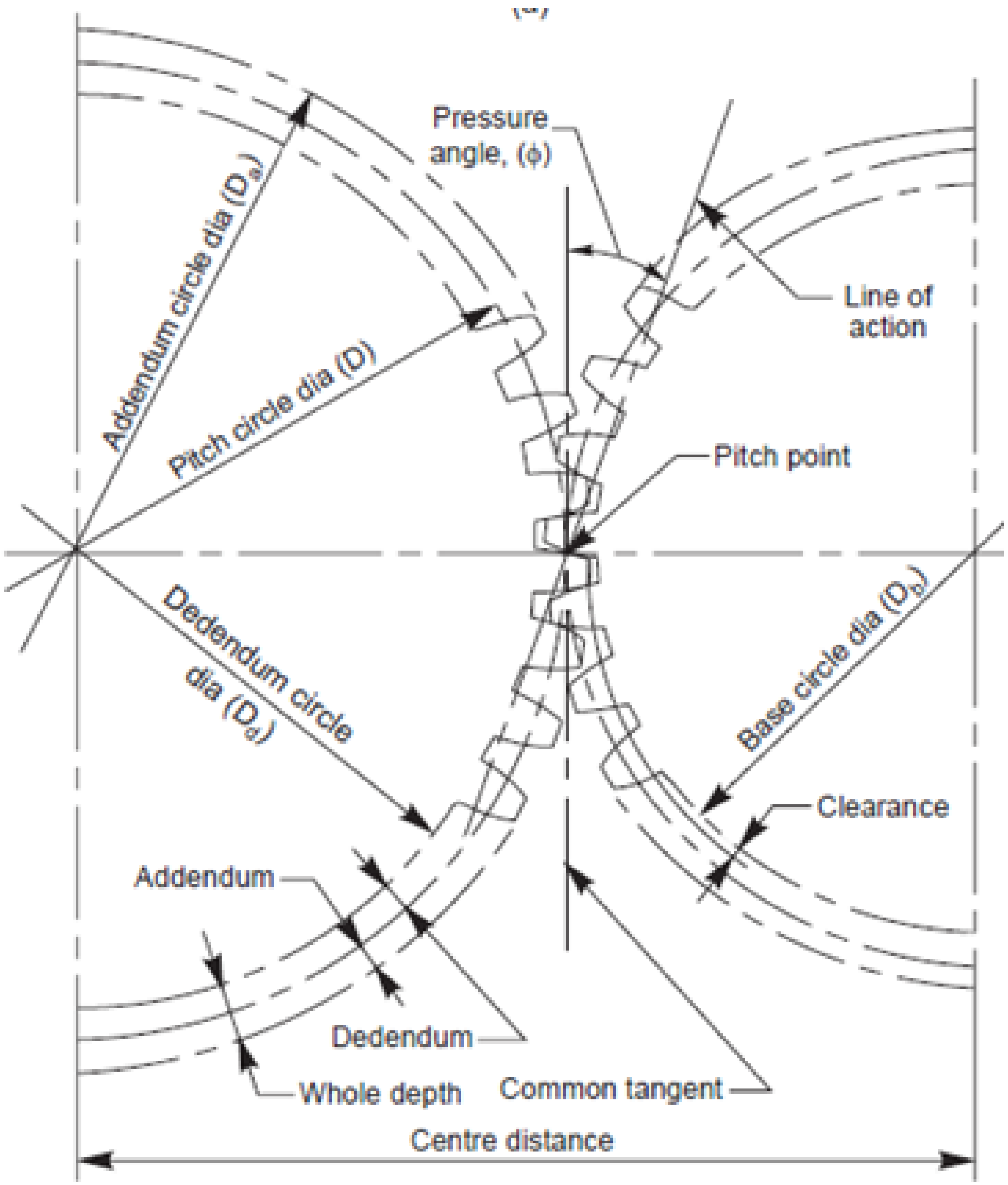
Symbol	*Interpretation*	
=	Parallel to the plane of projection of the view in which the symbol is used	
⊥	Perpendicular to the plane of projection of the view in which the symbol is used	
X	Crossed in two slant directions relative to the plane of projection of the view in which the symbol is used	
M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

