DRAUGHTSMAN MECHANICAL

NSQF LEVEL - 4

2nd Year

TRADE THEORY

SECTOR: CAPITAL GOODS & MANUFACTURING

(As per revised syllabus July 2022 - 1200Hrs)

Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

Sector : **Capital Goods and Manufacturing**

Duration : **2 Year**

Trade : **Draughtsman Mechanical - 2nd year Trade Theory - NSQF Level - 4 (Revised 2022)**

Developed & Printed by

National Instructional Media Institute
Post Box No.3142
Guindy, Chennai - 600032
INDIA
Email: chennai-nimi@nic.in
Website: www.nimi.gov.in

First Edition : January 2024 Copies : 1000

Rs. 250/-

FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Media Development Committee members of various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Draughtsman Mechanical 2nd Year Trade Theory** in **CG & M Sector** under **Yearly Pattern.** The NSQF Level - 4 (Revised 2022) Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Director General, Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

ATUL KUMAR TIWARI, ***I.A.S***
Secretary
Ministry of Skill Development & Entrepreneurship,
Government of India.

January 2024
New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime Objectives of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main Objectives of Vocational Training under NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

In order to perform the skills in a productive manner instructional videos are embedded in QR code of the exercise in this instructional material so as to integrate the skill learning with the procedural practical steps given in the exercise. The instructional videos will improve the quality of standard on practical training and will motivate the trainees to focus and perform the skill seamlessly.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

Chennai - 600 032 **EXECUTIVE DIRECTOR**

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisations to bring out this Instructional Material **(Trade Theory)** for the trade of **Draughtsman Mechanical 2nd Year NSQF Level - 4 (Revised 2022)** under **Capital Goods & Manufacturing** Sector for ITIs.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

Shri. V. Dhivakar	-	ATO, Govt ITI, Guindy, Tamil nadu.
Shri. C.S. Kumar	-	ATO, Govt ITI, North Chennai.
Shri. T. Chithra	-	ATO, Govt ITI, Cuddalore.
Shri. C.S. Nagarathinam	-	ATO, Govt ITI, Ulundurpet.
Shri. M.A. Mangaleshwaran	-	JTO, Govt ITI, Ramanadhapuram.
Shri. V. Dhanasekaran	-	ADT,(Retd) MDC member, "Nimi Chennai".
Shri. V. Janarthanan	-	Asst prof.(Retd) MDC member, "Nimi Chennai".

NIMI CO-ORDINATORS

Shri.Nirmalya Nath	-	Deputy Director of Training, NIMI- Chennai - 32.
Shri. V. Gopalakrishnan	-	Manager, NMI, Chennai - 32

NIMI records its appreciation of the Data Entry, CAD, DTP Operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks, the invaluable efforts rendered by all other staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intended to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the course. These exercises are designed to ensure that all the skills in compliance with NSQF Level - 4 (Revised 2022) syllabus are covered.

The manual is divided into Nine modules

Module 1	**Computer aided drafting practice**
Module 2	**Types of Pulleys**
Module 3	**Pipe joints**
Module 4	**Gears and cams**
Module 5	**IC Engine parts and assembly**
Module 6	**3D Solid objects**
Module 7	**Detailed and assemble drawing**
Module 8	**Solid works**
Module 9	**Production drawing**

The skill training in the shop floor is planned through a series of practical exercises centered around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual, a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI looks forward to the suggestions from the experienced training faculty for improving the manual.

TRADE THEORY

The manual of trade theory consists of theoretical information for the Course of the **Draughtsman Mechanical 2nd Year NSQF Level - 4 (Revised 2022)** in **CG & M**. The contents are sequenced according to the practical exercise contained in NSQF Level - 4 (Revised 2022) syllabus on Trade Theory attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

The trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indications about the corresponding practical exercises are given in every sheet of this manual.

It will be preferable to teach/learn trade theory connected to each exercise at least one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not for the purpose of self-learning and should be considered as supplementary to class room instruction.

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No	Learning Outcome	Ref. Ex.No.
1	**Construct projection views of geometrical figures with dimension and annotation on CAD in model space and viewport in layout space. (CSC/NO402)**	**2.1.94 - 2.1.101**
2	**Draw in CAD detail and assembly drawing of machine parts viz., Pulleys, Pipe fittings, Gears and Cams applying range of cognitive and practical skills. (CSC/NO402)**	**2.2.102 - 2.2.112**
3	**Construct drawing of engine parts with detailed and assembly in template layout applying quality concept in CAD. (CSC/NO402)**	**2.3.113 - 2.3.115**
4	**Create 3D solid by switching to 3D modeling workspace in CAD, generate views, Print Preview and Plotting. (CSC/NO402)**	**2.4.116**
5	**Construct detailed and assembled drawing applying conventional sign & symbolsusing CAD. (CSC/NO402)**	**2.5.117 - 2.4.132**
6	**Prepare drawing of machinepart by measuring with gauges and measuring instruments. (CSC/NO402)**	**2.6.133**
7	**Draw a machine shop layout considering process path and ergonomics (human factor). (CSC/NO402)**	**2.7.134**
8	**Create and plot assembly and detail views of machine part with Dimensions, Annotations, Title Block and Bill of materials in SolidWorks/AutoCAD Inventor/ 3D Modeling. (CSC/NO402)**	**2.8.135 - 2.8.143**
9	**Create production drawing of machine part. (CSC/NO402)**	**2.9.144 - 2.9.146**

SYLLABUS

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
Professional Skill 110 Hrs; Professional Knowledge 34 Hrs	Construct projection views of geometrical figures with dimension and annotation on CAD in model space and viewport in layout space. (Mapped NOS: CSC/NO402)	94. CAD: draw 2D object using line, polyline, ray, polygon, circle, rectangle, arc, ellipse commands. (20 hrs)	Drawing of Line, polyline, ray, polygon, circle, rectangle, arc, ellipse using different options. (07 hrs.)
		95. CAD: modify 2D objects using Break, Erase, Trim, Offset, Fillet, Chamfer Commands. (10 hrs) 96. CAD: manage 2D objects using Move, Copy, Array, Insert Block, Make Block, Scale, Rotate, Hatch Commands. (12 hrs)	Trim, Offset, Fillet, Chamfer, Arc and Circle under modify commands. Move, Copy, Array, Insert Block, Make Block, Scale, Rotate, Hatch Commands. (07 hrs.)
		97. CAD: Create templates, Insert drawings. Create objects in different Layers and Modify Layer properties. (20 hrs)	Creating templates, Inserting drawings, Layers, Modify Layers. (07 hrs.)
		98. CAD: Provide dimension on object. Create dimension by customizing dimension styles (lines, arrows, text, unit and alignment) Put dimension with scale factor. (20 hrs)	Format dimension style, creating new dimension style, Modifying styles in dimensioning. Writing text on dimension line and on leader. Edit text dimension. (07 hrs.)
		99. CAD: Construct orthographic sectional view of a steel bracket with dimension using shortcut keyboard command.(10 hrs) 100. Construct isometric view of machine blocks. (10 hrs) 101. Create viewports in layout space and place views for model space in different scale. (08 hrs)	Knowledge of shortcut keyboard command. Customization of keyboard command. Customization of drafting settings, changing orthographic snap to isometric snap. Procedure to create viewport in layout space in zooming scale. (06 hrs.)
Professional Skill 140Hrs; Professional Knowledge 50 Hrs	Draw in CAD detail and assembly Drawing of machine parts viz., Pulleys, Pipe fittings, Gears and Cams applying range of cognitive and practical skills. (Mapped NOS: CSC/NO402)	102. Construct Pulleys: solid, stepped and built up pulleys. (10 hrs) 103. Construct pulley with different types of arms. (10 hrs) 104. Draw rope pulley and v-belt pulley using CAD. (10 hrs)	Belt-drive. Materials of belts, slip and creep, Velocity of belt. Arc of contact. Simple exercise in calculation of belt speeds, nos. of belts needed in V-belt drive, velocity, pulley ratio etc. Standard pulleys width of pulley face, velocity ratio chain drive. (07 hrs.)
		105. Draw pipe fittings: tee, elbow (90° & 45°), flange, union and valve. (10 hrs) 106. Draw conventional symbols of different types of valves and joints used in pipe line diagram. (10 hrs) 107. Draw a piping layout systems from a sump to an overhead tank through a pump with possible fittings and valves. (10 hrs)	Knowledge of different pipe materials and specifications of Steel, W.I. & PVC pipes. Brief description of different types of pipe joints. Pipe threads. Pipe fittings (threaded, welded and pressed). Specifications of pipe fittings.

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
		108. Draw sectional views of different types of pipe joints using CAD. (10 hrs)	Different types of valves. (14 hrs.)
		109. Draw: i) spur gear, (08 hrs) ii) helical gear, (08 hrs) iii) bevel gear, (08 hrs) iv) worm and worm wheel. (08 hrs) 110. Construct involute tooth profile of a gear (using CAD). (08 hrs)	Gear drive- Different types of gears. Cast gears and machined gears. Knowledge of profile of gears etc. (14 hrs.)
		111. Draw a symmetrical cam profile. (15 hrs) 112. Draw different types of follower (using CAD).(15 hrs)	Use of Cams in industry. Types of cam, kinds of motion in cam, displacement diagrams. Terms used in cam. Types of follower. (15 hrs.)
Professional Skill 110Hrs; Professional Knowledge 35 Hrs	Construct drawing of engine parts with detailed and assembly in template layout applying quality concept in CAD. (Mapped NOS: CSC/NO402)	113. Construct detailed and assembly drawing (using CAD) of i) Eccentrics (10 hrs), ii) Stuffing box (12 hrs) iii) Piston assembly of a petrol engine (20 hrs), iv) IC engine connecting rod. (20 hrs)	Knowledge of engine mechanism. Transmission of motion from reciprocating to circular through eccentric, crank and connecting rod. (21 hrs.)
		114. Construct detailed drawing of an air valve. (28 hrs) 115. Construct detailed drawing of a fuel injector of a diesel engine. (20 hrs) (using CAD)	Knowledge of fuel injection system in petrol and diesel engine. (14 hrs.)
Professional Skill 46Hrs; Professional Knowledge 12Hrs	Create 3D solid by switching to 3D modeling workspace in CAD, generate views, Print Preview and Plotting. (Mapped NOS: CSC/NO402)	116. 3D Modeling: i) Create 3D solid objects using command from 3D primitive (viz. box, sphere, cylinder and poly-solids) , from solid (extrude, revolve, sweep and loft), from Boolean (union, subtract and intersect) (20 hrs) ii) Create 3D drawing using User co-ordinate systems. (13 hrs) iii) Annotate and dimension of the 3D model. (05 hrs) iv) Generate views from model space to layout space. (05 hrs) v) Generate Print preview and Plotting. (03 hrs)	Introduction to 3D modeling, 3D primitives (viz. box, sphere, cylinder, mesh and poly-solids), solid figure by extrude, revolve, sweep and loft command, solid editing: fillet, offset, taper, shell and slice command. Setting of User co-ordinate Systems, Rotating, Print preview and Plotting. (12 hrs)

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
Professional Skill 260 Hrs; Professional Knowledge 90 Hrs	Construct detailed and assembled drawing applying conventional sign & symbols using CAD. (Mapped NOS: CSC/NO402)	117. Construct detailed drawing of a lever safety valve.(20 hrs) 118. Construct detailed drawing of a gate valve.(20 hrs)(using CAD)	Working principle of valves and their description. (13 hrs.)
		119. Construct detailed drawing of a steam stop valve and blow off cock. (20 hrs) (using CAD)	Knowledge of simple stationary fire tube boiler, boiler mountings. Function and purpose of blow off cock. (07 hrs.)
		120.Create library folder containingblocks of hydraulic and pneumatic conventional signs and symbols. (10 hrs) 121. Draw a sectional view of a hydraulic jack and a pneumatic valve actuator. (10 hrs)(using CAD)	Brief description of a typical hydraulic system, components, working principle and function of hydraulic jack. Different types of hydraulic actuator. Symbol and working of hydraulic DC valve, non-return valve and throttle valve. Knowledge of typical pneumatic system, FRL or air service unit and pneumatic actuator. (07 hrs.)
		122. Draw detail and full sectional view of a volute casing centrifugal pump(using CAD). (20 hrs)	Different types of pump systems.Characteristics of a pump system: pressure, friction and flow.Energy and head in pump systems. (07 hrs.)
		123. Draw assembly and detailed drawing of tool post of a lathe. (using CAD) (20 hrs)	Different clamping devices on lathe. (07 hrs.)
		124. Construct detailed &assembly drawing of tail stock and revolving centre. (using CAD) (20 hrs)	Description of different job holding devices in lathe operation. (07 hrs.)
		125. Construct detailed drawing of a milling fixture. (using CAD) (20 hrs)	Different clamping devices on milling operation. (07 hrs.)
		126. Construct detailed & assembly drawing of shaper tool head slide. (using CAD) (20 hrs)	Different clamping devices on shaping operation. (07 hrs.)
		127. Draw a simple drilling jig for drilling holes in a given component. (using CAD) (20 hrs)	Knowledge of accuracy and interchangeabilityinthe manufacturing of products. (07 hrs.)
		128. Draw a Press Tool giving nomenclature of each part. (08 hrs) 129. Draw dies & punches for the production of simple work pieces. (using CAD) (06 hrs) 130. Develop isometric drawing for manufacturing 2 cavity injection moulds with side cavities. (using CAD)(06 hrs)	Knowledge of various parts of press tools and their function. Knowledge of different moulding processes. Introduction to Die casting, gating system design, force calculation, defects and remedies and estimation. (07 hrs.)
		131. Construct detailed drawing of a simple carburetor.(using CAD) (20 hrs)	Description of different parts of petrol engine. (07 hrs.)

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
		132. Construct detailed and assembly drawing of a simple pressure vessel. (using CAD) (20 hrs)	Knowledge of design, manufacture, and operation of pressure vessels. (07 hrs.)
Professional Skill 20Hrs; Professional Knowledge 08Hrs	Prepare drawing of machineparts by measuring with gauges and measuring instruments. (Mapped NOS: CSC/NO402)	133. Prepare detailed drawing of a C-clamp and a machine vice by taking measurement using gauges and measuring instrument. (using CAD) (20 hrs)	Proper measurement practice in workshop. Principles of good measurement result: right measurement, right tools, right sketching, review and right procedures.(08 hrs.)
Professional Skill 20Hrs; Professional Knowledge 06Hrs	Draw a machine shop layout considering process path and ergonomics (human factor). (Mapped NOS: CSC/NO402)	134. Draw a machine shop layout of small production industry showing material inflow to finished product stock. (using CAD) (20 hrs)	Lay out of Machine foundations. Brief treatment of the principle Involved and the precautions to be observed. Lay out of machine Foundation. Consideration of ergonomics (human factor) for shop layout. (06 hrs.)
Professional Skill 110 Hrs; Professional Knowledge 35 Hrs	Create and plot assembly and detail views of machine part with Dimensions, Annotations, Title Block and Bill of materials in SolidWorks/AutoCAD Inventor/ 3D Modeling. (Mapped NOS: CSC/NO402)	**SolidWorks/AutoCAD Inventor/ 3D Modeling:** 135. Draw 3D solid figures by Sketching features & applied features. (08 hrs) 136. Sketch an angle plate and a block – Create/ Modify constraints. (06 hrs) 137. Create a sketch of a new part. (08 hrs)	Introduction to SolidWorks/ AutoCAD Inventor/ 3D Modeling User interface - Menu Bar – Command manager – Feature manager – Design Tree – settings on the Default options – suggested settings – key board short cuts. Create the best profile – create a sketch – create a new part. (07 hrs.)
		138. Create 3D solid and edit using: i) Copy & Paste, (03 hrs) ii) Filleting, (03 hrs) iii) Chamfering, (03 hrs) iv) Editing a feature definition. (03 hrs) v) Create ribs, mirror pattern, the Hole wizard, (03 hrs) vi) Create part configurations, Part design tables, (03 hrs) vii) Inset Design Table, Inset new design table. (03 hrs)	Extrude bosses and cuts, add fillets, and chamfer changing dimensions. Revolved features using axes, circular patterning changes and Rebuild problems. (07 hrs.)
		139. Create New assembly part: i) Create a new assembly (06 hrs) ii) Insert components into an assembly, (03 hrs) iii) Add mates (degree of freedom). (03 hrs) iv) Perform components configuration in an assembly, (03 hrs)	Bottom up assembly modeling Components configuration in an assembly, Insert subassemblies, Interference detection. (07 hrs.)

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
		v) Insert subassemblies, (03 hrs) vi) Perform Interference detection. (03 hrs)	
		140. Create a 3D model putting: i) Driving dimensions, (02 hrs) ii) Bill of materials, (02 hrs) iii) Driven (Reference) Dimensions, (02 hrs) iv) Annotations, (02 hrs) v) Alternate position view. (02 hrs) 141. Prepare drawings & detailing: i) Create drawing sheets, (02 hrs) ii) Add drawing items, (02 hrs) iii) Named views, standard 3 views, auxiliary views, section views, detail views. (02 hrs) iv) Reattach and replace dimensions, (02 hrs) v) Edit sketch, (02 hrs) vi) Edit sketch plane, (02 hrs) vii) Edit definition. (02 hrs)	Drawings & Detailing, create drawing sheets, Add drawing items, Named views, std. 3 views, auxiliary views, section views, detail views. Drawings & Detailing, create drawing sheets, Add drawing items, Named views, standard 3 views, auxiliary views, section views, detail views. (07 hrs.)
		142. Create a 3D transition figure • using loft feature. (03 hrs) • using sweep feature. (03 hrs) • using library features.(03 hrs) i) Create 3D model by annotating Holes and Threads, (03 hrs) ii) Create Centerlines, symbols and leaders, (03 hrs) iii) Create Simulation. (03 hrs) iv) Plot the model. (01 hr) 143. Convert or save as Solid Works and Inventor file into .dwg format. (03 hrs)	Difference between sweep and loft. Exploded views – Configuration manager, Animation controller. Annotating Holes and Threads, Creating Centerlines, symbols and leaders, Simulation. Introduction to plot & Different ways of plotting. (07 hrs.)
Professional Skill 24 Hrs; Professional Knowledge 06 Hrs	Create production drawing of machine part. (Mapped NOS: CSC/NO402)	144. Create production drawing of a simple Drill jig – Part model – assembly-detailing (using CAD). (12 hrs) 145. Create production drawing of a Screw jack – Part model – assembly-detailing. (10 hrs) (using CAD) 146. Create a check list by self-assessment and provide Revision mark by noting in the Revision table. (02 hrs)	Knowledgeof production drawing, name plate and bill of materials, etc. Study of production drawing. Procedure of preparing Revision Drawing: putting revision mark, writing remarks in the table as per check list. (06 hrs.)

Draw commands

Objectives: At the end of this lesson you shall be able to
- **state the methods of drawing line - using different options / commands**
- **state the methods of drawing circles & polygons**
- **state the methods of drawing arcs**
- **state the methods of drawing ellipse**
- **state the use of line polyline, spline, ray & X line commands.**

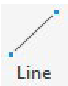
Introduction

After preparing the electronic drawing sheet called blank sheet with all required settings as per BIS, the drawing of 2D figures can be started. In AutoCAD 2D figures means the figures drawn on the xy plane of the screen.

Most commonly used Draw, modify and other commands are explained in this chapter

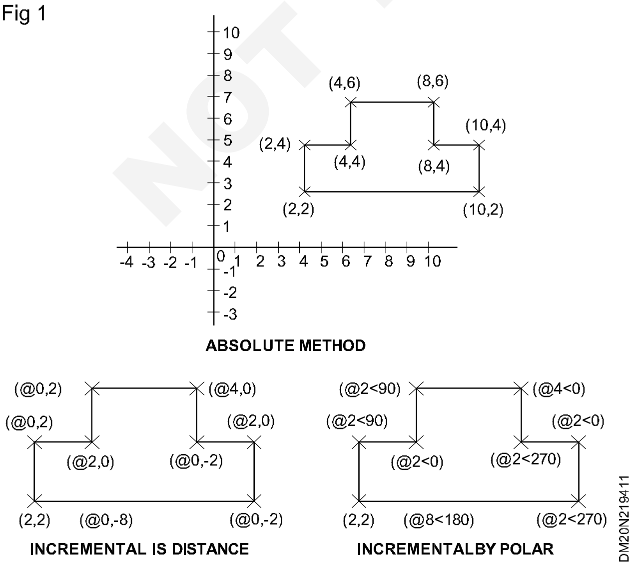
Frequently used draw commands are:

1 Line
2 Polyline
3 Spline
4 X line
5 Ray
6 Polygon
7 Rectangle
8 Circle
9 Arc
10 Ellipse
11 Hatch

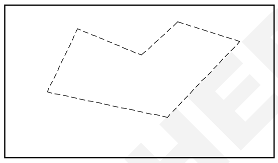
1 Line (Fig 1) 

- Most commonly used command in AutoCAD is line.
- More than 50% of typical drawings consists of lines.
- A line object itself consists of two points, a start point and an end point.
- There are three methods of defining co-ordinates to create a line.