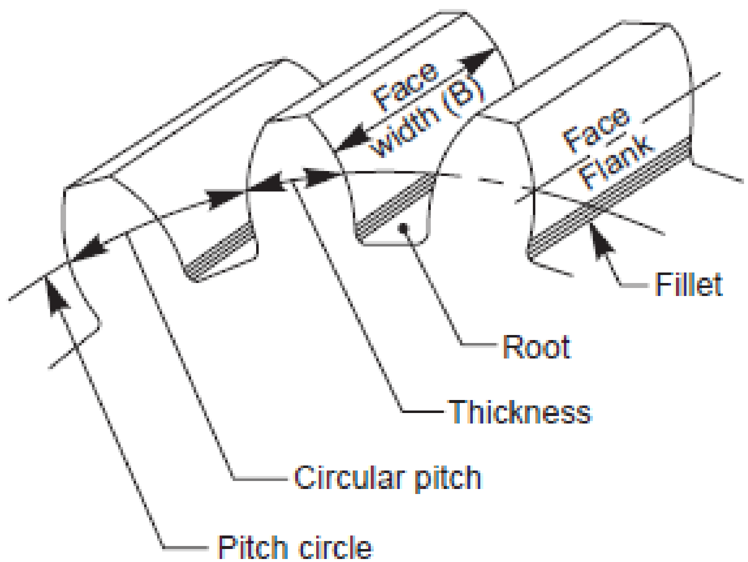
Gears

- Gears are machine elements, which are used for power transmission between shafts, separated by small distance.
- While two gears are meshing, the teeth of one gear enter the spaces of the other. Thus, the drive is positive and when one gear rotates, the other also rotates; transmitting power from one shaft to the other.



Gear Terminology





- Pitch Circle – Outlines of imaginary smooth rollers or fiction discs in every pair of mating gears.
- Pitch Diameter – Diameter of pitch circle (P.C.D.)
- Root Diameter – Diameter at the bottom of tooth space.
- Addendum – Height from pitch circle to the tip of the tooth.
- Dedendum – Depth of tooth space below pitch circle. (addendum + clearance)
- Circular Pitch (C.P.) – Length of arc of pitch circle between similar faces of successive teeth.
- Diametral Pitch (D.P.) – Number of teeth divided by pitch diameter.
- Module (m)- Pitch diameter divided by number of teeth.
- Circular Tooth Thickness – Length of arc of the pitch circle between opposite faces of same tooth (0.5 C.P.)

- Base Circle Diameter – Diameter of circle from which involute is generated.
- Line of Action – Common tangent to the two base circles, which passes through the pitch point of a pair of mating gears.
- Pressure Angle- Acute angle formed between the line of action and common tangent to the two pitch circles, which passes through the pitch point.
- Tooth Fillet – Rounded corner at the bottom of tooth space.
- Centre Distance – Distance between centers of a pair of mating gears and is equal to sum of the radii of pitch circles of the two gears.
- Pitch Point – Point of contact between the pitch circles of two gears in mesh & lies on the line joining their centers.

- Tooth face
- Tooth flank
- Crest of tooth
- Root of tooth
- Whole depth
- Working depth
- Addendum circle
- Dedendum / root circle
- Chordal pitch

Gear Calculation

- Circular Pitch = Circumference of P.C.D. / No. of teeth

  = P.C.D. x π / No. of teeth

  C.P. = P.C.D. x π / N

- Diametral Pitch = No. of teeth / Pitch Circle Diameter

  = N / P.C.D.

- C.P. x D.P. = π

  C.P. = π / D.P. And D.P. = π / C.P.

- Metric Module , m = Pitch Circle Diameter / No. of teeth

  = P.C.D. / N

  = 1 / D.P.

  C.P. = π / D.P. = π x m

Gear Calculation

Outside Diameter = Pitch diameter + 2xAddendum

Root Diameter = Pitch diameter - 2xDedendum

Clearance = Dedendum – Addendum

Tooth thickness = C.P. / 2

Addendum = 1 / D.P. = C.P. / π = m

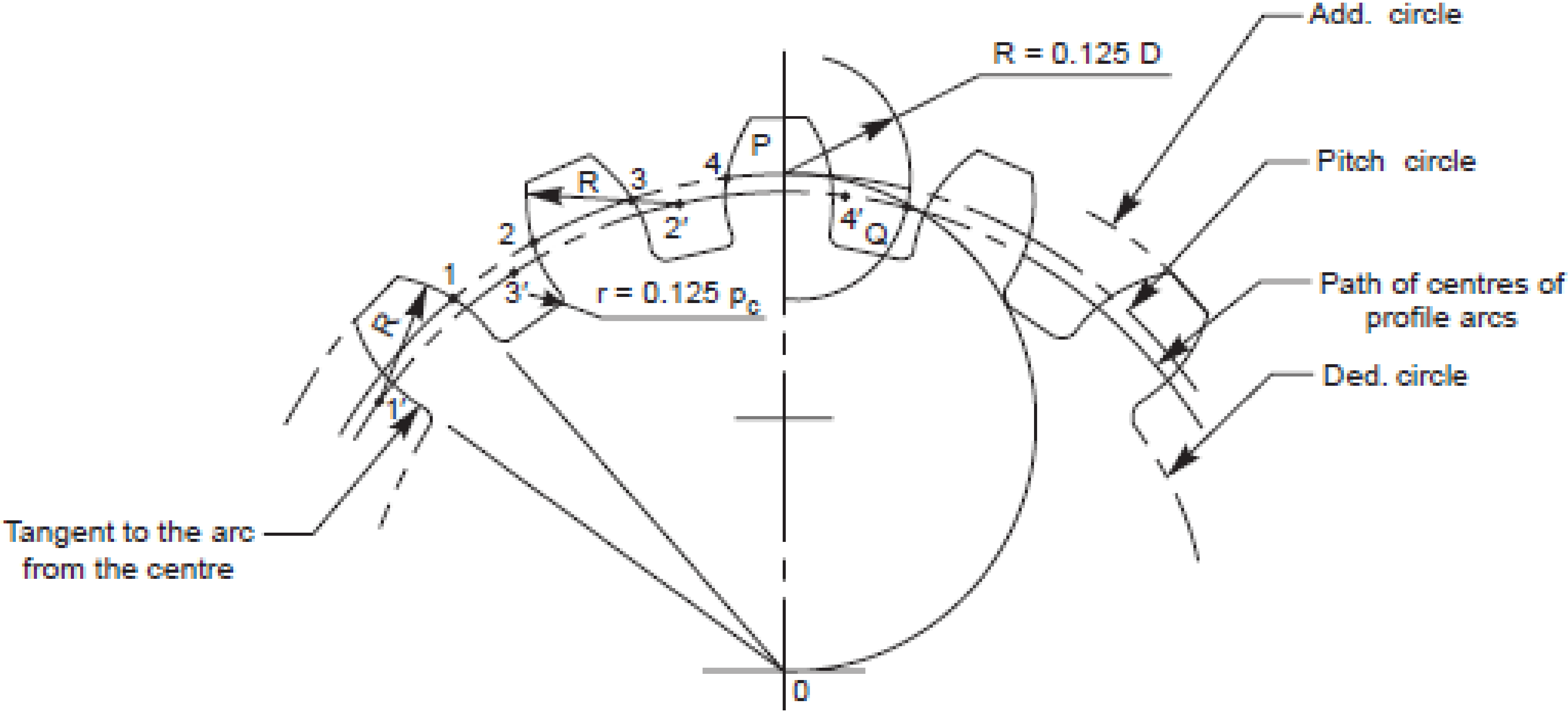
Clearance = C.P. / 20 = (π/D.P.) x (1/20) = 0.157 x m