1 Absolute method (with reference to origin (0,0) x,y)

Fig 1


2 Relative method (with reference to last co-ordinate @ x dist, y dist) (Fig 2)

Fig 2


3 Polar method (with reference to last co-ordinate @ dist < angle)

2 Polyline (Pline) 

Pline command is used to draw several line segments using a single line command.

From start to end, it is treated as a single object.

With Pline command we can draw objects with line width (Fig 3)

We can convert pline to spline using PEPIT command (Fig 4).

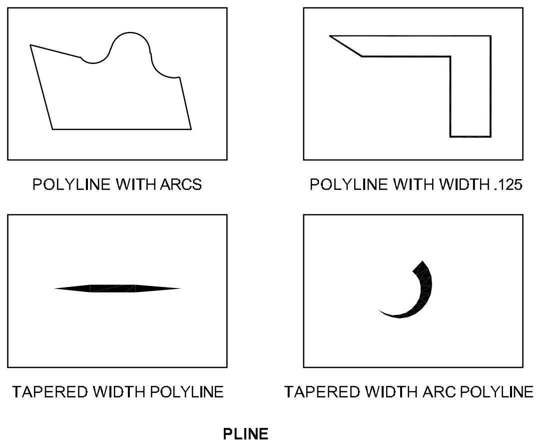
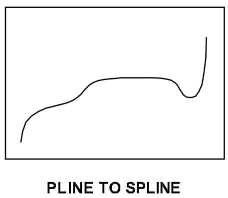
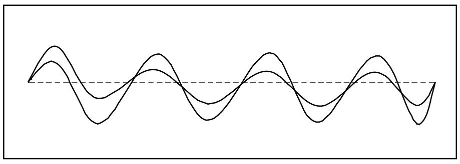
Fig 3


Fig 4


3 Smooth polyline (Spline) (Fig 5&6)

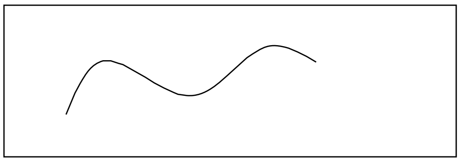
Fig 5



SPLINE

DM20N219415

Fig 6



SPLINE

DM20N219416

Spline is a smooth curve that passes through or near a given set of points.

4 XLine

Xline command is used to create a horizontal/vertical/ angled lines through a selected point.

Xline can be used to create construction and reference lines, and for trimming boundaries.

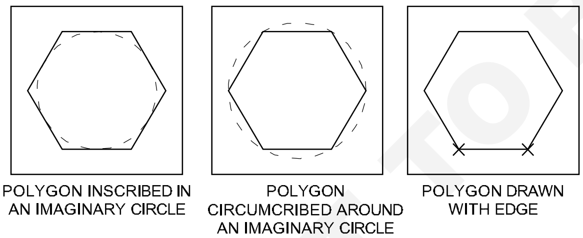
5 Ray

Ray command is used to create a semi infinite lines.

A ray has a finite starting point and extends to infinity.

6 Polygon (Fig 7)

Fig 7



POLYGON COMMAND

DM20N219417

- Polygons are closed polylines comprised of a minimum of 3 sides and a maximum of 1024 equal sides.
- Polygons can be drawn by the following three methods.

1 Edge method

2 Inscribed in circle (polygon is located inside a circle)

3 Circumscribed about a circle (polygon is located outside a circle)

7 Rectangle

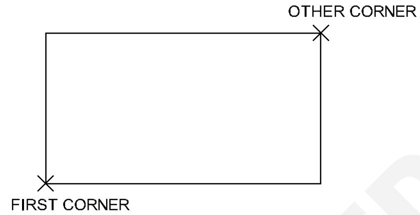
This command creates rectangles as closed lines with four sides. Rectangles can be drawn by three methods.

1 By specifying the co-ordinates at the "specify first corner point" prompt and a the "specify other corner point" prompt.

2 By entering area of rectangle in current units and specifying length or width of rectangle for this select "Area" option of rectangle command.

3 By specifying length distance and width distance of rectangle. For this select "Dimensions" option of rectangle command. (Fig 8)

Fig 8

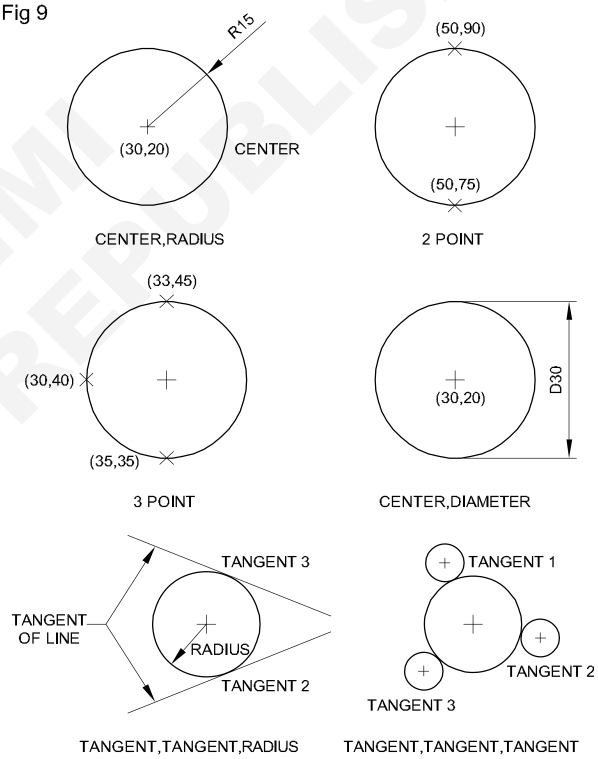


RECTANGLE COMMAND

DM20N219418

8 Circle (Fig 9)

Fig 9



CIRCLES

DM20N219419

This command is used to create circles

Circle can be created in six ways.

1 Center, Radius (default)

2 center, diameter

3 2 point method (2P)

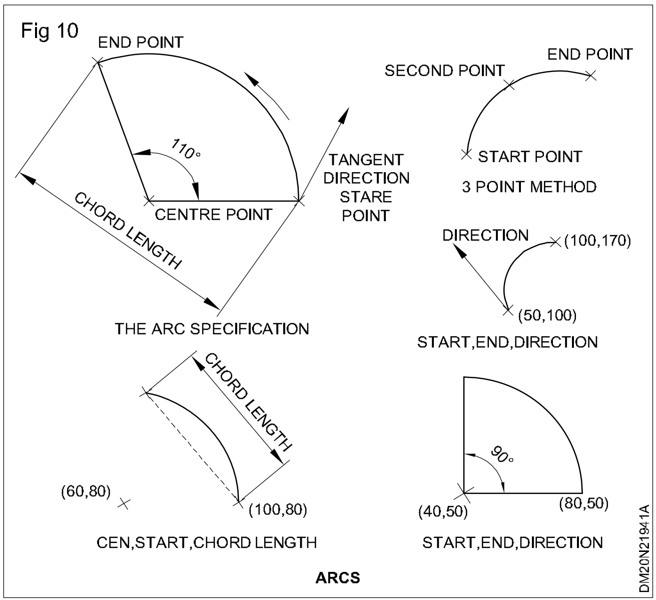
4 3 point method (3P)

5 Tangent, tangent, radius (TTR)

6 Tangent, Tangent, Tangent

9 ARC (Fig 10) 

Fig 10



An arc is a portion of a circle

The method used to draw arcs is to specify three points - the start point, a second point and the end point.

We can draw arcs by using the following methods.

1 3 point arc

2 Start, center, end

3 Start, center, chord length

4 Start, center, Included angle

5 Start, end, radius

6 Start, end, angle

7 Start, end, direction

8 Center, start, end

9 Center, start, chord length

10 Center, start, angle

11 Continuous

10 Ellipse 

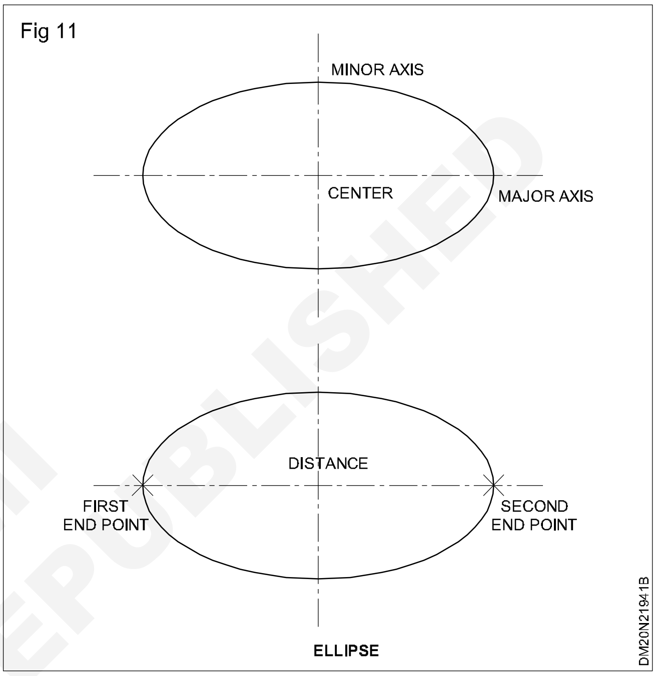
An ellipse is defined by two axes. The major axis and the minor axis.

To draw an ellipse we can use either of the following methods.

1 Specify the center of the ellipse and the two axes.

2 Specify the end points of one of the axis of the ellipse and then specify a distance representing half the length of the second axis. (Fig 11)

Fig 11



11 Hatch 

This command is used to fill up the closed area with a particular hatch pattern, gradient or solid fill.

Modify or Editing commands

Objectives: At the end of this lesson you shall be able to
- **state the list of modify commands**
- **state the difference between break and break at point**
- **state the use of fillet & chamfer commands.**

The following are the important editing commands in AutoCAD. These commands can be invoked from the toolbar, or pull-down menu, or can be entered at the command prompt

Frequently used modify (edit) commands are

1 Erase
2 Trim
3 Extend
4 Stretch
5 Break
6 Break at point
7 Fillet
8 Chamfer
9 Offset
10 Explode
11 Join

1 Erase

Erase command is used to remove one or a group of entities simultaneously.

For this modification, press on the icon "Erase" select the objects, and press the enter key of keyboard.

The selected objects are identified by the conversion of dotted lines before erasing.

2 Trim

This command trims the objects that extend beyond a required point of intersection. We can trim existing object of a drawing.

3 Extend

This command extends the lines, polylines and arcs upto the boundaries specified. This command may be considered as opposite of the trim command.

4 Stretch

This command can either lengthen entities or shorten them, and thus alter their shapes. The centre points of arcs or polyline arcs are adjusted centre points of arcs or polyline arcs are adjusted accordingly

Select the drawing objects to be stretched and specify the distance and direction of stretching.

5 Break

This command erases a portion of line, arc circle or a 2D polyline between two selected points.

6 Break at point

This command selects an entity first and then breaks into two entities at the point clicked without and gap.

7 Fillet

This command is used to create a round corner between two lines.

Fillet works on any combination of two line arcs, circles, non-parallel lines or a single polyline.

Once the radius value is identified the direction of the fillet is determined by the cursor location which is used to identify the two objects.

8 Chamfer

This command is used to create a beveled edge between two lines or a single polyline. It works quite like the fillet command.

The chamfer distance determines the sizes of the chamfer.

9 Offset

This command creates concentric circles, parallel lines and parallel curves at a specified offset distance.

Each offset creates a new entity with the same line type, color and layer settings.

This is just like duplicating object like copy command.

10 Explore

This command breaks a polyline into its individual segments.

These segments can then individually edited and rejoined again to form an edited polyline.

11 Join

This command is used to join two or more objects and to form a single, unbroken object.

Manage 2D Objects using modify commands

Objectives: At the end of this lesson you shall be able to
- **state the list of modify commands**
- **state the difference between copy and array commands.**

Someother modify (edit) commands are

1 move

2 copy

3 rotate

4 mirror

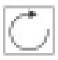
5 array

1 Move 

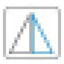
- The move command is used to move one or more objects from their current location to new location without changing their size or orientation.
- We can simply rearrange the existing drawing objects.
- This is a very useful tool for analyzing design alternatives and making quick adjustments to drawings.
- The selected objects are moved with reference to the base point.

2 Copy 

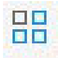
- The copy command is used to copy an existing object.
- This command is similar to move command, but it makes copies of the selected objects at a specified location.
- We can make multiple copies of drawing objects within seconds. The selected objects are copied with reference to the basepoint.

3 Rotate 

- While creating designs sometimes we have to rotate an object or group of objects. This requirement can be accomplished by using rotate tool.
- The selected objects are rotated with reference to a single point (base point)

4 Mirror 

- The mirror command creates mirror image of the selected objects, about a specified line.
- This command is helpful in drawing symmetrical figures.
- The specified line (line of reflection) about us the selected objects are mirrored.

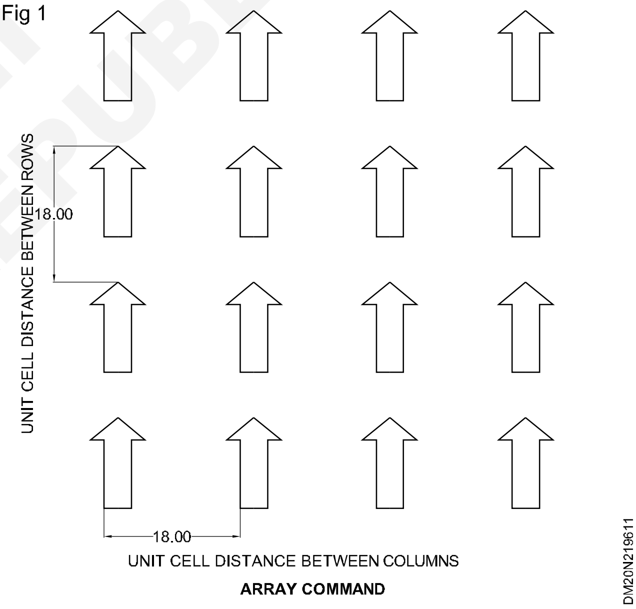
5 Array 

- This command creates multiple copies of selected objects in rectangular or polar form.
- This is a form of copy command.
- It allows to copy objects in a defined angle and exact number of copies.

i Rectangular array (Fig 1)

A rectangular array is formed by making copies of selected object along the X and Y axes (along rows and columns)

Fig 1

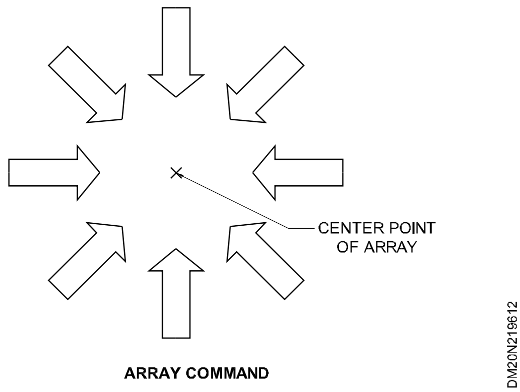


ARRAY COMMAND

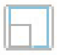
ii Polar array (Fig 2)

A polar array is an arrangement of objects around a point in a circular pattern.

Fig 2



ARRAY COMMAND

6 **Scale** 

The scale command allows to shrink or enlarge the existing drawing objects about a base point by specifying a scale factor.

Make block insert block XREF & Block edit commands

Objectives: At the end of this lesson you shall be able to
- **define make block and insert block commands**
- **state the concept of external reference.**

Make block

This command is used for creating a block, the properties of the block can be defined using the block definition.

Blocks are drawing which can be inserted into other drawings.

Insert Block (I)

- This command is used to insert an existing block or a drawing as a block.
- This is a form of copy command.
- We can insert the existing blocked drawing by specifying the insertion point.

Block Edit (BE)

This command is used to edit an object or drawing which was already blocked & saved. By right clicking on the blocked objects we edits save.

W block

This command is used to export certain part of our drawing or any of its blocks to an external file. This is also called as write block tool.

External reference (XREF)

External references (XREF) are one of the most important concepts to understand in a CAD environment. The idea is simple enough to link one file to another so that any changes made to the source file, will show up in the destination file as well. An XREF is a graphic image of an external file that appears and prints inside your drawing just as if it were drawn inside that file.

Creating templates and layers

Objectives: At the end of this lesson you shall be able to
- **define template on AutoCAD**
- **describe the use of layers**
- **state the features of layer system.**

Templates

- A drawing template file is a drawing file that has been saved with a dwt file extension and it specifies the styles, settings and layout in a drawing including title block.
- We can setup a new template for the needs of each type of document or drawing.
- We can setup units, limits, dimension style, text layers title blocks and blocks of repeating parts etc.
- For example if we want to create a set of drawings with the same scale and sheet size as an existing drawing, we can turn one or more of our typical drawings into template.
- By using templates we can save a lot of setup time for subsequent drawings.

Layers

- A layer can be considered as transparent sheet which can be placed one over the other so that entities are drawn separately on each layer but can be viewed and edited together.
- The layers are also called as overlays or levels.

The important features of layer system are as follows.

1 Only one layer will be active at a time for drawing i.e the drawing can be done only in the current layer.

2 Modification (edit) of drawing can be done in all visible layers together.

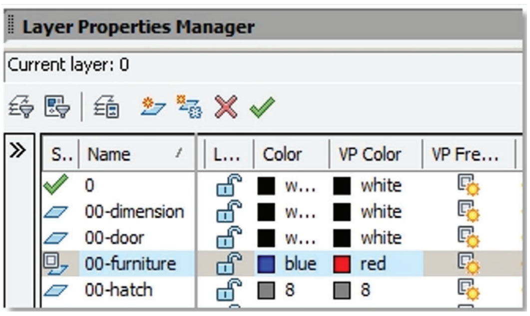
3 Layers can be made visible, hidden or locked.

4 The entities drawn in one layer can be transferred to another layer.

5 In printing the layer can be switched on or off as required.

6 In autoCAD we can work with virtually unlimited number of layers. (Fig 1)

Fig 1



Organizing with layers

The layer system is very much useful tool for machine assembly drawing, building drawing etc. where a large number of items are coming together.

Engineering drawing is prepared by using different types of line.

Standard line patterns are usually provided in CAD software for selection.

Generally separate layers are assigned for each line type.

Layer properties manager provide colour facility for the lines & Line weight.

Layer properties manager

We can add, delete and rename layers, change their properties, set properly overrides in layout viewports and add layer descriptions.

Layers and layer properties

New layer

Creates a layer with a default name that we can change immediately.

Delete - deletes the selected layer

Set current layer - set the selected layer current. All objects will then be drawn on this current layer.

Show details - To see more details information about the selected layer.

Each layer also has the following options against it.

Name - Displays the layer name

ON - Controls if the layer is on or off. Select the light bulb to turn the layer off on the drawing.

Freezing in all VP - Pressing this will freeze the layer in all viewports as well as the current model view.

Lock - This handy feature locks a layer preventing any content of the layer from being modified.

Colour - We can provide the colour whichever we like. All objects drawn on the layer will display the chosen colour

Line type - Set the default line type for all objects drawn on the layer ie continuous, dashed, dotted etc.

Line weight - Set the thickness of a line that appears. Default is no thickness. This option can be toggled on/off on the display by the LWT button above the command console.

Plot - Select if the layer will be shown when the drawing is plotted (Printed)

Modify layers

To change or modify layer of selected objects.

1 Select the object.

2 Right click in the drawing area and choose properties from the short cut menu.

3 In the properties palette click layer and then the down arrow.

4 From the drop down list, choose the layer that you want to assign to the objects.

5 Press ESC to remove the selection.

Dimensioning in Auto CAD

Objectives: At the end of this lesson you shall be able to
- **state the fundamental dimensioning terms**
- **to know the dimensioning commands**
- **to know the dimedit commands**
- **to know the options in dimstyle manager.**

Dimensioning

To manufacture an object, the drawing must contain size descriptions such as length width height, angle, radius and diameter features. All these information are added to the drawing with the help of dimensioning.

Dimensioning in AutoCAD (Fig 1)

The objects can be dimensioned in autocad range from straight lines to Arcs. The dimensioning commands provided by AutoCAD can be classified into four categories.

1 Dimension drawing commands

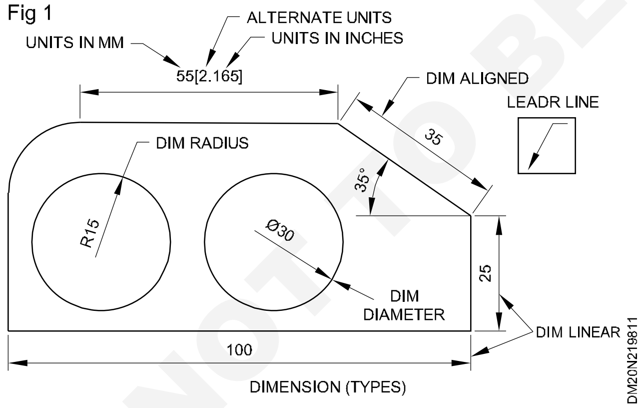
2 Dimension style Commands.

3 Dimension editing commands.

4 Dimension utility commands.

While dimensioning an object, Auto CAD automatically calculates the length of the object or the distance between two specified points. The generation of arrows, lines (dimension lines, extension lines) and other objects that form a dimension are automatically performed by AutoCAD to save the user's time.

Fig 1



Fundamental Dimensioning terms

The following are the fundamental dimensioning terms used in autocad.

Dimension line

A dimension line shows where a dimension begins and ends. Usually this line has arrows at the ends, and the dimension text is place along the dimension line. By default the dimension line is draw between the extension lines. The dimension line for angular dimensions is an arc.

Dimension text

This is a text string that reflects the actual measurement between the selected points.

Arrow

Arrows are used as terminators in a dimension line.

Extension lines

Extension lines also called projection lines that extends away from the object for which you are creating a dimension. Extension lines are used for linear and angular dimensioning. Generally extension lines are drawn perpendicular to the dimension line.

Leader

A leader is a line that stretches from the dimension text to the object being dimensioned.

Center mark

The center mark is a cross mark that identifies the center point of a circle or an arc.

Center lines

Center lines are crossing lines that extend out from the center of a circle or an arc.

Alternate units

With the help of alternate units we can generate dimensions for two systems of units at the same time. If the dimensions are in inches, we can use the alternate units dimensioning facility to append the dimensions in metric units.

Linear dimensioning (dim linear)

Linear dimensioning command draws the dimension between two points. The points can be any two points in the space, the end points of an arc or line.

Linear dimensions include horizontal & vertical dimensioning. Dimension will create after responding to all the dimensioning prompts.

Aligned dimensioning (Dim aligned)

Aligned dimensions are linear dimensions that align parallel to either a selected object or to the selected origin points. This allows us to align a dimension with an angled line

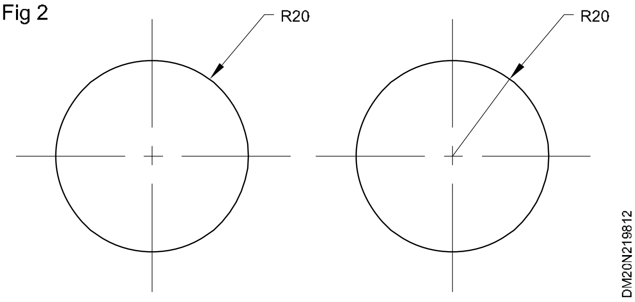
Angular dimensioning (Dim angular)

Angular dimensioning is used to dimension an angle. This command generates a dimension arc to indicate the angle between two non-parallel lines.

Radius dimensioning (Dim radius) (Fig 2)

Radius dimensioning is used to create a radius dimension for a circle or an arc. This command is also used to measure the radius of a selected circle or arc and displays the dimension text with a radius symbol in front of it.

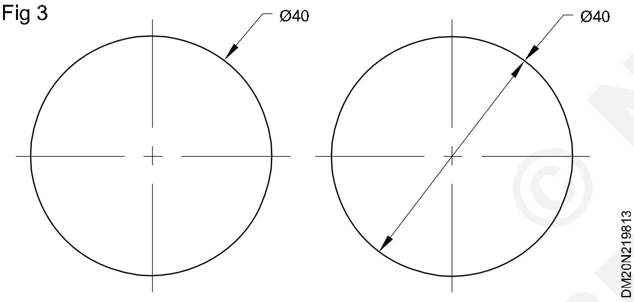
Fig 2



Diameter dimensioning (Dim diameter) (Fig 3)

Diameter dimensioning is used to create a diameter dimension for a circle or an arc. Here the measurement is done between two diametrically opposite points on the circumference of the circle or an arc.

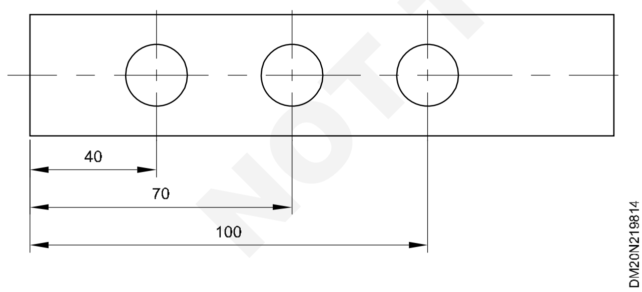
Fig 3



Dim Base Line (Fig 4)

BaseLine dimensions are multiple dimension with offset dimension lines measured from the same location.

Fig 4



Dimcontinue (Fig 5)

Continued dimensions are also called as chain dimensions. These are multiple dimensions place end to end.

M Leader (Fig 6)

This command is used to create leader objects. It includes an arrow head, a leader line or curve and a horizontal landing. It also consists a block or multiline text object.

Fig 5

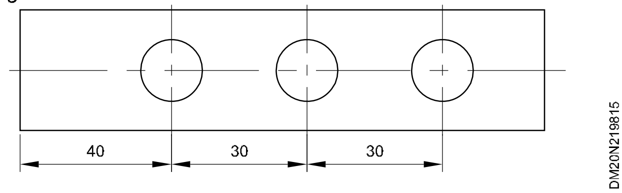
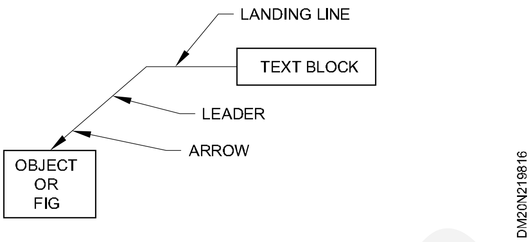


Fig 6



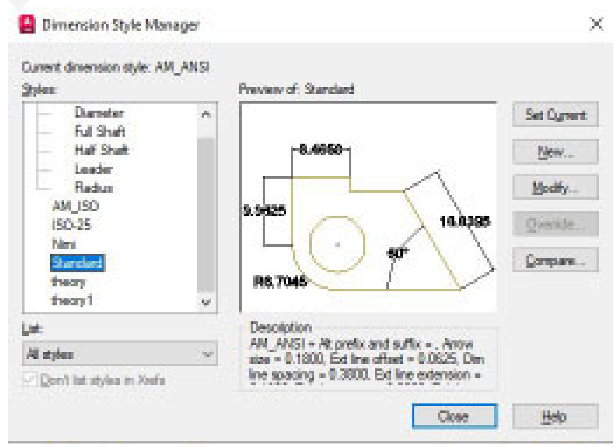
Adjusting dimension styles

Dim style - To open the dimension style manager dimension style manager is used to create modify, override, and compare the new styles and dimensions in AutoCAD. The standard dimension style is considered as the default dimension style Fig 7 to Fig 15

Modify option includes

- Lines selection
- Symbols and arrow selection
- Text selection
- Fit selection
- Primary units selection
- Alternate units selection

Fig 7



After saving you can click on modify button to edit your dimension style. (Fig 7&8)

Line tab in dialog box is activated now. You can Change the dimension line and extension line features in this tab. (Fig 9)

In the symbol arrow tab you can change arrow head size, shape and some other features. (Fig 10)

With Text tab you can redefine the properties of dimension text ie; size, color, alignment, font etc.(Fig 11)

Fig 8

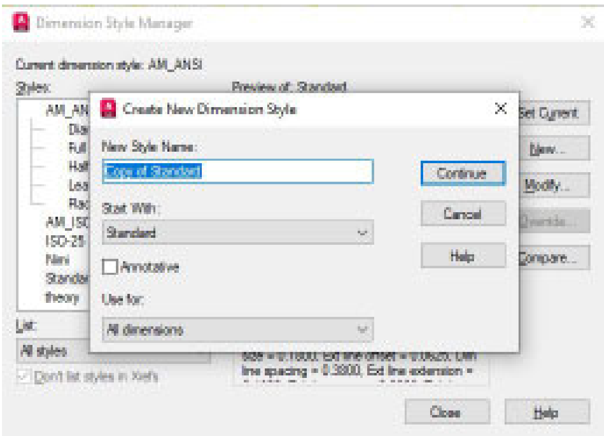


Fig 9

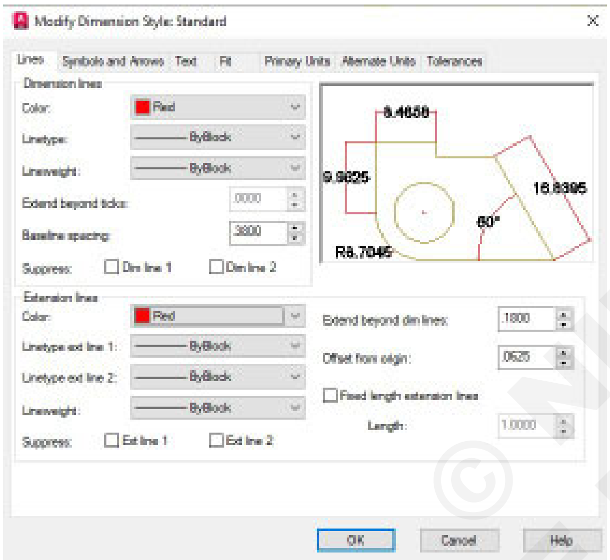


Fig 10

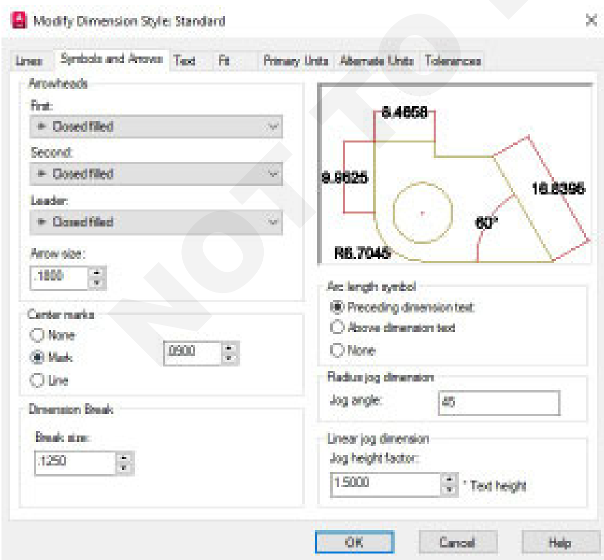
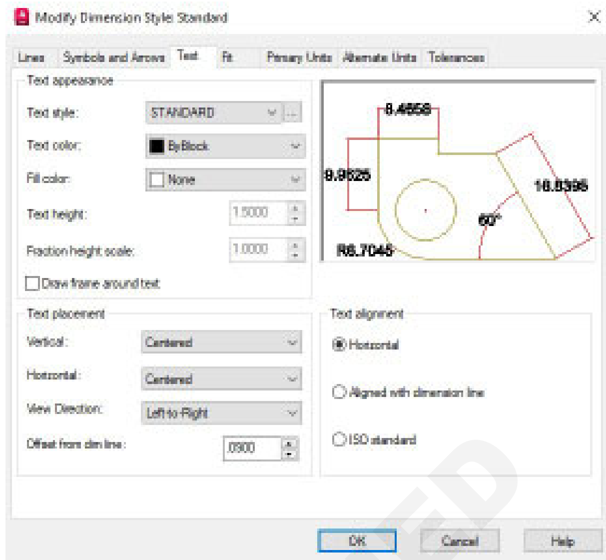
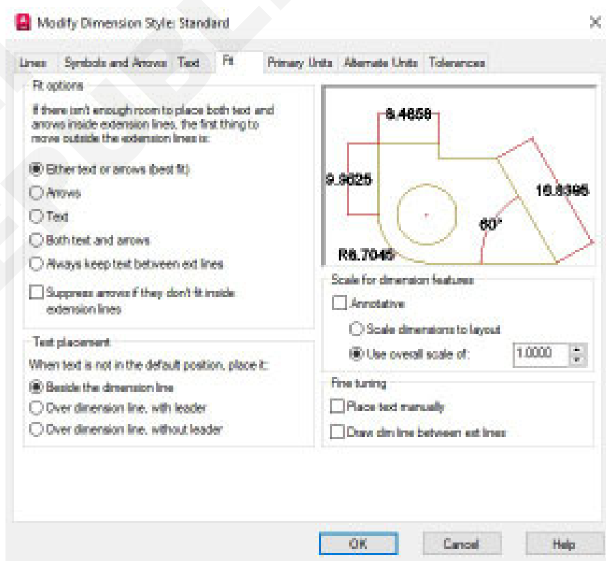


Fig 11



With fit Tab we can select the best fit for the dimension text in the dimension object. (Fig 12)

Fig 12



AutoCAD allows primary and alternate unit for a drawing. In this tab we can adjust primary unit features such as precision round off, Decimal separator symbol, angular measurement unit and its precision. (Figs 13,14 & 15).

Editing Dimension (Dim edit)

Dim edit command allows to replace the dimension text with new text, rotate existing text, move the text to a new location, and if necessary restore the text back to its home position.

Fig 13

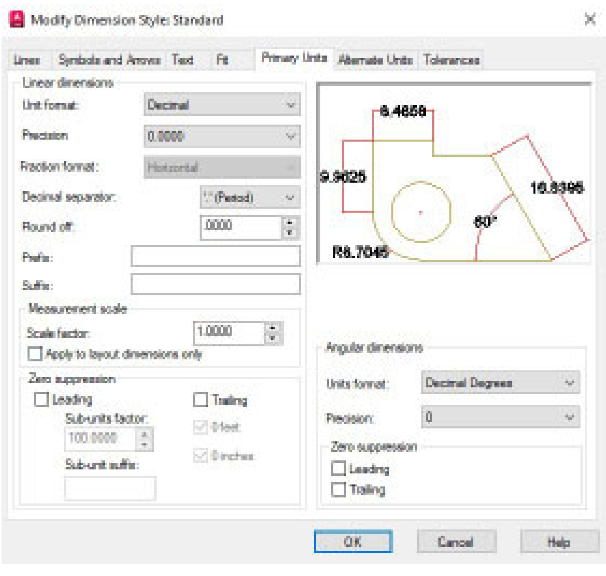


Fig 14

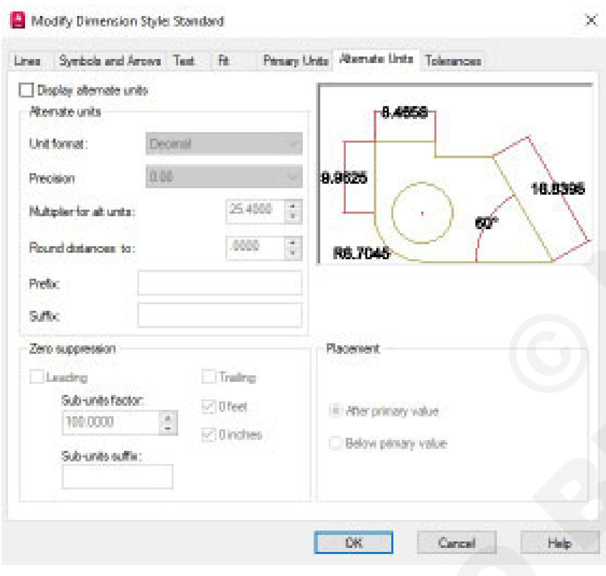
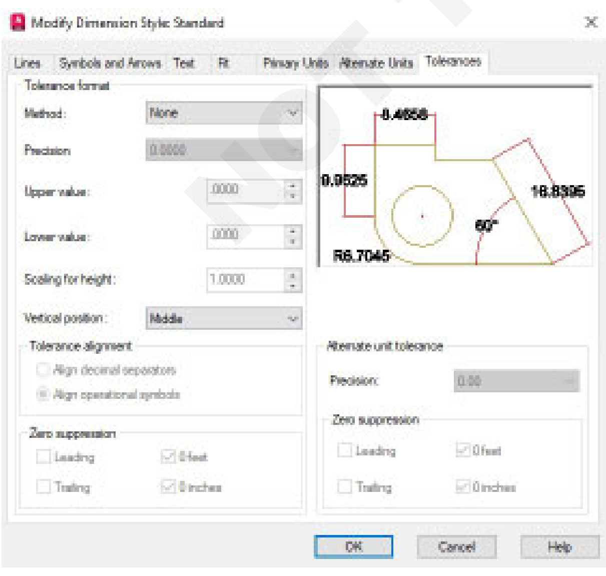


Fig 15



In addition we can also change the angle of the extension lines relative to the direction of the dimension style.

Available options include.

- **Home** selection returns the dimension text to its default position.
- **New** selection change the original dimension text to the new text.
- **Rotate** selection change the angle of the dimension text.
- **Oblique** selection adjusts the oblique angle of the extension lines for linear dimensions.

Location for dimension text

DIMEDIT command is also used to change the location of dimension text (with the left/right/Home options) along the dimension line and its angle (with the rotate option)

Available option include:

- **Left** selection cause the text to be drawn towards the left of extension line.
- **Right** selection cause the test to be drawn towards the right of extension line.
- **Home** selection returns the dimensions text to its default position.
- **Angle** selection changes the angle of the dimension text.

Text and Text edit commands

Text

There are two kinds of text used in AutoCAD

1 D Text or single line text

- Makes every line a separate object
- It is great for short annotation in a drawing

2 M Text or Multiline text

- Has more formatting options
- Better for larger amount of text
- If we move the text multiple lines stay grouped together

Text Edit

Edits a selected multiline or single line text object or the text in a dimension object

Displays in place text editor, and accepts your changes to the selected multiline text, single line text or dimension text.

Knowledge of short cut key board commands

Objectives: At the end of this lesson you shall be able to
• **describe the features of key board commands in detail.**

Toggle general features

Ctrl + d	Toggle coordinate display
Ctrl + g	Toggle grid
Ctrl + e	Cycle isometric planes
Ctrl + f	Toggle running object snaps
Ctrl +h	Toggle pick style
Ctrl + Shift + h	Toggle hide pallets
Ctrl + I	Toggle cords
Ctrl + Shift + I	Toggle infer Constraints

Toggle drawing modes

F1	Display Help
F2	Toggle text screen
F3	Toggle object snap mode
F4	Toggle 3DO snap
F5	Toggle Iso plane
F6	Toggle Dynamic UCS
F7	Toggle grid mode
F8	Toggle ortho mode
F9	Toggle snap mode
F10	Toggle polar mode
F11	Toggle object snap tracking
F12	Toggle dynamic input mode

Manage screen

Ctrl + o(zero)	Clean screen
Ctrl + 1	Property palette
Ctrl + 2	Design center palette
Ctrl + 3	Tool palette
Ctrl + 4	Sheet set palette
Ctrl + 6	DB connect manager
Ctrl + 7	Markup set manager palette
Ctrl + 8	Quick calc
Ctrl + 9	Command line

Manage workflow

Ctrl + c	Copy object
Ctrl + x	Cut object
Ctrl + v	Paste object
Ctrl + Shift + C	Copy to clipboard with base point
Ctrl + Shift + V	Paste data as block
Ctrl + Z	Undo last action
Ctrl + Y	Redo last action
Ctrl + [	Cancel current Command (or+ Ctrl +\)
ESC	Cancel current command

Manage Drawings

Ctrl + n	New drawing
Ctrl + s	Save drawing
Ctrl +o	Open drawing
Ctrl + p	Plot dialog box
Ctrl + Tab	Switch to next
Ctrl+shift+Tab	Switch to previous drawing
Ctrl +page up	_Switch to next Tab in current drawing
Ctrl + Q	Exit
Ctrl + a	Select all objects

AutoCAD commands shortcuts

This form of shortcut commands are easy to refer.