Pressure angle, θ = 14.5 or 20 degree

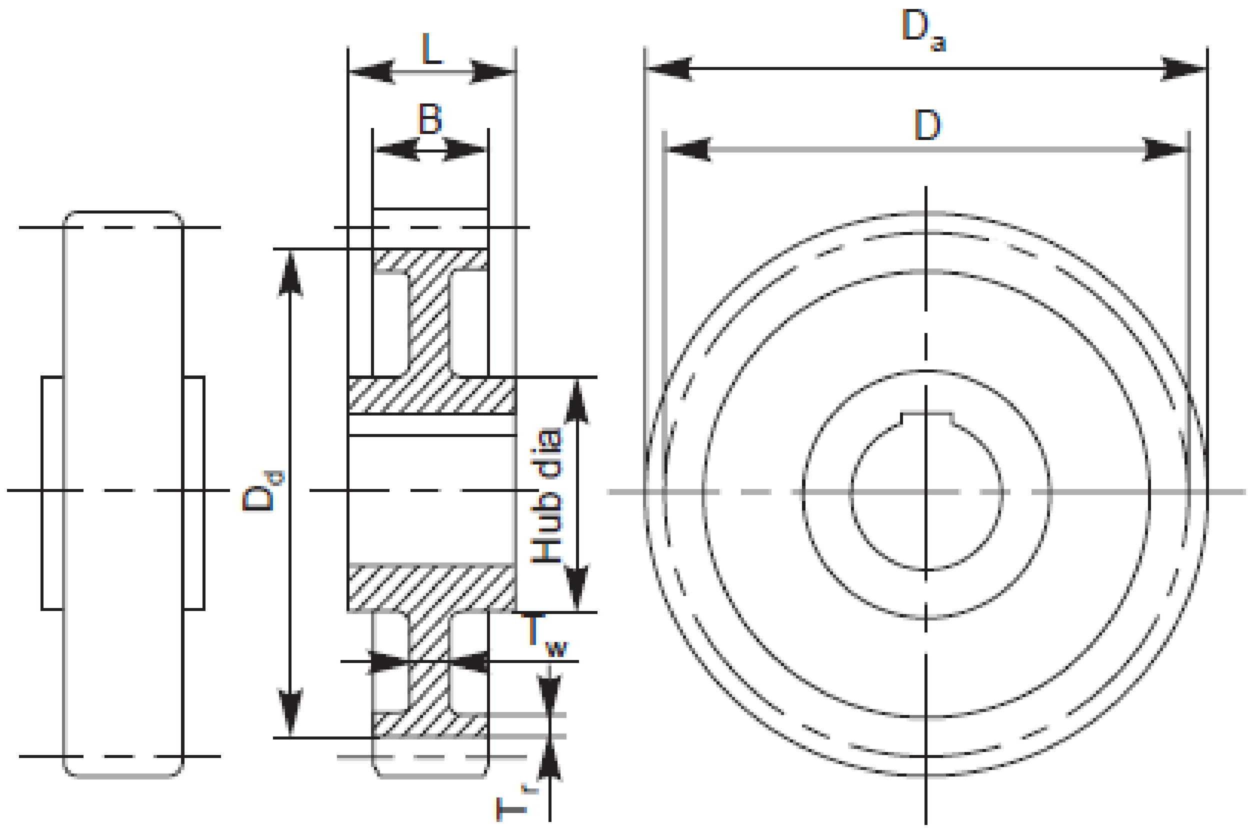
Base circle diameter, B.C.D. = P.C.D. x Cos θ

Involute gears will work correctly together if they have the same pressure angle and diametral pitch.