Quick Link

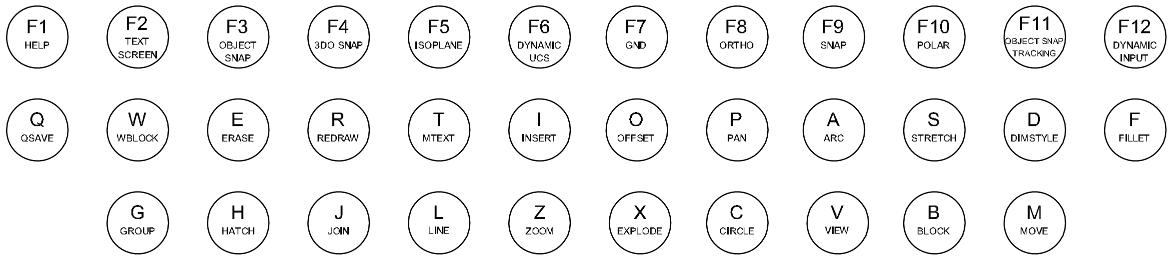
Blocks-common commands-control keys-coordinate entry

Dimensioning-drawing objects-external reference-formatting

function keys-inquiry-layers-modifying objects-object selection

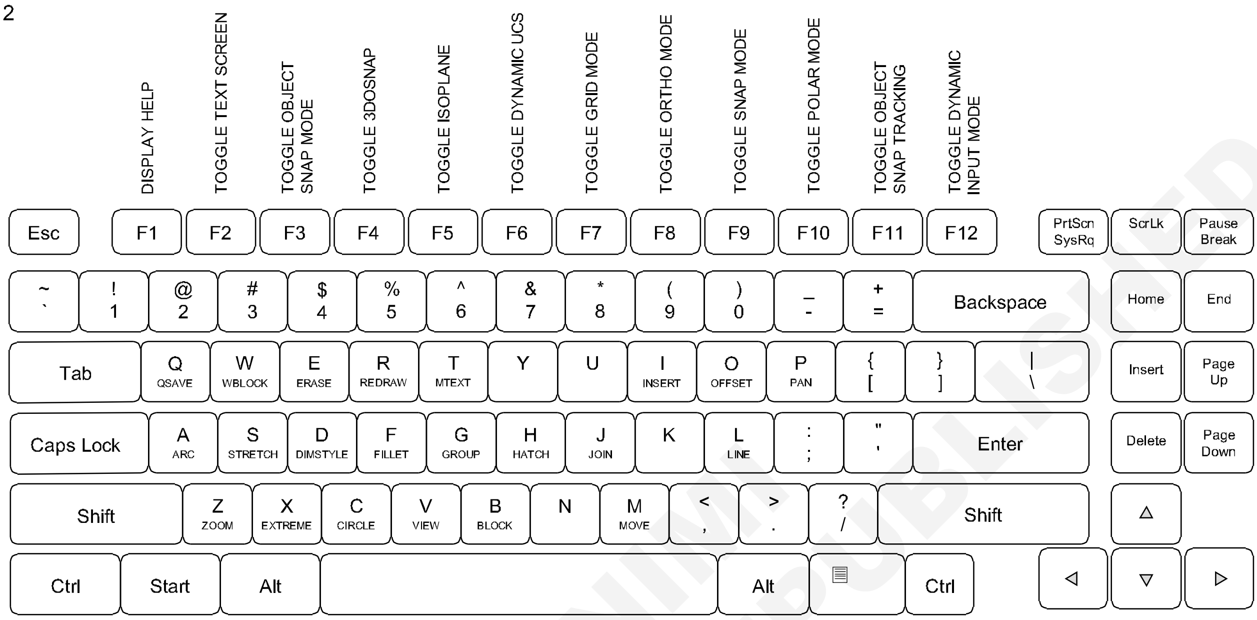
object snap-text-3d-ucs-viewports

Fig 1



DM20N219911

Fig 2



Q QSAVE / SAVES THE CURRENT DRAWING

A ARC / CREATES AN ARC

Z ZOOM / INCREASES OR DECREASES THE MAGNIFICATION OF THE VIEW THE CURRENT VIEWPORT

W WBLOCK / WRITES OBJECTS OR A BLOCK TO A NEW DRAWING FILE

S STRETCH / STRETCHES OBJECTS CROSSED BY A SELECTION WINDOW OR POLYGON

X EXPLODE / BREAKS A COMPOUND OBJECT INTO ITS COMPONENT OBJECTS

E ERASE / REMOVES OBJECTS FROM A DRAWING

D DIMSTYLE / CREATES AND MODIFIES DIMENSION STYLES

C CIRCLE / CREATES A CIRCLE

R REDRAW / REFRESHES THE DISPLAY IN THE CURRENT VIEWPORT

F FILLET / ROUNDS AND FILLETS THE EDGES OF OBJECTS

V VIEW / SAVES AND RESTORE NAMED VIEWS, CAMERA VIEWS, LAYOUT VIEWS, AND PRESET VIEWS.

T MTEXT / CREATES A MULTILINE TEXT OBJECTS

G GROUP / CREATES AND MANAGES SAVED SETS OF OBJECTS CALLED GROUPS

B BLOCK / CREATES A BLOCK DEFINITION FROM SELECTED OBJECTS

H HATCH / FILLS AN ENCLOSED AREA SELECTED OBJECTS WITH A HATCH PATTERN, SOILD FILL OR GRADIENT FILL

J JOIN / JOINS SIMILAR OBJECTS TO FORM A SINGLE, UNBROKEN OBJECT

M MOVE / MOVES OBJECTS A SPECIFIED DISTANCE IN A SPECIFIED DIRECTION

I INSERT / INSERTS A BLOCK DRAWING INTO THE CURRENT DRAWING

O OFFSET / CREATES CONCENTRIC CIRCLES, PARALLEL LINES AND PARALLEL CURVES

L LINE / CREATES STRAIGHT LINE SEGMENTS

P PAN / ADDS A PARAMETER WITH GRIPS TO A DYNAMIC BLOCK DEFINITION

DM20N219912

BLOCKS

SHORTCUT	COMMAND	COMMENT
ATT	ATTDEF	Opens attribute definition dialogue box
ATTEDIT	ATTEDIT	Edit attribute values for a specific block
B	BLOCK	Opens block dialogue box in order to makea block
BATTMAN	BATTMAN	Opens block attribute manager
BATTORDER	BATTORDER	Displays attribute order dialogue box
BC	BCLOSE	Closes the block editor
BCOUNT	BCOUNT	Counts the blocks in a drawing
BE	BEDIT	Opens the edit block definition dialogue box
EATTEXT	EATTEXT	Enhanced attribute extraction wizard to count blocks
GATTE	GATTE	Global attribute edit of multiple blocks
I	INSERT	Opens insert dialogue to insert a block
-I	INSERT	Insert a block by name
MINSERT	MINSERT	Insert block in rectangular array
REFEDIT	REFEDIT	Edit a block reference in place
REN	RENAME	Opens rename dialogue box to rename blocks, layers, etc
W	WBLOCK	Write a block - for use in other drawings
XLIST	XLIST	Lists type/block name/layer name/color/linetype of a nested object in a block or an xref

TIPS

1 Create a new block on layer 0 so that the block will use the layer and properties of the current layer it is inserted on. Text can be set to colour white.

2 Set ATTDIA to 1 to use dialog box with block attributes or 0 to use command line.

3 AutoCAD 2006 allows you to change the insertion point on the fly. INSERT and select BASEPOINT. This allows you to pick anywhere in the drawing (and anywhere in the block you are inserting) as your new insertion point (basepoint).

COMMON COMMANDS

SHORTCUT	COMMAND	COMMENT
A	ARC	Draw an arc
AL	ALIGN	Align an object with another
AP	APPLOAD	Opens application load dialogue box
AR	ARRAY	Opens array dialogue box
AUDIT	AUDIT	Audit drawing for errors
AV	DSVIEWER	Opens ariel view of drawing
B	BLOCK	Opens block dialogue box
C	CIRCLE	Draw a circle
CO	COPY	Copy an object
CHA	CHAMFER	Chamfer between 2 non-parallel lines
COL	COLOR	Opens select color dialogue box
CUI		Opens customise user interface dialogue
D	DIMSTYLE	Opens dimstyle manager
DC	ADCENTER	Opens designcenter

SHORTCUT	COMMAND	COMMENT
DI	DIST	Check a distance
DIV	DIVIDE	Inserts point node a set division
DO	DONUT	Draw a solid donut shape
DV	DVIEW	Perspective view
E	ERASE	Erase a selection
EX	EXTEND	Extend a selection
F	FILLET	Draw an arc between 2 intersecting lines
FI	FILTER	Opens filter dialogue box
FLATTEN	FLATTEN	Converts 3D to 2D
G	GROUP	Launches the group dialogue box
H	HATCH	Opens hatch and gradient dialogue box
I	INSERT	Insert a block
IM	IMAGE	Launches image manager
J	JOIN	Joins 2 objects to form single object
JPGOUT	JPGOUT	Creates a JPEG file of current drawing
L	LINE	Draw a line
LA	LAYER	Opens layer manager
LE	QLEADER	Draw a leader line (may need to adjust settings)
LEAD	LEADER	Leader line with annotation
LI or LS	LIST	Display information about objects in a text window
LO	-LAYOUT	Creates a new layout tab
LTS	LTScale	Change the linetype scale
M	MOVE	Move a selection
MA	MATCHPROPERTIES	Match properties of an object
ME	MEASURE	Inserts point node at input distance
O	OFFSET	Offset a selection
OP	OPTIONS	Launches options dialogue box
P	PAN	Pan in drawing
PE	POLYEDIT	Edit a polyline
PL	PLINE	Draw a polyline
PLOT	PLOT	Opens plot/print dialogue box
PO	POINT	Point marker or node - DDPTYPE to change point style
PR	PROPERTIES	Opens properties dialogue box
PRE	PREVIEW	Preview a plot
PU	PURG	Opens purge dialogue box to remove unused elements
RE	REGEN	Regenerate the display
REC	RECTANG	Draw a rectangle
REN	RENAME	Opens rename dialogue box to rename blocks, layers, etc
RO	ROTATE	Rotate a selection
SP	SPELL	Spell check a selection - ALL to check entire drawing

SHORTCUT	COMMAND	COMMENT
T	MTEXT	Insert multiline text
TB	TABLE	Opens insert a table dialogue box
TP	TOOLPALETTES	Displays tool palette
TR	TRIM	Trim a selection
U	UNDO	Undo last command
UN	UNITS	Opens units dialogue box
V	VIEW	Opens view dialogue box
W	WBLOCK	Write a block
WHOHAS	WHOHAS	Displays who has a drawing open
X	EXPLODE	Explode a selection
XR	XREF	Opens x-reference manager
Z	ZOOM	Zoom in display - A=All, E=EXTENTS, W=WINDOW

CONTROL KEYS

CTRL+0	CLEANSCREEN	Turns user interface elements on/off
CTRL+1	PROPERTIES	Turns properties on/off
CTRL+2	ADCENTER	Turns design center on/off
CTRL+3	TOOLPALETTES	Turns tool palettes window on/off
CTRL+8	QUICKCALC	Launches calculator window
CTRL+A		Select all
CTRL+C	COPYCLIP	Copies objects to clipboard
CTRL+H		Turns a group on or off
CTRL+J		Repeats last command
CTRL+N	NEW	Opens create new drawing dialogue box
CTRL+O	OPEN	Opens the select file dialogue box
CTRL+P	PLOT	Opens the plot dialogue box
CTRL+R	CVPORT	Switches between viewports
CTRL+S	QSAVE	Opens the save drawing as dialogue box
CTRL+SHIFT+S		Save as
CTRL+V	PASTECLIP	Pastes data from clipboard to drawing
CTRL+X	CUTCLIP	Removes select object from drawing to clipboard
CTRL+Y	REDO	Performs the operation cancelled by UNDO
CTRL+Z	UNDO	Undoes the last operation
CTRL+TAB		Switches between open drawings
CTRL+PAGE UP		Switch up between layout tabs
CTRL+PAGE DOWN		Switch down between layout tabs
ARROW UP/Down		Recall last command

COORDINATE ENTRY

#X,Y	Location measured by distance from 0,0 in current UCS
@X,Y	Location measured by distance from last point
#distance<angle	Location measured by distance and angle from 0,0 in current UCS
@distance<angle	Location measured by distance and angle from last point
.x or.y or .xy etc	Location by extracting and combining coordinate values from 2 or 3 points
distance	Location direct from current position in direction of movement
<angle	An angle override from current point

DIMENSIONING

SHORTCUT	COMMAND	COMMENT
CTRL+8	QUICKCALC	Displays the calculator
D	DIMSTYLE	Opens dimension style manager dialogue box
DAL	DIMALIGNED	Aligned linear dimension line
DAN	DIMANGULAR	Angular dimension line
DAR	DIMARC	Arc length dimension
DBA	DIMBASELINE	Ordinate dimension from baseline of previous dimension
DCO	DIMCONTINUE	Ordinate dimension from 2nd extension line of previous dimension
DDI	DIMDIAMETER	Diameter dimension for circles and arcs
DED	DIMEDIT	Edit dimension text on dimension objects
DI	DIST	Check a distance
DIMCENTER	DIMCENTER	Creates center mark
DLI	DIMLINEAR	Linear dimension
DOR	DIMORDINATE	Ordinate point dimension
DOV	DIMOVERRIDE	Override dimension style
DRA	DIMRADIUS	Radial dimension for circles and arcs
ID	ID	Display the co-ordinate values of a point
UN	UNITS	Opens drawing units dialogue box

DRAWING OBJECTS

SHORTCUT	COMMAND	COMMENT
A	ARC	Draw an arc with 3 points
B	BLOCK	Opens block dialogue box in order to make a block
BO	BOUNDARY	Draw a boundary
C	CIRCLE	Draw a circle
DO	DONUT	Draw a solid donut shape
DT	TEXT	Single line text
DIV	DIVIDE	Inserts point node a set division
EL	ELLIPSE	Draw an ellipse
F	FILLET	Draw an arc between 2 intersecting lines
G	GROUP	Opens object grouping dialogue
H	HATCH	Opens hatch and gradient dialogue box
L	LINE	Draw a line

SHORTCUT	COMMAND	COMMENT
LE	QLEADER	Draw a leader line (may need to adjust settings)
LEAD	LEADER	Leader line with annotation
ML	MLINE	Draw multilines
O	OFFSET	Offset an object by distance
PL	PLINE	Draw a polyline - a complex line
PO	POINT	Point marker or node - DDPTYPE to change pointstyle
POL	POLYGON	Draw a regular polygon 3 to 1024 sides
RAY	RAY	Construction line in one direction
REC	RECTANG	Draw a rectangle
REG	REGION	Region - for shading for example
REVCLOUD	REVCLOUD	Revision cloud - note can select a polyline
SPL	SPLINE	Spline or smooth curve along points
T	MTEXT	Multi-line text
WIPEOUT	WIPEOUT	Masks part of drawing for clarity
XL	XLINE	Construction line of infinite length

TIP

1 Use PO to create node point - if you do not see anything try changing the node properties DDPTYPE.

2 Alternatively set PDMODE to 3 to display an X at id point set PDMODE to 0 to clear.

External reference - XREF

SHORTCUT	COMMAND	COMMENT
REFEDIT	REFEDIT	Edit an external reference in place
XA	XATTACH	Opens select reference file dialogue for attaching Xref
XB	XBIND	Opens Xbind dialogue - allows import only of symbols etc
XC	XCLIP	Create a border in an xref to hide outside area
XOPEN	XOPEN	Opens a selected xref in a new window
XR	XREF	Opens Xref manager dialogue box

TIP

1 Using RELATIVE PATH to find the Xref file relative to the existing location can be a benefit if files are moved between locations or sent to others.

2 OVERLAID should be used in place of ATTACH if 2 drawings share a common Xref, eg a mechanical drawing could be overlaid an electrical drawing to prevent the building outline 'appearing' twice.

NOTES

1 If a drawing has an Xref, the status bar will show the Manage Xref icon.

FORMATTING

SHORTCUT	COMMAND	COMMENT
AP	APPLOAD	Opens application load dialogue box
BE	BEDIT	Opens the edit block definition dialogue box
BH	BHATCH	Opens hatch and gradient dialogue box
CUI		Opens customise user interface dialogue
D	DIMSTYLE	Opens dimension style manager dialogue box
DC	ADCENTER	Opens design center

SHORTCUT	COMMAND	COMMENT
DDPTYPE	DDPTYPE	Opens point style dialogue box
LA	LAYER	Opens layer manager
LT	DDLTYPE	Opens line type manager
LTS	LTSCALE	Change the line type scale
LW	LWEIGHT	Opens line weight settings dialogue box
MA	MATCHPROPERTIES	Match properties of an object
OP	OPTIONS	Launches options dialogue box
OS	DDOSNAP	Opens drafting settings object snap dialogue
PR	DDCHPROP	Opens properties dialogue box
SSM	SHEETSET	Opens sheet set manager palette
ST	DDSTYLE	Opens text style dialogue box
TP	TOOLPALETTES	Displays tool palette
TS	TABLESTYLE	Opens table style dialogue box

FUNCTION KEYS

SHORTCUT	COMMAND	COMMENT
F1	HELP	Opens Autocad help
F2	TEXTSCR GRAPHSCR	Switches between text screen and graphic area
F3	OSNAP	Switches osnap on/off
F5 or CTRL+E	ISOPLANE	Cycles through isoplanes
F6 or CTRL+D	COORDS	Turns coordinate display on/off
F7 or CTRL+G	GRID	Turns grid on/off
F8 or CTRL+L	ORTHO	Turns ortho on/off
F9 or CTRL+B	SNAP	Turns snap on/off
F10 or CTRL+U	POLAR	Turns polar on/off
F11 or CTRL+W	OSNAP TRACK	Turns object snap tracking on/off
F12	DYNMODE	Turns dynamic input on/off

INQUIRY

SHORTCUT	COMMAND	COMMENT
AA	AREA	Calculate the area
DI	DIST	Calculate a distance and angle
DDPTYPE	DDPTYPE	Opens point style dialogue box
ID	ID	Display the co-ordinate values of a point
LI or LS	LIST	Display information about objects in a text window
MASSPROP	MASSPROP	Calculate the region/mass properties of a solid
PR	PROPERTIES	Opens properties dialogue box
WHOHAS	WHOHAS	Displays who has a drawing open
XLIST	XLIST	Lists type/block name/layer name/color/linetype of a nested object in a block or an xref

TIP

1 **If you wish to identify a known location use ID and enter co-ordinates on command line to mark that location with a node point - if you do not see anything try changing the node properties DDPTYPE.**

2 **Alternatively set PDMODE to 3 to display an X at id point set PDMODE to 0 to clear.**

LAYERS

SHORTCUT	COMMAND	COMMENT
LA	LAYER	Opens layer manager
LAYCUR	LAYERCURRENT	Change objects to current layer
LAYDEL	LAYERDELETE	Delete a layer by selecting object
LAYFRZ	LAYERFREEZE	Freeze a layer by selecting object
LAYISO	LAYERISOLATE	Isolates a layer by selecting object
LAYLCK	LAYERLOCK	Lock a layer by selecting object
LAYMCH	LAYERMATCH	Match properties of a layer
LAYMRG	LAYERMERGE	Moves objects from first layer to second and de lets first
LAYOFF	LAYEROFF	Switches a layer off
LAYON	LAYERON	Switches all layers on except frozen layers
LAYERP	LAYERPREVIOUS	Restores previous layer state
LAYTHW	LAYTHW	Thaws all layers
LAYWALK	LAYERWALK	Walk through layers
LMAN	LMAN	Access Layer manager to save and restore layer states

TIP

Layer States - Create a layer state in Layer Manager (LA then Alt+S) to quickly switch between different layer property settings.