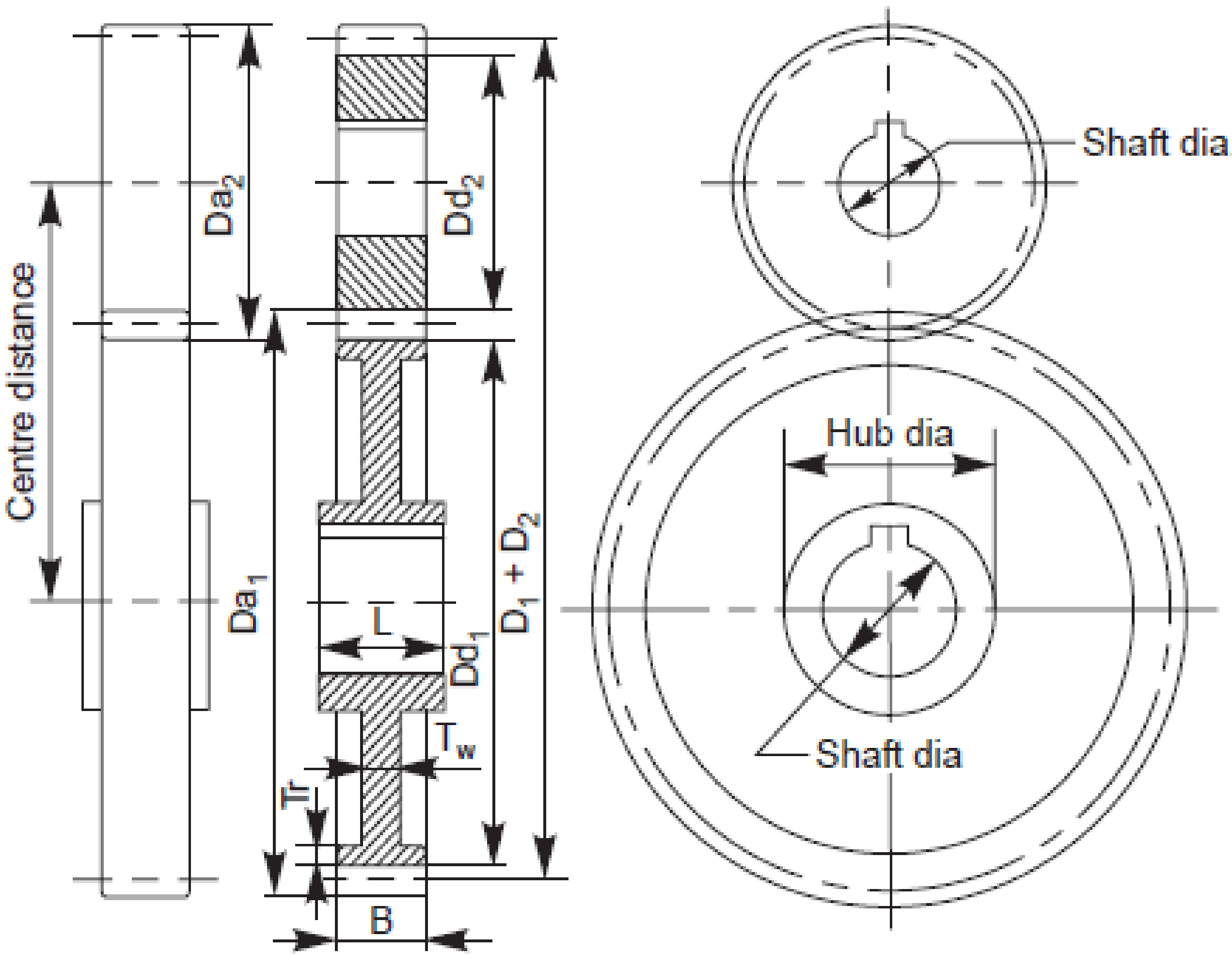
Approximate construction of tooth profile (number of teeth less than 30)