MODIFYING OBJECTS

SHORTCUT	COMMAND	COMMENT
AL	ALIGN	Align an object with another
AR	ARRAY	Make multiple copies of an object
BR	BREAK	Break a line by defining 2 points
CO or CP	COPY	Copy object
COPYTOLAYER	COPYTOLAYER	Copy object from one layer to another
CHA	CHAMFER	Chamfer between 2 non-parallel lines
E	ERASE	Erase selection
EX	EXTEND	Extend a line to meet another
F	FILLET	Draw an arc between 2 intersecting lines
G	GROUP	Opens object grouping dialogue - use to copy or move
LEN	LENGTHEN	Lengthen or shorten a line
M	MOVE	Move an object
MI	MIRROR	Mirror an object
MOCORO	MOVE/COPY/ROTATE	Copy move and rotate an object with one command
O	OFFSET	Offset an object by distance
RO	ROTATE	Rotate an object

SHORTCUT	COMMAND	COMMENT
S	STRETCH	Stretch an object
SC	SCALE	Scale an object
TR	TRIM	Trim objects
X	EXPLODE	Explode single entity to component parts

TIP

1. **When a grip point is selected cycle through command options using keyboard spacebar -sequence STRETCH, MOVE, ROTATE, SCALE, MIRROR.**
2. **Switch between Group and Ungroup using CTRL+H, yes H!!**

OBJECT SELECTION (use with editing commands)

SHORTCUT	COMMAND	COMMENT
A	ADD	Adds each successive object, switches from remove
ALL	ALL	All objects on thawed layers
CP	CPOLYGON	Objects touching or enclosed by selection polygon
C	CROSSING	Objects touched or enclosed by window - Move right to left
F	FENCE	Objects touch by single selection fence
G	GROUP	Opens object grouping dialogue - use with copy/move/etc
L	LAST	Most recently created visible object
P	PREVIOUS	Most recent selection set
R	REMOVE	Objects to remove from selection set
SNAPANG	SNAPANGLE	Change the snap angle from default 0°
W	WINDOW	Objects enclosed by window - Move left to right
WP	WPOLYGON	Objects within a window polygon

TIP

1. **Use SHIFT+LEFT MOUSE BUTTON to deselect an object.**
2. **When a grip point is selected cycle through command options using keyboard spacebar - sequence STRETCH, MOVE, ROTATE, SCALE, MIRROR.**
3. **Object Cycling - hold down the Control key while picking, AutoCAD will cycle through all the objects that fall under the pickbox as you continue to pick. When the correct object is highlighted, simply hit Enter. You don't need to continue to hold down the Control key after the first pick.**

OBJECT SNAP - OSNAP

SHORTCUT	COMMAND	COMMENT
F3	OSNAP	Switches snap on/off
F9 or CTRL+B	SNAP	Turns snap on/off
F11 or CTRL+W	OSNAP TRACK	Turns object snap tracking on/off
APP	APPARENT INT	Apparent intersection of 2 objects
CEN	CENof	Snap to centre point
DS	DDOSNAP	Opens drafting settings/object snap dialogue
END	ENDPOINT	Snap to end of line etc
EXT	EXTENSION	Extends lines beyond endpoint
FRO	FROM	Snap to an offset distance from an object snap
INS	INSERTION	Snap to insertion point of text or block

SHORTCUT	COMMAND	COMMENT
INT	INTERSECTION	Snap to intersection of lines, circles, arcs
MID	MIDPOINT	Snap to midpoint of line etc
MTP		Snap midpoint between two points
NEA	NEAREST	Snap near to an object
NOD	NODE	Snap to point node
NON	NONE	Turns off object snap modes
PAR	PARALLEL	Continues a line parallel to existing
PER	PERPENDICULAR	Snap to perpendicular of line etc
QUA	QUADRANT	Snap to quadrant of circle, arc, ellipse
TAN	TANGENT	Snap to tangent of circle, arc, ellipse
TK	TRACK	Locate points without drawing lines
TT	TT	Temporary tracking point

TIP

1 Use TAB to cycle through Osnap points.

2 SHIFT+RIGHT MOUSE BUTTON to reveal Osnap options

TEXT

SHORTCUT	COMMAND	COMMENT
%%C	Ø	Diameter dimensioning symbol
%%D	°	Degrees symbol
%%O	OVERSCORE	Toggles overscore mode on/off
%%P	±	Plus/minus symbol
%%U	UNDERSCORE	Toggles underscore on/off
DT	DTEXT	Single line dynamic text - Justify/Align to fit within text line
ED	DDEDIT	Edit text
FIND	FIND	Opens find and replace dialogue box
JUSTIFYTEXT	JUSTIFYTEXT	Change the justification point without moving text
MIRRTEXT	MIRRTEXT	Mirrtext 0 to turn off
SCALETEXT	SCALETEXT	Scales text without moving the text insertion point
SPELL	SPELLCHECK	Performs spellcheck - ALL checks all text in drawing
ST	STYLE	Opens text style dialogue box
T or MT	MTEXT	Multiline/paragraph text
TCIRCLE	TCIRCLE	Places circle, slot, or rectangle around each selected text object
TEXT	DTEXT	Single line dynamic text
TEXTFIT	TEXTFIT	Stretches/shrinks text by selecting new start and/or end points
TORIENT	TORIENT	Rotates text, mtext, and attribute definition objects
TXT2MTXT	TXT2MTXT	Converts DTEXT to MTEXT
WIPEOUT	WIPEOUT	Masks part of drawing for clarity

TIPS

1 To fit or align text in a defined area use DTEXT and select JUSTIFY/ALIGN or FIT - very useful if text is enclosed by a rectangle/ circle/etc.

NOTES

1 Text entered in paper space is 1:1, e.g. 5mm high text will print 5mm high.

THREE DIMENSIONAL - 3D

SHORTCUT	COMMAND	COMMENT
3D	3D	Command line 3D solid options
BOX	BOX	Draw a cube
CYLINDER	CYLINDER	Draw a cylinder
DDUCS	DDUCS	Opens ucs dialogue
DDUCSP	DDUCSP	Opens ucs dialogue at orthographic tab
EXT	EXTRUDE	Extrude a face
IN	INTERSECT	Intersect an object
REV	REVOLVE	Revolves an object about an axis
RR	RENDER	Open render dialogue box
SE	SECTION	Section
SL	SLICE	Slice a solid
SU	SUBTRACT	Subtract selection from solid
TOR	TORUS	Draw torus shape
UC	DDUCS	Displays UCS manager dialogue box
UCS	UCS	UCS command line options
UNI	UNION	Union solids
VPORTS	VPORTS	Opens viewport dialogue box
WE	WEDGE	Draw a wedge

UCS

SHORTCUT	COMMAND	COMMENT
OB	OBJECT	Align UCS with an object, first select UCS
UC	DDUCS	Display UCS manager dialogue box
UCS	UCS	Universal co-ordinate system options
UCSICON	UCSICON	Change the UCS icon appearance
W	WORLD	Return to the WCS

VIEWPORTS

SHORTCUT	COMMAND	COMMENT
CTRL+R		Cycle through viewports
CTRL+PAGE UP		Switch up between layout tabs
CTRL+PAGE DOWN		Switch down between layout tabs
DV	DVIEW	Perspective view.
MS	MSPACE	Switch to modelspace in a viewport
MV	MVIEW	Make a viewport in paperspace
PS	PSPACE	Switch to paperspace from viewport

SHORTCUT	COMMAND	COMMENT
VPORTS	VPORTS	Opens viewports dialogue box
-VPORTS	-VPORTS	Create a viewport using command line
TIP		
1 To prevent a viewport from editing right mouse click on the viewport and select DISPLAY LOCKED/YES		

TEXT AND TEXT EDIT COMMANDS

Text

There are two kinds of text used in AutoCAD

1 D Text or single line text

- Makes every line a separate object
- It is great for short annotation in a drawing

2 M text or multiline text

- Has more formatting options
- Better for larger amounts of text
- if we move the text multiple lines stay grouped together.

Text Edit:

Edits a selected multiline or single line text object or the text in a dimension object.

Displays in-place text editor, and accepts your changes to the selected multiline text, single line text or dimension object.

Drafting settings

Objectives: At the end of this lesson you shall be able to
- **know the options in drafting settings**
- **know the object snap**
- **change the orthographic snap to isometric snap.**

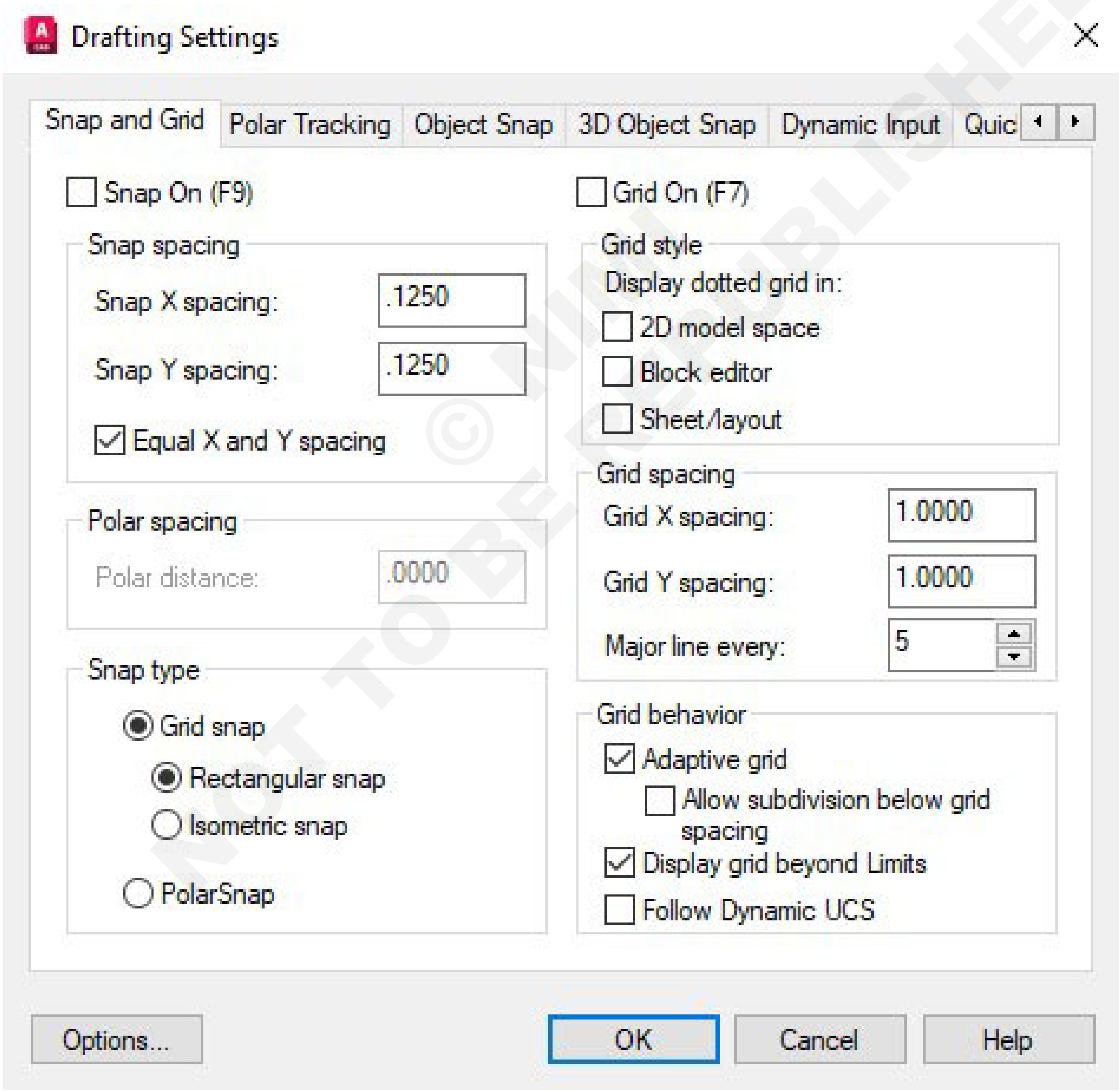
Drafting settings (D settings or DS) (Fig 1)

Sets grid and snap, polar tracking, object snap modes. Dynamic input and quick properties.

Snap and Grid

This tab controls the snap and grid settings

Fig 1

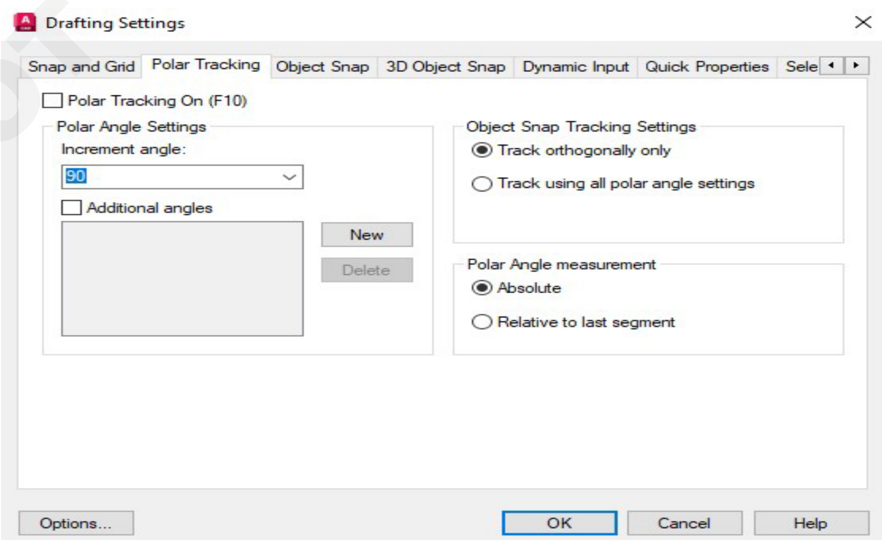


Icon/Button	Description
☐ Snap On (F9)	Turns Snap mode on or off. You can also turn Snap mode on or off by clicking Snap on the status bar,by pressing F9
☐ Grid On (F7)	Turn the grid on or off. You can also turn grid mode on or off by clicking Grid on the status bar,by pressing F7
Snap X spacing: 1.0000 Snap Y spacing: 1.0000	Specifies the snap spacing in the X and Y direction. The value must be a positive real number.
☑ Equal X and Y spacing	Forces the X and Y spacing to the same values for snap spacing and for grid spacing. The snap spacing intervals can b different from the grid spacing intervals.
Polar spacing Polar distance: .0000	Sets the snap increment distance when PolarSnap is selected under Snap Type & Style. If this value is 0, the PolarSnap distance assumes the value for snap X Spacing. The Polar Distance setting is used in conjunction with polar tracking and /or object snap tracking / If neither tracking feature is enabled, the Polar Distance setting has no effect.
◉ Grid snap	Sets the snap type to Grid. When you specify points, the cursor snaps along vertical or horizontal grid points.
◉ Rectangular snap	Sets the snap style to standard Rectangular snap mode. When the snap type is set to Grid snap and snap mode is on, the cursor snaps to a rectangular snap grid.
○ Isometric snap	Sets the snap style to isometric snap mode. when the snap type is set to grip snap and snap mode is on, the cursor snaps to an isometric snap grid.
○ PolarSnap	Sets the snap type to Polar. When snap mode is on and you specify points with polar tracking turned on , the cursor snaps along polar alignment angles set on the Polar Tracking tab relative to the starting polar tracking point.
Grid spacing Grid X spacing: 1.0000 Grid Y spacing: 1.0000	Specifies the grid spacing in the X and Y direction .If this value is 0, the grid assumes the value set for snap X spacing and Snap Y spacing respectively.
Major line every: 5	Specifies the frequency of major grid lines compared to minor grid lines.
☑ Adaptive grid	Limits the density of the grid when zoomed out.
☐ Allow subdivision below grid spacing	Generates additional , more closely spaced grid lines when zoomed in .The frequency of these grid lines is determined by the frequency of the major grid lines.
☐ Display grid beyond Limits	Displays the grid beyond the area specified by the LIMITS command.
☐ Follow Dynamic UCS	Changes the grid plane to follow the XY plane of the dynamic UCS.

Polar Tracking (Fig 2)

This tab controls the Auto Track Settings

Fig 2

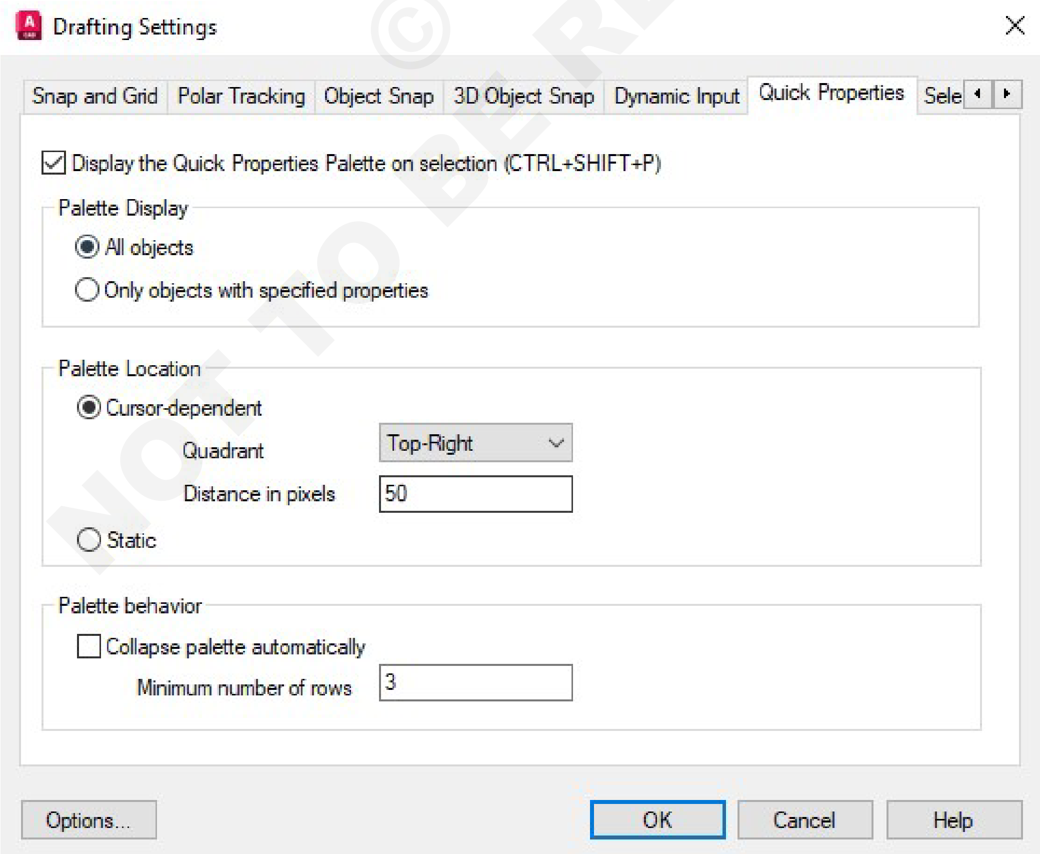


Icon/Button	Description
☑ Polar Tracking On (F10)	Turn polar tracking on and off. You can also turn polar tracking on or off by pressing F10.
Increment angle: 90	Sets the polar increment angle used to display polar tracking alignment paths. You can enter any angle ,or select a common angle of 90,45,30,22.5,18,15,10, or 5 degrees from the list.
☐ Additional angles	Makes any additional angles in the list available for polar tracking.
New	Adds up to 10 additional angles in the list available for polar tracking
Delete	Deletes selected additional angles. Set options for object snap tracking.
Object Snap Tracking Settings ◉ Track orthogonally only ○ Track using all polar angle settings	**Track orthogonally only-** AutoCAD Displays only orthogonal (horizontal /vertical) object snap tracking paths for acquired object snap points when object snap tracking is on. **Track using all polar settings-** Applies polar tracking settings to object snap tracking. when you use object snap tracking, the cursor tracks along polar alignment angles from acquired object snap points. Sets the basis by which polar tracking alignment angles are measured.
Polar Angle measurement ◉ Absolute ○ Relative to last segment	**Absolute** - Bases polar tracking angles on the current user coordinate system (UCS) **Relative to last segment** - Bases polar tracking angles on the last segment drawn.

Quick Properties (Fig 3&4)

This tab specifies the settings for displaying the Quick Properties palette.

Fig 3



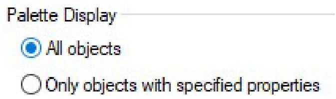
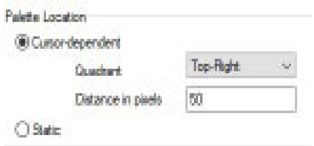
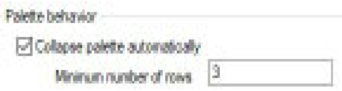
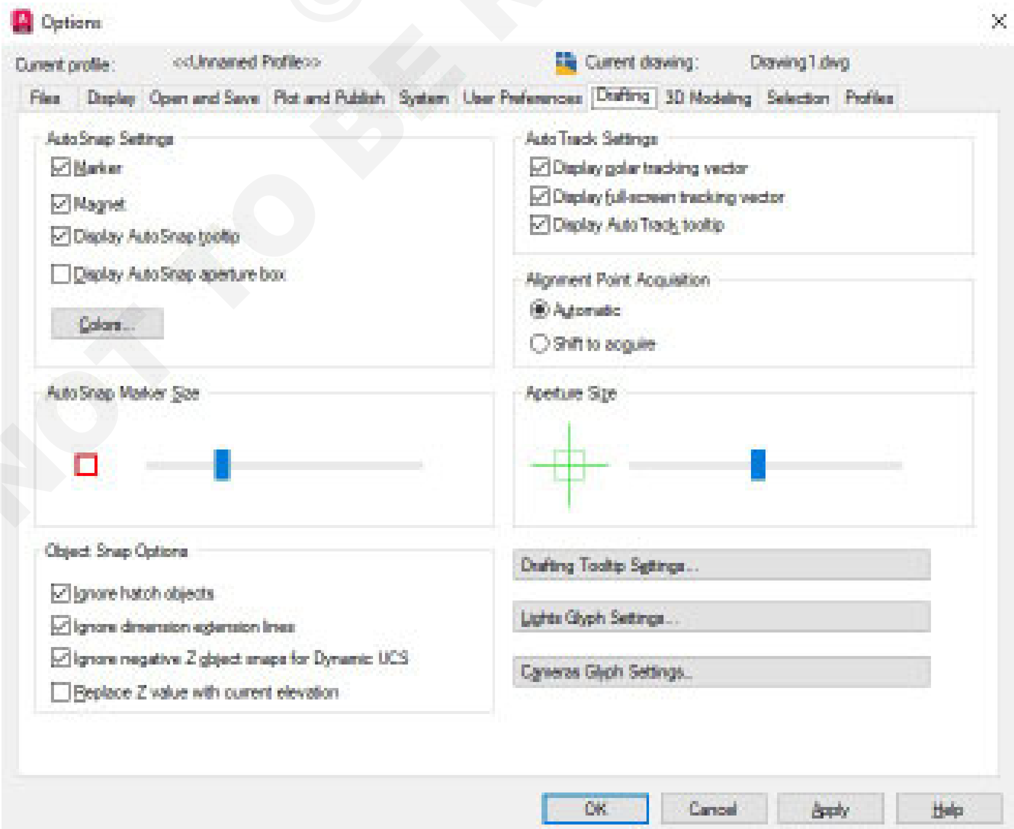
Icon/Button	Description
	Depending on the object type, you can enable or disable Quick Properties palette. Quick Properties palette can also be turned on or off by clicking Quick Properties on the Status bar
	Sets the display settings of the Quick Properties on the status bar. Sets the display settings of the Quick Properties palette. **All Objects -** Sets the Quick Properties palette to display for any selection of objects. **Only Objects with Specified Properties -** Sets the Quick Properties palette to display only for objects that are defined in the Customize User Interface (CUI) editor to display properties
	Sets the display position of the Quick Properties palette. **Cursor- Dependent -** Sets the Platte Location mode to Cursor-dependent. In cursor -dependent mode, the Quick Properties palette displays in a location relative to where you selected the object. Quadrant: Specifies the relative location to display the Quick Properties palette. You can select one of the four quadrants top-right,top-left,bottom-left. Distance in Pixels: Sets the distance in pixels when Cursor is selected under the Palette Location modes.You can specify values in the range of 0 to 400 (only integer values) **Static -** Sets the location mode to Static.
	Sets the behavior of Quick Properties palette. **Collapse Palette Automatically -** Enables the Quick Properties palette to display only a specified number of properties in the idle state. Minimum Number of Rows: Sets the minimum number of rows for the Quick Properties palette to display in the collapsed idle state.You specify values in the range of 1 to 30 (only integer values)

Fig 4



Tools Options

The following options are displayed.

Current Profile -Displays the name of the current profile above the tabs. To set the current profile, create a new profile, or edit an existing profile, use the profiles tab.

Drawing Icon - signifies that an option is saved with the drawing. An option saved with the drawing affects only the current drawing. An option saved in the registry and not displayed with a drawing file icon affects all drawings in a work session. Options that are saved in the registry are saved in the current profile.

Current Drawing - Displays the name of the current above the tabs.

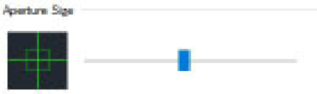
The Options dialog box includes the following tabs:

Files, Display, Open and Save, Plot and Publish, System, User Preferences, Drafting

3D Modeling, Selection, Profiles

In this chapter drafting tab alone will be discussed in detail. It sets options for several editing features, including AutoSnap and Auto Track.

Icon/Button	Description
☑ Marker	Controls the display of the AutoSnap marker. The marker ie a geometric symbol that is displayed when the crosshairs move over a snap point.
☑ Magnet	Turns the Autosnap magnet on or off. The magnet is an automatic movement of the crosshairs that locks the crosshairs onto the nearest snap point.
☑ Display AutoSnap tooltip	Controls the display of the Autosnap tooltip. The tooltip is a label that describes which part of the object you are snapping to.
☐ Display AutoSnap aperture box	Controls the display of the Autosnap aperture box. The aperture box that appears inside the crosshairs when you snap to an object.
Colors...	Sets the display colors of the interface elements for each context in the application. A context is an operating environment such as model space. An interface elements is an item that is visible in that context such as the crosshairs pointer or the background color.
AutoSnap Marker Size	Sets the display size for the Autosnap marker.
☑ Ignore hatch objects	Specifies that object snaps ignore hatch patterns when object snapping is turned on.
☐ Replace Z value with current elevation	Specifies that object snaps ignore the Z- value of the object snap location and use the Z- value of the elevation set for the current UCS.
☑ Ignore negative Z object snaps for Dynamic UCS	Specifies that object snaps ignore geometry with negative z values during use of a dynamic UCS.
☑ Display polar tracking vector	Displays a vector along specified angles when polar tracking is on. With polar tracking, you can draw lines along angles. Polar angles are 90-degree divisors, such as 40,30, and 15 degrees. In a 3D view,a polar tracking vector parallel to the Z axis of the UCS is also displayed, and the tooltip displays +Z or -Z for the angle depending on the direction along the Z axis You can disable Display Polar Tracking Vector by setting TRACKPATH to 2.
☑ Display full-screen tracking vector	Controls the display of tracking vectors. Tracking vectors are construction lines from which you can draw objects at specific angles or in specific relationships to other objects.If this option is selected, alignment vectors are displayed as infinite lines. You can disable Display Full -screen Tracking Vector by setting TRACKPATH to 1.
☑ Display AutoTrack tooltip	Controls the display of the Auto Track and Ortho tooltips.Tooltips are labels that display the tracking coordinates.
Alignment Point Acquisition ◉ Automatic ○ Shift to acquire	Controls the method of displaying alignment vectors in a drawing.

	Automatic - Displays tracking vectors automatically when the aperture moves over an object snap. Shift to Acquire - Displays tracking vectors when you press shift and move the aperture over and object snap.
	Sets the display size for the Autosnap aperture.
Drafting Tooltip Settings...	Controls the color, size, and transparency of drafting tooltips.
Lights Glyph Settings...	Specifies the appearance of the light glyphs.
Cameras Glyph Settings...	Specifies the appearance of the camera glyphs.

Changing Orthographic Snap to Isometric snap

Isometric drawings (Fig 5)

In Auto CAD Isometric drawings are not actual 3D drawings, they are made with 2D geometries but they appear like 3D.Isometric drawing in Auto CAD can be made by fitting viewing angle to 30 for all of its sides in the 2D plane.

At first we need to change snap settings to isometric

Type DS (Drafting settings) on the command line and press enter.

Drafting settings window will pop up from this window

Select snap and grid tab and make sure isometric snap is on.

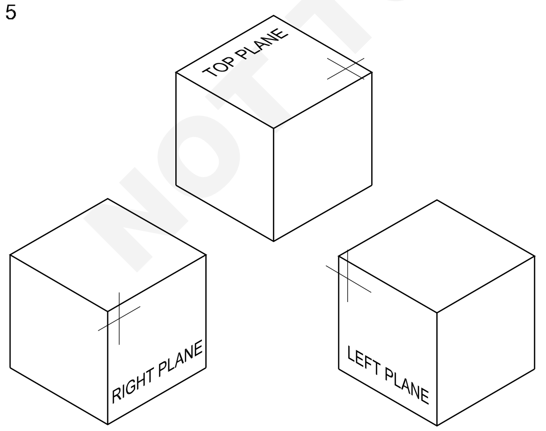
Click OK to exit drafting settings window.

Now make sure Ortho mode is turned on from the status bar.Press F8 to turn it on.

Select Isoplane command top,right and left or by pressing the F5 key.

In later versions of Auto CAD the process of creating an isometric drawing has been simplified by using ISODRAFT option of the status bar.

Fig 5



DM20N2110015

Isometric Circles (Fig 6)

It represents circles on isometric planes using ellipse.

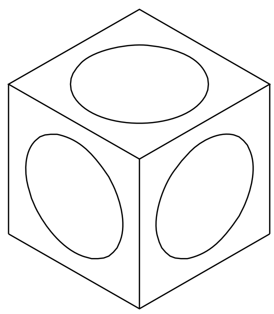
The easiest way to draw an ellipse with the correct shape is to use the Isocircle option of ELLIPSE

The Isocircle option is available only when the style option of snap mode is set to Isometric.

Isometric grid and snap mode orient the grid and snap to isometric angles.

To represent concentric circles, draw another ellipse with the same center rather than off setting the original ellipse.

Fig 6



DM20N2110016

Procedure to create viewport in layout space, zooming scale

Objectives: At the end of this lesson you shall be able to
- **define view port**
- **state the two types of AutoCAD viewports**
- **state the difference between model space viewport and layout viewport**
- **create or modify view ports.**

View port

- View port was simply a partition of the display graphics area.
- It eliminates the need to pan or zoom into particular sections everytime you want to assess the minute details, thereby saving time.
- Autocad viewport makes it easy to spot error you would have otherwise missed.

There are two types of AutoCAD viewports

1 Model space viewport

2 Layout viewport

Model space

When we click 'New Drawing' the software opens a drawing area containing gridlines, which is located in the model tab. This drawing area is limitless in that it covers somewhat of an infinite area and can be zoomed in or out endlessly. In short it is the drawing area that is known as model space.

The model space lets you to draw any 2D drawing or 3D model you desire.

1 Model space viewport

By default the model space has a single drawing area known as a model space viewport.

This viewport generally enables you to view your drawing. Depending on the complexity of the drawing we can split the drawing area into more than one drawing area.

Create a model space viewport in AutoCAD

- Using VPORTS command
- Using viewport controls button.

Procedure

1 On the command line type VPORTS and hit enter

2 Select the number and configuration of viewports you want to add on the viewports pop-up window (upto four viewports)

3 Click enter.

2 Layout viewports

The layout viewport is the paper space (in the layout tab). This allows you to scale the model space view based on the paper space. This paper space is limited based on the paper size you select in the page setup manager.

- The paper space allows you to include the title block and notes.
- Based on the available area you can include multiple layout viewports within the area.

Create a layout viewport

There are two approaches to create a layout viewport namely.

- Using VPORTS command.
- Using creation tools on the layout contextual tab.

Procedure to create a layout viewport using VPORTS command.

1 Click on the layout tab

2 On the command line, type VPORTS and hit enter. This open the viewports pop-up window which shows the paper space.

3 Select the number and configuration of viewports you desire and click ok.

4 Specify the extent of the paperspace AutoCAD lets you to do this by clicking the first corner and dragging the mouse to the opposite corner.

AutoCAD automatically separates the area based on the number of viewports selected

Procedure to create a layout viewport using the tools on the layout contextual tab.

1 Click on the layout tabs to move from the model space to paper space. Alternatively you can create a new layout by clicking the (+) button to the left of the status bar. This second approach enables you to choose the paper size as well as define the plot area, given that you can access the page setup manager.

2 Click the layout ribbon tab on the ribbon bar. This tab contains several ribbons, including layout, layout viewports, create view, Modify view, update and style and standards.

3 Select the rectangular, polygonal or object button on the layout viewports ribbon panel.

4 Define the size of the viewport by clicking the opposite corners of the rectangle. Once you have defined the size, AutoCAD will automatically create the viewport.

To change or assign a viewport.

1 Click on the viewport in the paper space to highlight it.

2 Head over to click the home ribbon

3 Select the viewport layer on the layers dropdown menu in the layers panel.

4 AutoCAD also allows to rotate the rectangular or polygonal view port.

Zooming to a specific scale

To increase or decrease the magnification of particular view by a precise scale factor measured relative to the overall size of the drawing or in relation to the current display. When we change the magnification factor, the portion of the drawing located at the centre of the current viewport remains centered on the screen.

To change the magnification of the view relative to the overall size of the drawing, type a number representing the magnification scale factor. For example, if we type a scale factor of 2, the drawing appears at twice its original size. It we types a magnification factor of 0.5 the drawing appears at half its original size.

To modify the scale of a layout viewport

Using the triangular scale grip

1 Select the layout viewport that we want to modify.

2 Click the triangular scale grip near the centre of the viewport and click the desired scale from the list.

The scale we choose is applied to the viewport.

Using the properties palette

1 Select the layout viewport that you want to modify.

2 Right-click and the choose properties.

3 If necessary click display locked and choose no.

4 In the properties palette, select standard scale and the select a new scale from the list.

The scale we choose is applied to the viewport.

Note: To use a custom scale, enter a scale in the custom scale field in the properties palette.

Belt drives

Objectives: At the end of this lesson you shall be able to
- **state different types of belts and belt drives**
- **state the materials used for belts**
- **explain velocity ratio, slip and creep & Arc of contact**
- **calculate pulley speed.**

Introduction:

The belts or ropes are used to transmit power from one shaft to another by means of pulleys which rotate at the same speed or at different speeds.

Types of belts:

Though there are many types of belts used these days. Yet the following are important from the subject point of view.

i Flat belt:

The flat belt is mostly used in the factories and workshops, where a moderate amount of power is to be transmitted, from and pulley to another when the two pulleys are not more than 10m apart.

ii V-belt:

The v-belt is mostly used in the factories and workshops, where a great amount of power is to be transmitted, from one pulley to another, when the two pulleys are very near to each other.

iii Circular Belt Or Rope :

The circular belt or rope is mostly used in the factories and workshops, where a great amount of power is to be transmitted, from one pulley to another, when the two pulleys are more than 5m apart.

If a huge amount of power is to be transmitted then a single belt may not be sufficient. In such a case wide pulleys (for v-belts or circular belts) with a number of grooves are used. Then a belt in each groove is provided to transmit the required amount of power from one pulley to another.

Belt drives:

The belt drive is the most common method of power transmission.

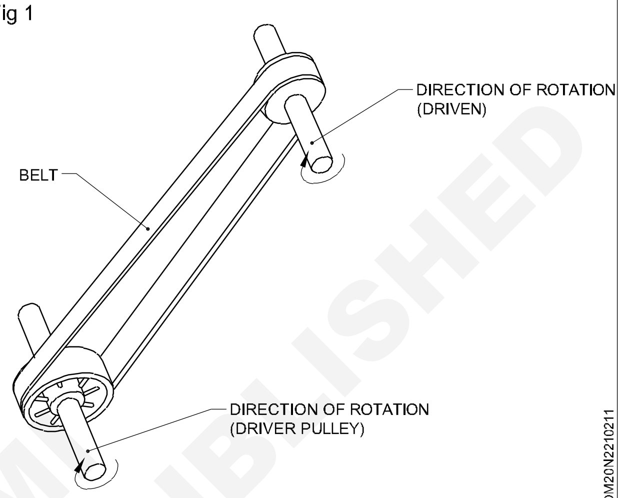
Types of belt drives (Flat belts)

The power from one pulley to another may be transmitted by any of the following types of belt drives.

Open belt drive (Fig 1)

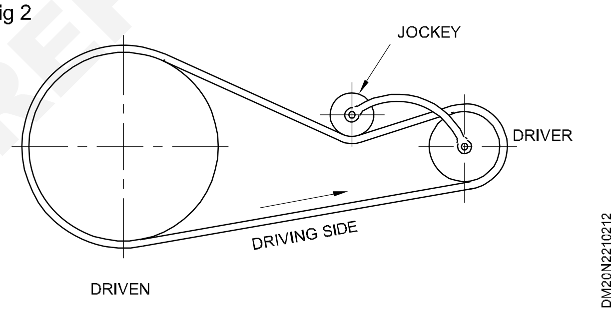
An open belt drive is used between parallel shafts in which the direction of rotation of driving and driven shafts is the **same.**

Fig 1



Jockey or idler pulley (Fig 2)

Fig 2



If the centre distance between the pulleys exceeds 3 times the larger pulley diameter and the ratio of the pulley diameters exceeds 6 to 1, a jockey or idler pulley is fitted near the driver pulley on the slack side of the belt to **increase the arc of contact.** This increases the **wrapping angle and tension on the belt**, necessary for the transmission of the torque.

Cross - belt drive (Fig 3)

A cross -belt drive is shown in Fig 3 in which the direction of rotation of driving and driven shafts is **opposite.**

Stepped drives (Fig 4)

Stepped drives are used to obtain different speed ratios. Pulleys of different sizes are employed.

Three different speeds can be obtained by changing the belt position from one step to another.

Right angled drive (Fig 5)

A right angle drive is a belt drive between pulleys whose axes are right angles.

Fig 3

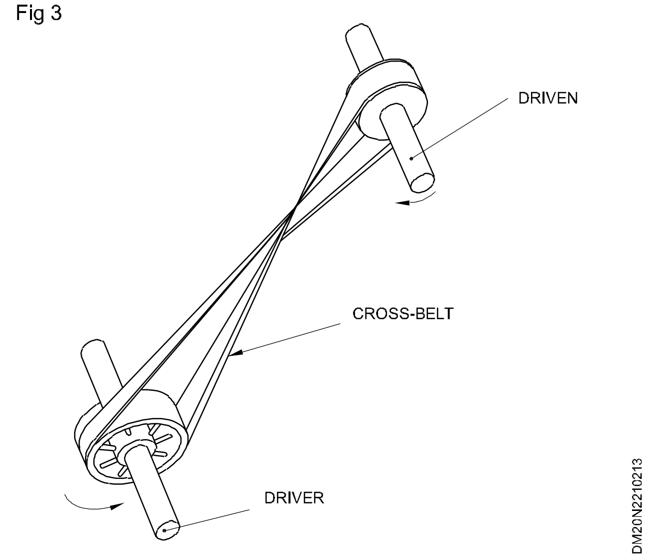


Fig 4

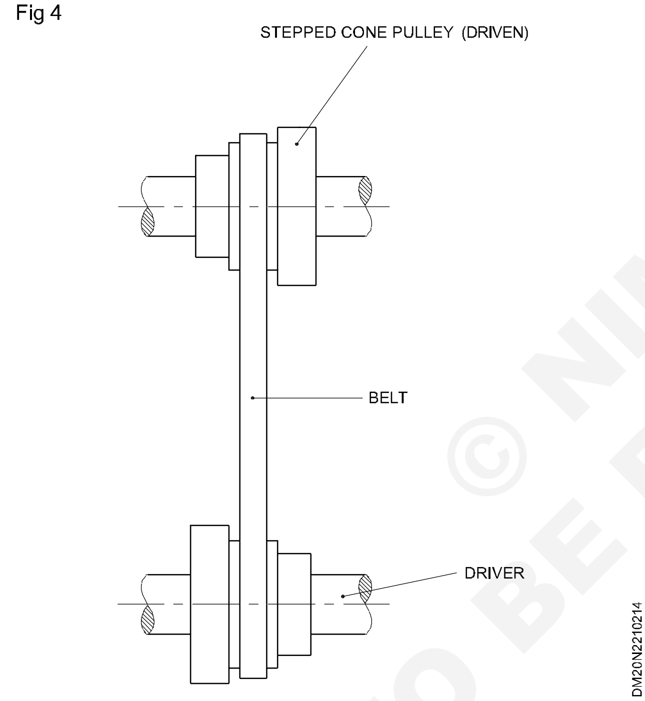
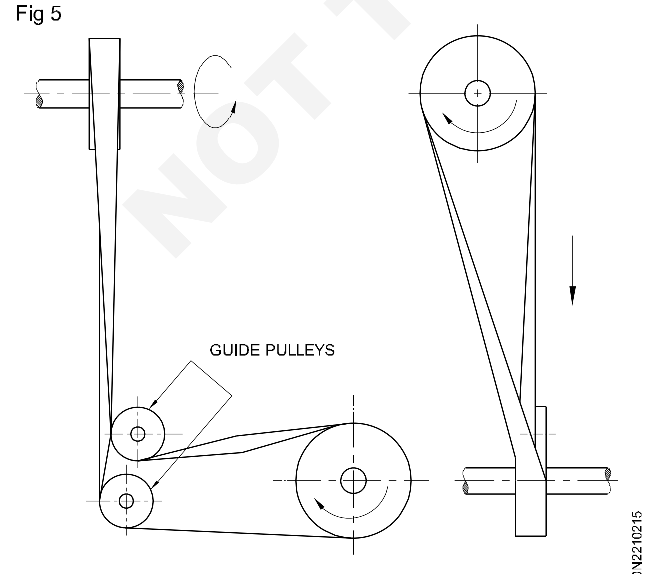


Fig 5



BELT DRIVE BETWEEN SHAFT AT RIGHT ANGLES USING GUIDE PULLEYS

Materials used for belts

The materials used for belts and ropes must be strong, flexible, and durable. It must have a high co-efficient of friction. The belts, according to the material used are classified as follows:

1 Leather belt

The most important material for flat belts is leather. The best leather belts are made from 1.2 metres to 1.5 metres long strips cut from either side of the back bone of top grade steer hides. These belts are specified according to the number of layers e.g. single, double or triple according to the thickness of hides used.