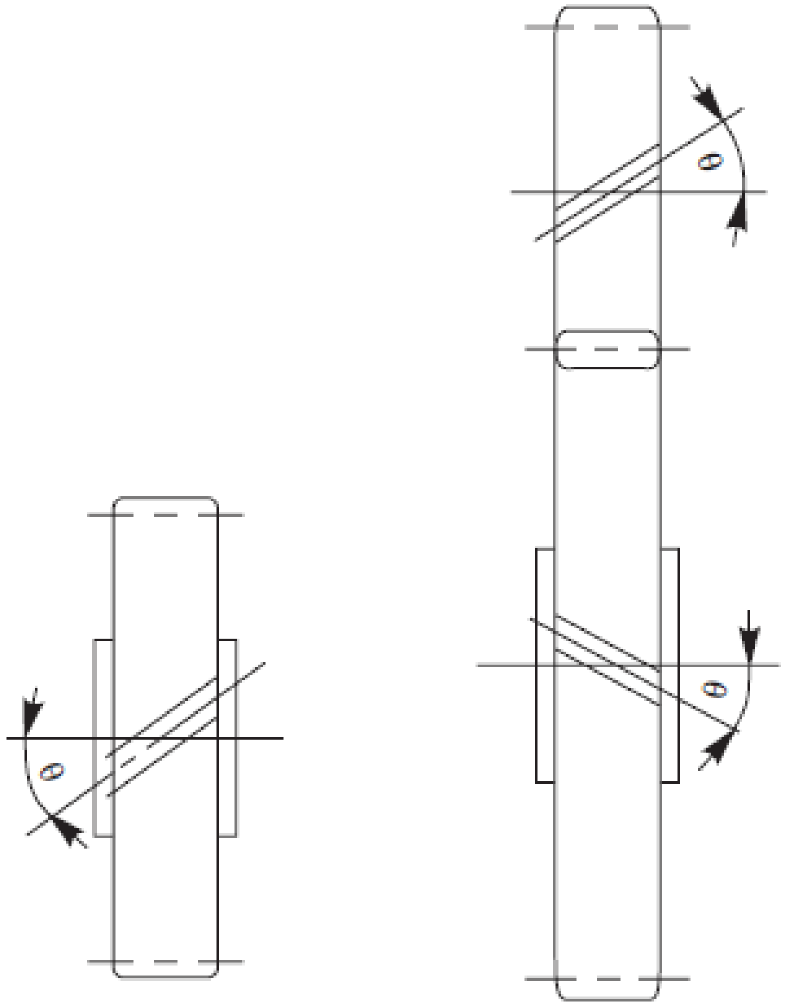
Spur Gear



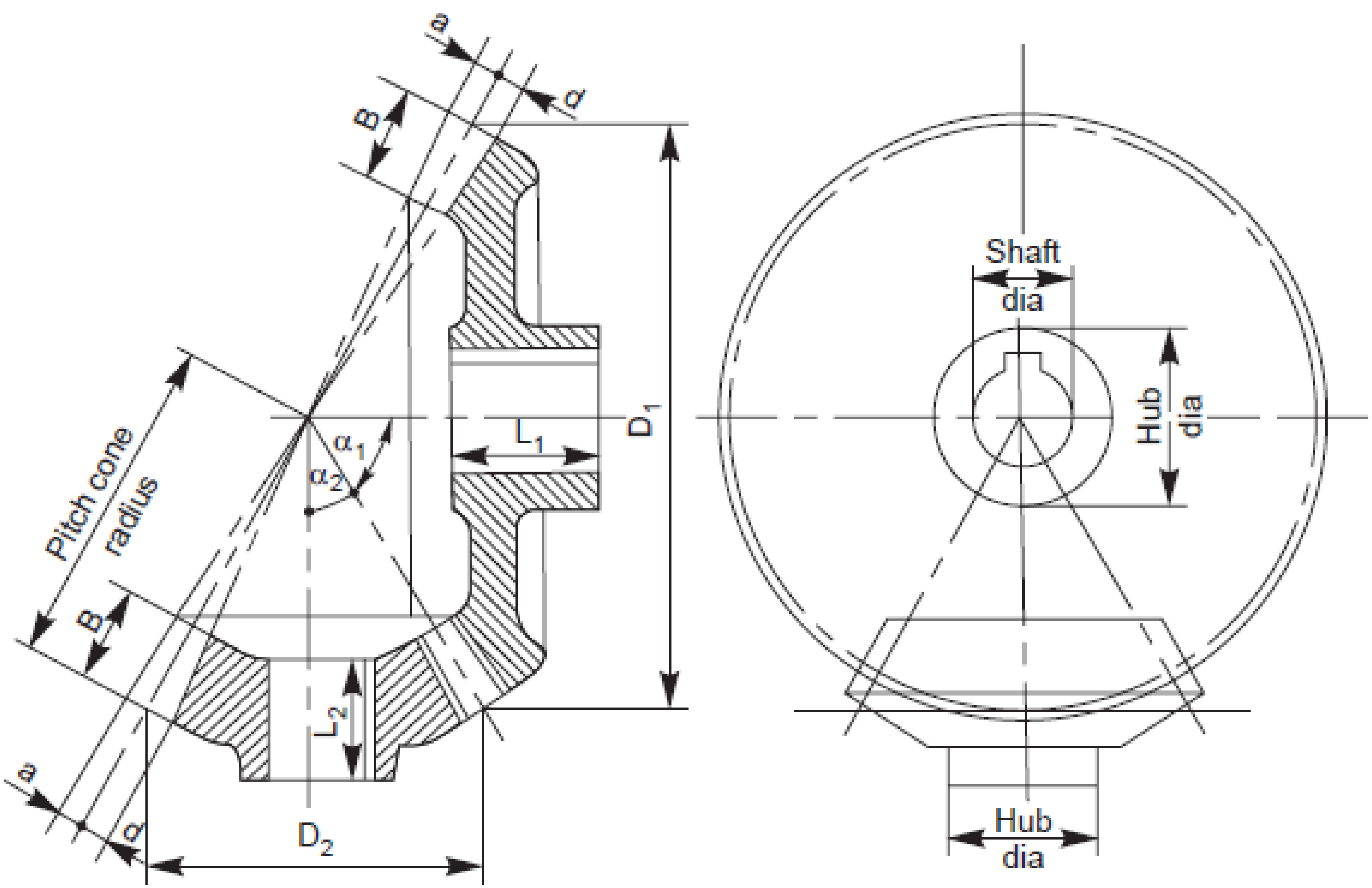
Assembly of Spur Gears



Assembly of Helical Gears



Assembly of Bevel Gears



Assembly of Worm & Worm Wheel