2 Cotton or fabric belts

Most of fabric belts are made by folding canvas or cotton duck to three or more layers (dependingupon the thickness desired) and stitching together. These belts are woven also into a strip of the desired width and thicknes. The cotton belts are cheaper and suitable in warm climates, and in damp atmospheres. Since the cotton belts require little attention, therefore these belts are mostly used in farm machinery, belts conveyors etc.

3 Rubber belts

The rubber belts are made of layers of fabric impregrated with rubber composition and have a thin layer of rubber on the faces. These belts are very flexible but are quickly destroyed if allowed come into contact with heat , oil or grease. These belts are found suitable for saw mills, paper mills where they are exposed to moisture.

4 Balata belts

These belts are similar to rubber belts except that balata gum is used in place of rubber. These belts are acid proof and water proof and it is not affected by animal oils or alkalies. The balata belts should not be at temperature above 40 c , because at this temperature the balata begins to soften and becomes sticky. The strength of balata belts is 25 percent higher than rubber belts.

Velocity ratio of a belts drive

It is the ratio between the velocities of the driver and the follower or driven. It may be expressed, mathematically, as discussed below.

d_1 = Diameter of the driver.

d_2 = Diameter of the follower.

N1 = Speed of the driver in r.p.m

N2= Speed of the follower in r. p.m

… Length of the belt, that passes over the driver in one minute = TTd,N,

Length of the belt that passes over the follower, in one minute = TTd2 N2.

Since the length of the belt that passes over the driver in one minute is equal to the length of belt that passes over the follower in one minute.

…TTd1N1 = TT d2 N2.

Or … $\frac{N2}{N1}=\frac{d1}{d2}$

Or velocity ratio … $\frac{N2}{N1}=\frac{d1}{d2}$

When the thickness of the belt is considered, then

velocity ratio,……….. $\frac{N2}{N1}=\frac{d1+t}{d2+t}$

t = Thickness of the belt.

Slip of the belt

The motion of belt and pulleys assuming a firm frictional grip between the belts and shafts. But sometimes, the frictional grip becomes insufficient.

This may cause some forward motion of the driver without carrying the belt with it. This may also cause some forward motion of the belt without carrying the driven pulley with it. This is called slip of the belt and is generally expressed as a percentage. The result of the belt slipping is to reduce the velocity ratio of the system.

Let. S_1% = Slip between the driver and the belt.

S_2%= Slip between the belt and the follower.

$$\frac{N2}{N1}=\frac{d1}{d2}\left(1-\frac{S1}{100}-\frac{S2}{100}\right)$$

$$=\frac{d1}{d2}\left(1-\left(\frac{S1+S2}{100}\right)\right)$$

$$\frac{N2}{N1}=\frac{d1}{d2}\left(1-\frac{S}{100}\right)$$

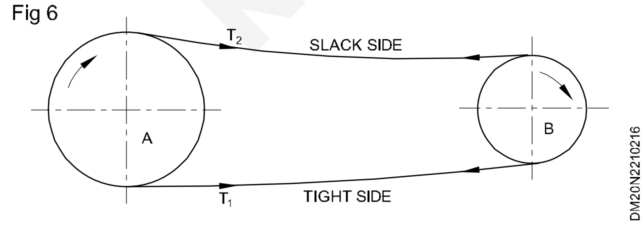
If thickness of the belt is considered. Then

$$\frac{N2}{N1}=\frac{d1+t}{d2+t}\left(1-\frac{S}{100}\right)$$

Where t is the thickness of the belt.

Power transmitted by a belt (Fig 6)

Fig 6



In fig-6 is shown the driving pulley (i.e. driver) A and follower B. the driving pulley pulls the belt from one side and delivers the same to the other. It is thus obvious that the tension on the tight side will be greater than the slack side.

Let, T1 = Tension in the tight side in kg .

T2 = Tension in the slack side in kg .

V= Velocity of the belt in meters/ sec.

The effective turning (driving) force at the circumference of the follower is the difference between the two tension. (i.e.T1- T2).

..Work done per second

=Force x distance=(T1-T2)XVkg.m.

$$\ldots\ Power=\frac{(T1-T2)\text{X}V}{75}HP$$

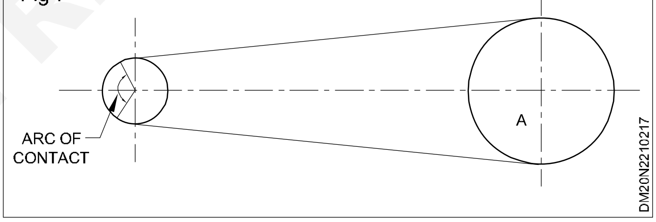
In s.I. units. The power transmitted will be in watts and the two tensions (i.e.T1 and T2) will be in newtons.

Creep of belt

Tensions on the two sides of the pulleys are not equal. On one side, the tension is greater than the other side. Due to the difference of two tensions, the belt continuously creeps (i.e.moves with a very negligible velocity) over the pulleys. This movement of the belts is very small, and is generally neglected

Arc of contact (Fig 7)

Fig 7



The angle subtended by the belt on the smaller pulley is known as angle of contact or arc of contact . For better performance the angle of contact should be between 90° to 170° To increase the angle of contact, idler pulleys can be used.

In systems that use pulleys with equal diameter, the arc of contact is 180° for each pulley, but equal sized pulleys are not always used.

Exercise :

1 An engine running at 150 r.p.m drives a line shaft by means of a belt. The engine pulley is 75 cm diameter and the pulley on the line shaft is 45cm. Find the speed of the pulley on the line shaft.

Given :

Speed of engine shaft (driver) N1 = 150r.p.m.

Diameter of engine pulley (driver) d1 = 75cm.

Diameter of pulley on the line shaft (driven)d2 = 45cm.

Required:

Speed of the pulley on the line shaft (driven)N2 = ?

Solution:

$$\frac{N2}{N1} = \frac{d1}{d2}$$

$$\frac{N2}{150} = \frac{75}{45}$$

$$N2 = \frac{75x150}{45}$$

= 250

Speed of the pulley on the line shaft (driver) N2= 250 r.p.m.

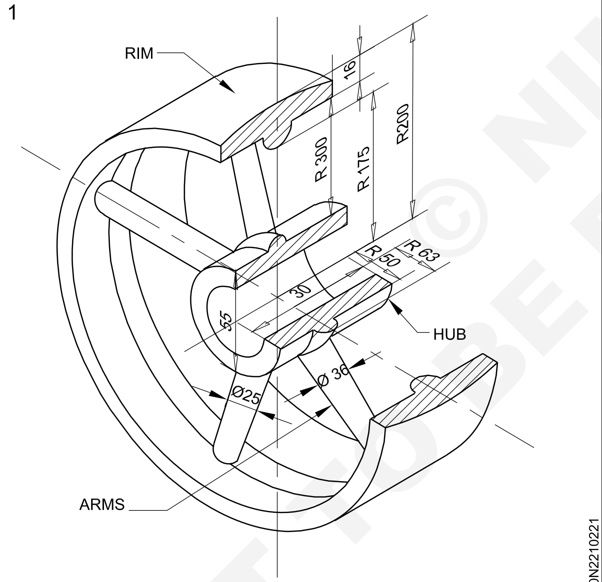
Pulleys

Objectives: At the end of this lesson you shall be able to
- **state the use of pulleys**
- **explain the types of pulleys.**

Pulleys are used for transmission of power from one shaft to another by means of belts and ropes. They are made of **cast - iron, wrought-iron, steel wood or plastics.**

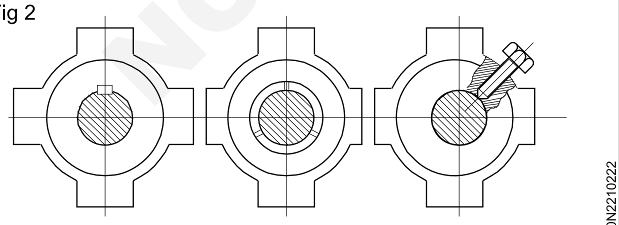
A pulley may be **cast** in one piece or may be **built - up** from separate parts (Fig 1). The three parts of a belt pulley are - **hub or boss, arms and rim.** Fig 2 shows in, three methods of mounting a pulley rigidly on a shaft, viz. by means of (i) a key, (ii) cone keys and (iii) a set -screw. (Fig 2)

Fig 1



BELT PULLEY

Fig 2



METHODS OF FIXING A PULLEY

Types of pulleys

- Solid C.I. pulleys
- Stepped pulleys
- Fast and loose pulleys
- Built up pulleys
- Rope pulleys
- 'V' belt pulleys

Solid cast iron pulleys

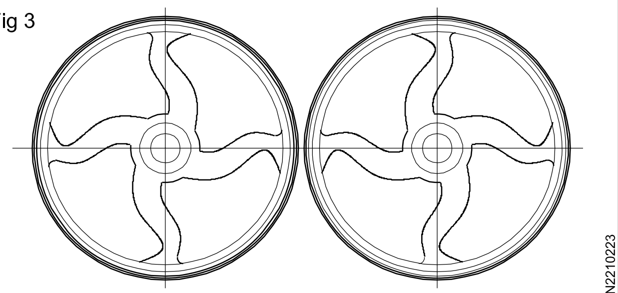
These are one piece castings. When the pulley is smaller in size (upto about 20cm dia), soild web is provided to connect the outer rim with the boss. For the larger pulleys arms of elliptical section, which may be straight (fig 1) or curved (fig 3) are provide to hold the boss and rim in position.

When the castings of the pulleys cool in the mould, contraction takes place. Due to unequal masses of different parts contraction at different places is unequal and this gives rise to different stresses in the arms. Curved arms have the advantages over the straight arms that these can yield under the stresses rather than breaking.

Crowning (Fig 3)

Rims of the pulleys are given slight convexity that prevents the slipping of the belt off the pulley. The convexity is called " crowning" of the pulley. As the belt has the tendency to rise to the highest point the crowning tends to keep the belt central on pulley rim and thus makes up for the irregularities in alignment.

Fig 3

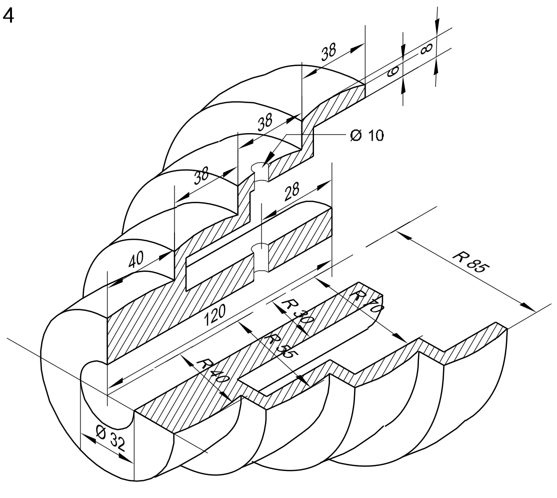


SOLID C.I PULLEYS

Speed cone or stepped pulleys

These are made of cast - iron and are secured to shafts by means of keys or set - screws (Fig 4) A machine - spindle can be driven at **different speeds**, by fixing stepped pulleys on the spindle and on the counter -shaft in reverse positions as shown in Fig 4. The speed of the machine - spindle will be (i) greater than, (ii) equal to and (iii) less than of the counter - shaft.

Fig 4



SPEED CONE PULLEY

Fast and loose pulleys:

The arrangement consists of two pulleys, one of which, called loose pulley is free to rotate about the shaft, while the other, called fast pulley is keyed to the shaft. The set of pulleys is mounted on the driving shaft and is used to stop or start the driven shaft when desired, without interfering with the running of driving shaft. To stop the shaft the belt is shifted to the loose pulley to keep a little less than that of the fast pulley. it is done to relieve the belt of its tension.

Fig 5

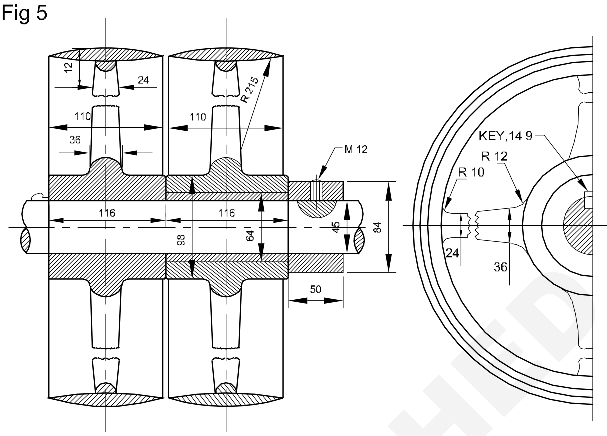


Fig 5 shows the sectional view of a set of fast and loose pulleys. The fast pulley is secured to the shaft by a gib-head sunk key. To allow the free running of the loose pulley, a gunmetal or brass bush is provided, which should be driving fit in the hub and running fit on the shaft. To check the axial movement of the loose pulley, a collar is secured to the shaft by a setscrew.

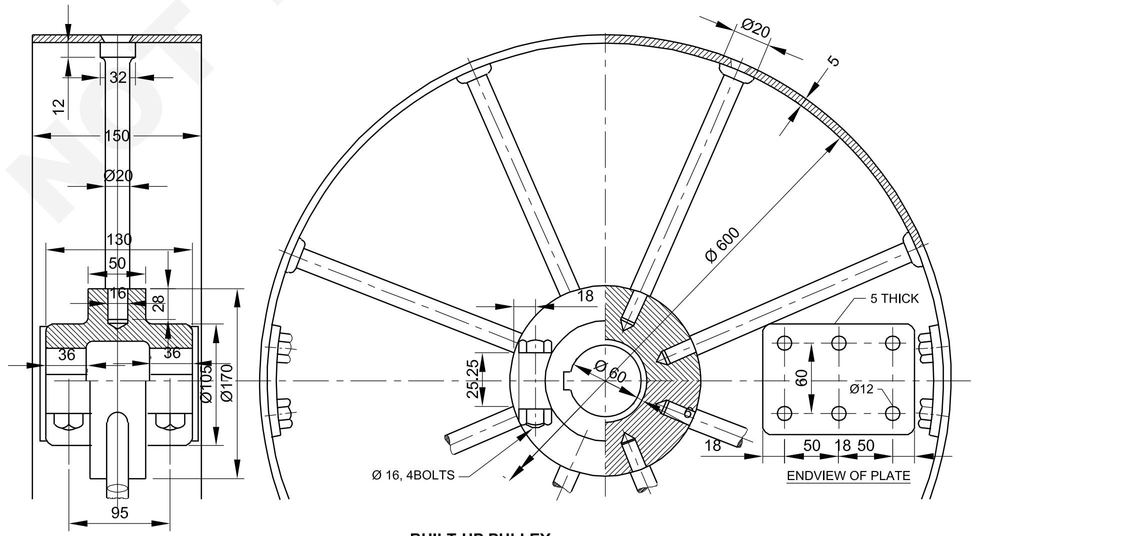
Built up pulleys

Objectives: At the end of this lesson you shall be able to
- **built up pulleys, rope pulleys 'V' belt pulley.**

Built - up pulleys

In this type of pulleys (Fig 1) the hub is made of cast-iron and in **two halves**. The rim, which is also made in two halves, and the arms are of wrought-iron or steel. The two halves of the hub are bolted together and fixed to the shaft by a sunk key. The arms are of circular cross - section, the inner ends of which are shrunk inside the holes in the outer surface of the hub. Their outer ends are riveted to the rim and are provide with collars pressing against the inner side of the rim. The two halves of the rim are fastened together by two butt - strap riveted to one half and bolted to the other, alternately. The rivet heads and the bolt heads are **counter sink** inside the rim.

Fig 1

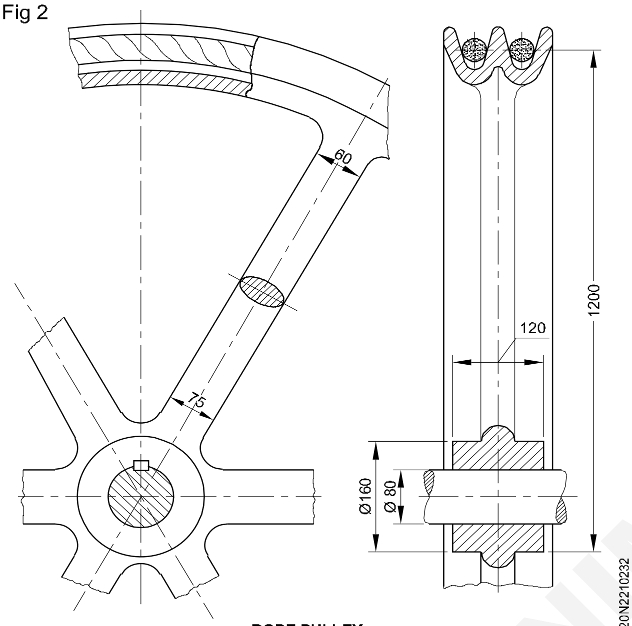


BUILT-UP PULLEY

Rope pulleys

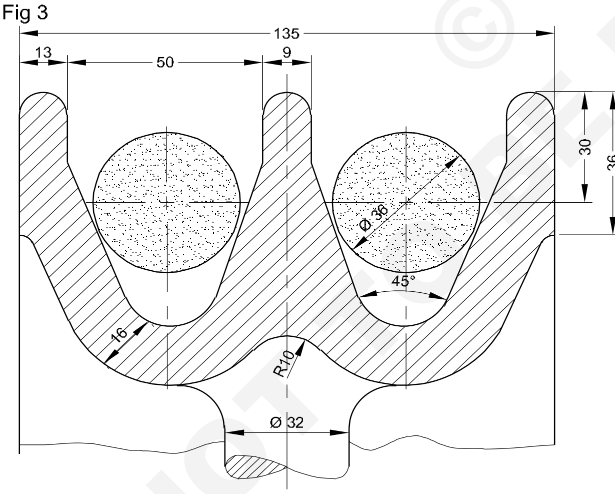
Rope pulleys are grooved to carry one or more ropes by means of which power is transmitted to shafts at different heights and it varying distances. Ropes made of cotton or hemp are usually of 25mm to 50mm in diameter. The diameter of the pulley is keep at least 30 times the diameter of the rope Fig 2. shows two views of a rope pulley to carry two ropes. The view in detail, of only the rim is shown fully dimensioned in Fig 3.

Fig 2



ROPE PULLEY

Fig 3



SECTION OF RIM

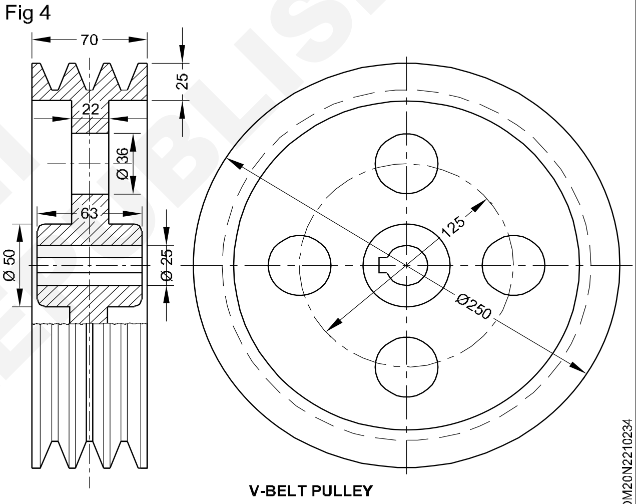
When ropes made of steel wire are used, the pulley is generally built - up and is not less than 2 meters in diameter. The hub and the rim are cast in two halves, while the arms are made of steel. unlike the cotton ropes, the steel rope rests on the bottom of the groove, which is packed with soft material such as leather or gutta-percha to minimize slipping. The method of transmitting power by means of ropes is very rarely used these days.

V - belt pulleys

These pulleys have one or more V-grooves to carry V-belts which are made of rubber and fiber and moulded as endless loops. This form of transmission is very widely used in **modern times.** Fig 4 shows two views of a V-belt pulley having three grooves. Details of a V-groove along with the belt - section are shown in Fig 5.

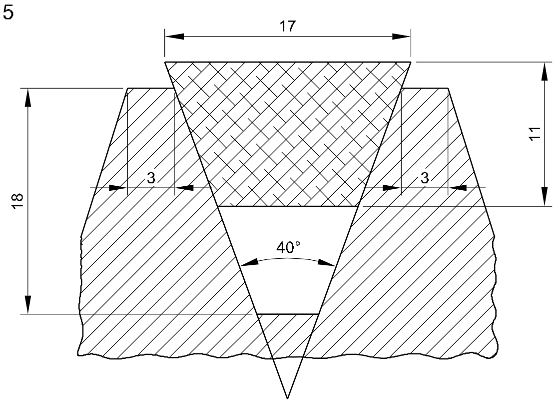
The calculations of a V-belt drive are confined to (i) the selection of a belt of standard profile and length, and (ii) number of belts are determined for the transmission of given power. The number of belts should not exceed 8 to12; if it exceeds then the next larger belt section should be used. Table 2 shows the useful data for V-belt drives.

Fig 4



V-BELT PULLEY

Fig 5



DETAILS OF V-GROOVE

Table 2

Width of belt (mm)		5	6	8	10	13	17	20	22	32	38
Height of belt (mm)		3	4	5	6	8	11	12.5	14	19	23
Length of belt (mm)	From	150	212	296	420	585	832	1100	1650	2303	3230
	To	1860	1262	1916	2820	4275	6332	9540	14050	18063	18080

V- belts

Advantages of V-belts drive

'V' - belt drives are generally used when the distance between the shafts is **too short for flat belt drives**. Owing to the wedge action between the belt and the sides of the groove in the pulley, the V belt is less **likely to slip**, hence **more power** can be transmitted.

The endless V belt is shaped roughly like a trapezium in cross - section, and is made of **cord and fabric**, and is treated with rubber and moulded together in a uniform manner and shape. The cross - sectional symbol of a V- belt is shown in Fig 6.

- It is compact, so installation is possible in limited space.
- It is used when the centre distance between the driver and the driven pulleys is short.
- Less vibration and noise.
- Cushions the motor and bearing against load fluctuation
- Easy replacement and maintenance.

Classification of 'V' belts

The 'V' belts are classified into 5 groups as per IS.2494-1974 namely A, B, C, D and E. The nominal included angle of the V- belt shall be **40°**.

Table 3 gives lists the standard sizes of V - belts from section A to E.

Table 3

Cross -section Symbol	Nominal top width W (mm)	Nominal Thickness (T)
A	13	8
B	17	11
C	22	14
D	32	19
E	38	23

Individual manufacturer's belts may deviate slightly from these dimensions for various constructional reasons. Crowning, if any, in belts should be disregarded for the measurement of thickness.

Designation of V-belt as per IS. 2494

The V belts conforming to this standard shall be designated by the cross - section symbol, nominal inside length and the number of IS : standard.

Example

C 3048 IS : 2494

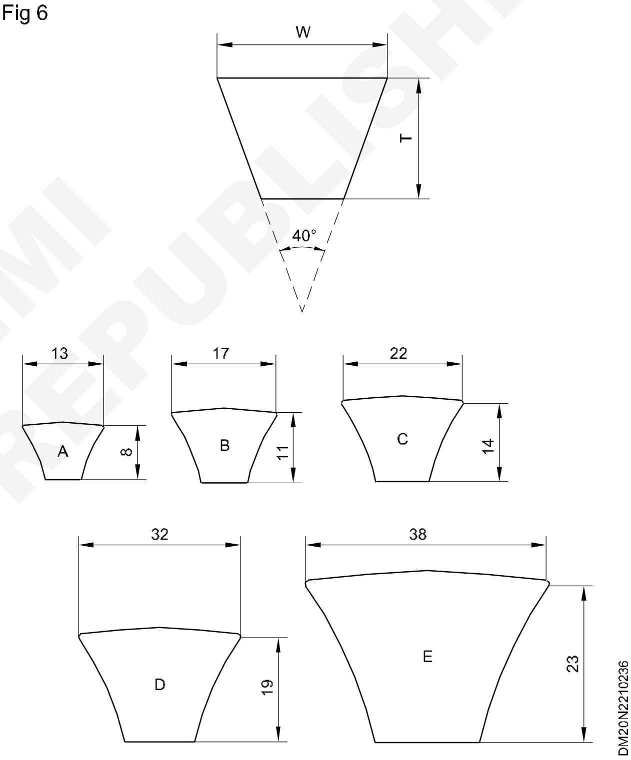
C = V - belt cross section

3048 = Nominal inside length in mm (intensioned state)

Belt length calculation - (flat belts) (Fig 6)

The best way to determine the correct length of a belt is by wrapping a steel tape around the pulleys and recording the measurement. If the belts are to be spliced and cemented, an additional amount of belt length must be provided for making the lap.

Fig 6



Width of pulley

Width of the pulley or face of the pulley is taken 1.25 times the width of the belt.

Chain drive

Objectives: At the end of this lesson you shall be able to
- **explain chain drive**
- **explain velocity ratio of chain drive.**

Chain drive

Chain drives are most commonly used to transmit power between two components that are at a greater distance, but they may also be used for short distances.

A chain drive is also called a positive drive because there is no slip. If the distance is slightly larger, a chain drive can be used for making it a positive drive.

A chain is built up of rigid links are hinged together to provide necessary flexibility. Wheels having teeth especially designed for chains are known as chain sprockets which are resemblance to spur sear.

Types of chain drive:

The following are the common types of chain drive used for power transmission.

- Roller chain
- Silent chain
- Leaf chain
- Flat top chain
- Engineering steel chain

Components of chain drive:

The components of roller chain drives consists of a bush, inner link, pins, outer plate, inner plate and rollers. A bush along with a roller is fitted in side both the plates then a pin is passed through both end of the roller to fasten it.

Materials used for sprockets:

The materials used in sprockets are high quality carbon steels (in forged steel or with welded hub).

When conditions call for heavy duty use, we can provide hardened teeth sprockets. In corrosive operating conditions, stainless steel is recommended.

Advantages of chain drive:

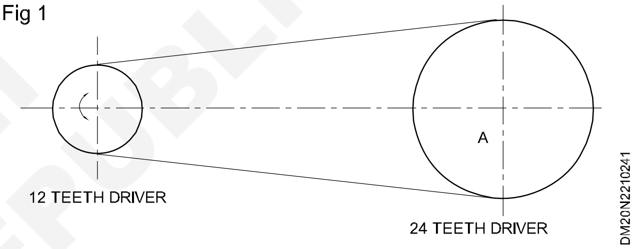
- They can be used for both long and short distances.
- A number of shafts can be driver from a single chain.
- They are compact and have small overall dimensions.
- They do not present fire hazard.
- Temperature and environmental conditions do not affect their working.
- They do not require initial tension.

Velocity ratio of chain drive (Fig 1)

As no slip takes place during chain drive, hence perfect velocity ratio is obtained velocity ratios are calculated by dividing the driver gear teeth by the driven gear teeth. Driver is one of the pulley connected to the power. e. g. the pedals on a bicycle or the motor.

$$\text{Velocity ratio} = \frac{\text{No. of teeth in the driver sprocket}}{\text{No. of teeth in the driven sprocket}}$$

Fig 1



To calculate the speed of the driven gear, multiply the speed of the driver gear by the velocity ratio. In all the calculations the driver is on the left, i.e. the first wheel.

Driver speed = 1000rpm

Driver speed= 1000x0.5

= 500rpm.

The above calculations are based on sprocket and chain system.

Pipe materials

Objectives: At the end of this lesson you shall be able to
- **state the names of different pipe materials.**
- **explain the uses of different pipes.**
- **explain specification of pipes.**

Introduction

Pipes with joints and fittings are used for the purpose in almost all the engineering projects. They are commonly used for carrying fluids such as water, steam, gas, oil, waste etc, from one place to another, they are also sometimes used as structural elements such as columns and beams.

Different pipes and their uses

The material of a pipe depends upon the purpose for which the pipe is used . A large number of materials varying from cast iron, steel, brass, copper, lead and aluminium etc, to wood, concrete, clay, glass, plastic& rubber etc, are used these days in pipe manufacture.

1 Cast-iron pipes.

2 Wrought iron or malleable iron pipe.

3 Steel pipes.

4 Lead pipes.

5 Copper & Brass pipes

6 Plastic pipes.

Cast iron pipes

C.I. pipes are widely used for carrying water, gas and steam from one place to another. They are available in various sizes from 50mm to 1200mm diameter, C.I. pipes are connected together by flanged joints, socket and spigot joints, hydraulic joint etc. they are used only for low pressure applications such as under ground sewer pipe.

Wrought iron or malleable iron pipes

W.I. pipes are used for carrying water for domestic purposes and also gas at low pressure. They are galvanized all over. They are generally made by welding process. They are available in various sizes from 6mm to 150mm diameter.

Steel pipes

Steel pipes are more popular for carrying water, steam, sewage, and air at high pressure. They have much greater strength as compared to cast iron and wrought iron pipes. They can be made of longer lengths and less liable to breakage. Steel pipes may be welded seams or may be seamless. Welded steel pipes are manufactured by rolling steel plates are rolled to cylindrical shape and finally, the joint is welded and finished. Weldless steel pipes are made by piercing the ingot to red hot and after putting in to mandrel, rolling it through dies of size required steel pipes are available in various sizes from 50mm to 1800mm diameter.

Steel pipe is used for high temperature and pressure applications Its size is specified by its nominal diameter. Referred to NPS (Nominal pipe size) this nominal size is roughly the inside diameter (ID) of the pipe.

Lead pipes

Lead pipes are used for domestic purposes. They are made by expanding molten lead through a die over mandrel. Two lead pipes are joined by soldering process and such a joint is called wiped joint. Lead pipes can be easily bent to desired shape. Hence these pipes are used where the pipe line contains frequent bends.

Copper & Brass pipes

Copper and brass pipes are generally used for carrying hot water and in fabricating radiator. These pipes can be easily bent or coiled to desired shapes. They are good conductors of heat hence used where there is no consideration of heat losses these are either solid drawn or made from sheet with longitudinal joint welded or brazed. These pipes are connected by separate flanges made of brass or gunmetal attached to the pipe ends by brazing.

Copper pipe and tubing is used where corrosion is a problem. Copper is one of the most expensive material used for piping.

Plastic pipes

Plastic pipe is corrosion resistant, flexible, easily installed and in expensive. Sprinkler systems, and domestic sewer systems are a common application of plastic pipes.

Specification of pipes

Mental pipes are specified by their nominal diameter, which differs some what from their actual diameter, when it is upto 25cm. for all pipes over 25cm diameter, the nominal diameter equals the actual outside diameter, and such pipes are called O.D. (outside diameter) pipes.

Steel pipe size is specified by its nominal diameter, referred to NPS (Nominal pipe size). This nominal size is roughly the inside diameter (ID) of the pipe. There are ten weights of pipes with different wall thickness and many sizes in each weight.

Pvc pipe sizes are specified by the ID (internal diameter) of schedule 40pipe. This means that for a standard schedule 40 pvc pipe, the pvc industry uses the measure of the 'hole' inside the pvc pipe as its size. This is the measurement from top to bottom of the inside of the pvc pipe.

Different types of pipe joints

Objectives: At the end of this lesson you shall be able to
- **name the different types of pipe joints**
- **explain the different types of pipe joints.**

Pipe joints

C.I. pipes are available in lengths upto 5.5 metres only, due to manufacturing. Transportation, storing and handling difficulties.

In many cases when a pipeline longer than the available lengths are required, two or more such pipes are axially connected end - to- end.

The various methods of connecting pipes depends upon the material of pipes, material to be handled by pipes, pressure, shock and stresses to which the joint may be subjected. Some common pipe joints are described below.

1 Screwed joint.
   a Nipple joint
   b Socket joint
   c Taper pipe threads
2 a Welded pipe joint.
   b soldered pipe joint.
3 Cemented or glued pipe joint.
4 Flanged pipe joint.
5 Spigot and socket joint.
6 Hydraulic pipe joint.
7 Expansion joint
8 Union joint
9 Wiped joint

Screwed joint

Nipple joint (Fig-1(a))

A people which is threaded on the outside, is screwed inside the internally threaded ends of the two pipes. In this case the passage of the fluid is partially chocked due to the resulting smaller inside diameter of the nipple.

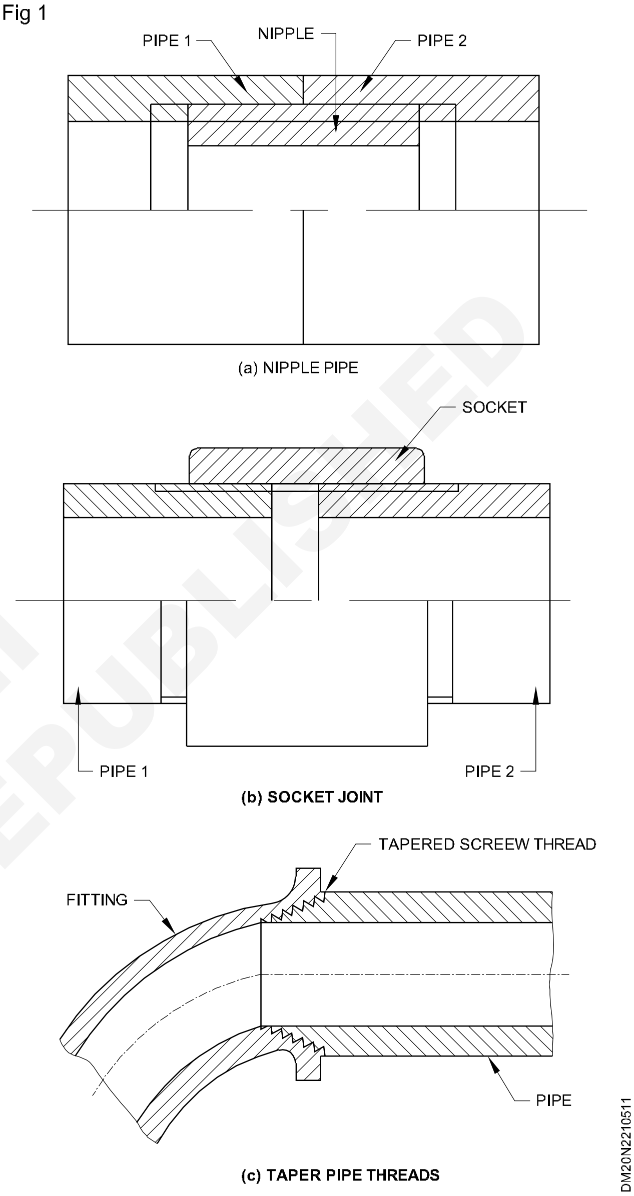
Socket or couples joint (Fig-1-(b)

A short cylindrical sleeve called a socket or a couples, threaded from inside, is screwed on to the threaded ends of the two pipes.

Taper pipe threads (Fig- 1-(c))

Tapered pipe threads may be used for all types of pipe. This type of joint is not really disassembled . as flange joints and may be designed to with stand relatively high pressure. To make the joint leak-proof a few strands of jute or hemp coated with red lead, are wind round the bottom of the thread on each pipe end.

Fig 1



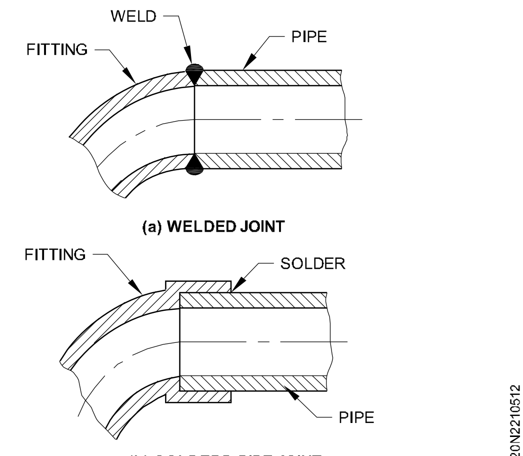
Welded pipe joint (Fig 2(a))

Figure shows a butt welded joint, which can be subjected to high pressure, but cannot be disassembled welded joints are light weight and less bulky than screwed or flanged joints.

Soldered pipe joint (Fig-2(b))

Copper and brass tubes are usually connected by soldering, these cannot be subjected to pressure and temperature. Fittings are made very precise and the solder flows into make a good tight connection.

Fig 2



(a) WELDED JOINT

(b) SOLDERD PIPE JOINT

Cemented or glued pipe joint

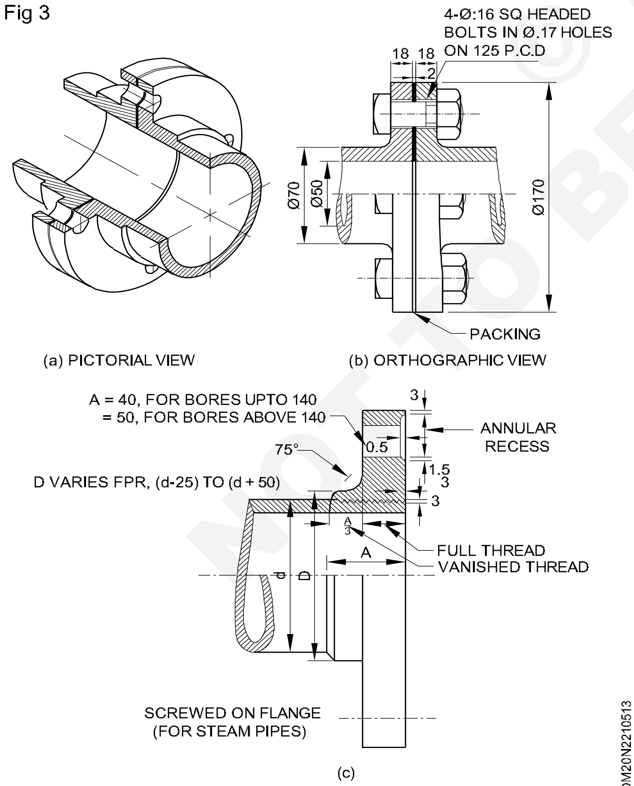
Cementing or gluing is a common method of connecting plastic pipes. It is easy and takes no special tools or skills.

Flanged pipe joint

Flanged connections are used to connect large diameter pipes.

In the cast iron pipes the flanges are cast with the pipes and then their faces are machined Fig 3(a & b) while in the case of M.S. and W.I. pipes these are usually screwed on to the pipe ends (Fig 3(c)) the flanges are held together by a number of bolts, with a gasket of soft material in between them to make the joint leak proof.

Fig 3



(a) PICTORIAL VIEW

(b) ORTHOGRAPHIC VIEW

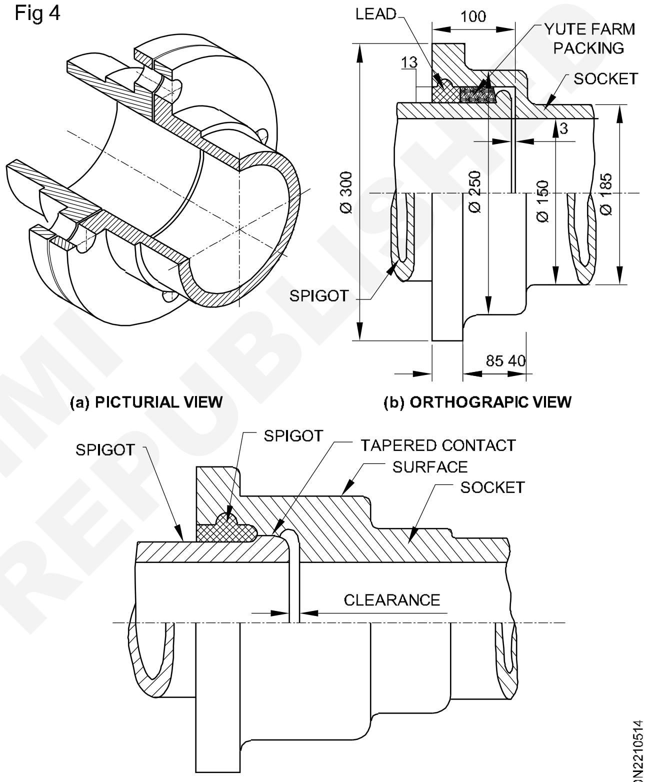
(c)

Spigot and socket joint

These joints are adopted for connecting cast iron pipes in underground installations, where there is low pressure and little vibrations. As these joints are flexible, they can adopt themselves to the settlement of earth, which takes place due to climatic or other conditions. As shown in Fig 4(b) this joint consists of two main parts, "socket" and "spigot" after placing the spigot in position in the socket, the remaining space between the two is filled with some packing material, which may be lead, cement Sulphur compound and jute.

In another joint of this type (Fig 4(c)) the enlarged end of the spigot is machined to fit a corresponding machined and tapered portion of the socket. Before connecting the machined surfaces are pointed with lead. This joint is used for pipes, which are strictly in a straight line. A common application is for domestic sewer lines.

Fig 4



(a) PICTURIAL VIEW

(b) ORTHOGRAPIC VIEW

(c) SPIGOT AND SOCKET JOINT (WITH DIRECT CONTACT OF PIPES)

Hydraulic pipe joint

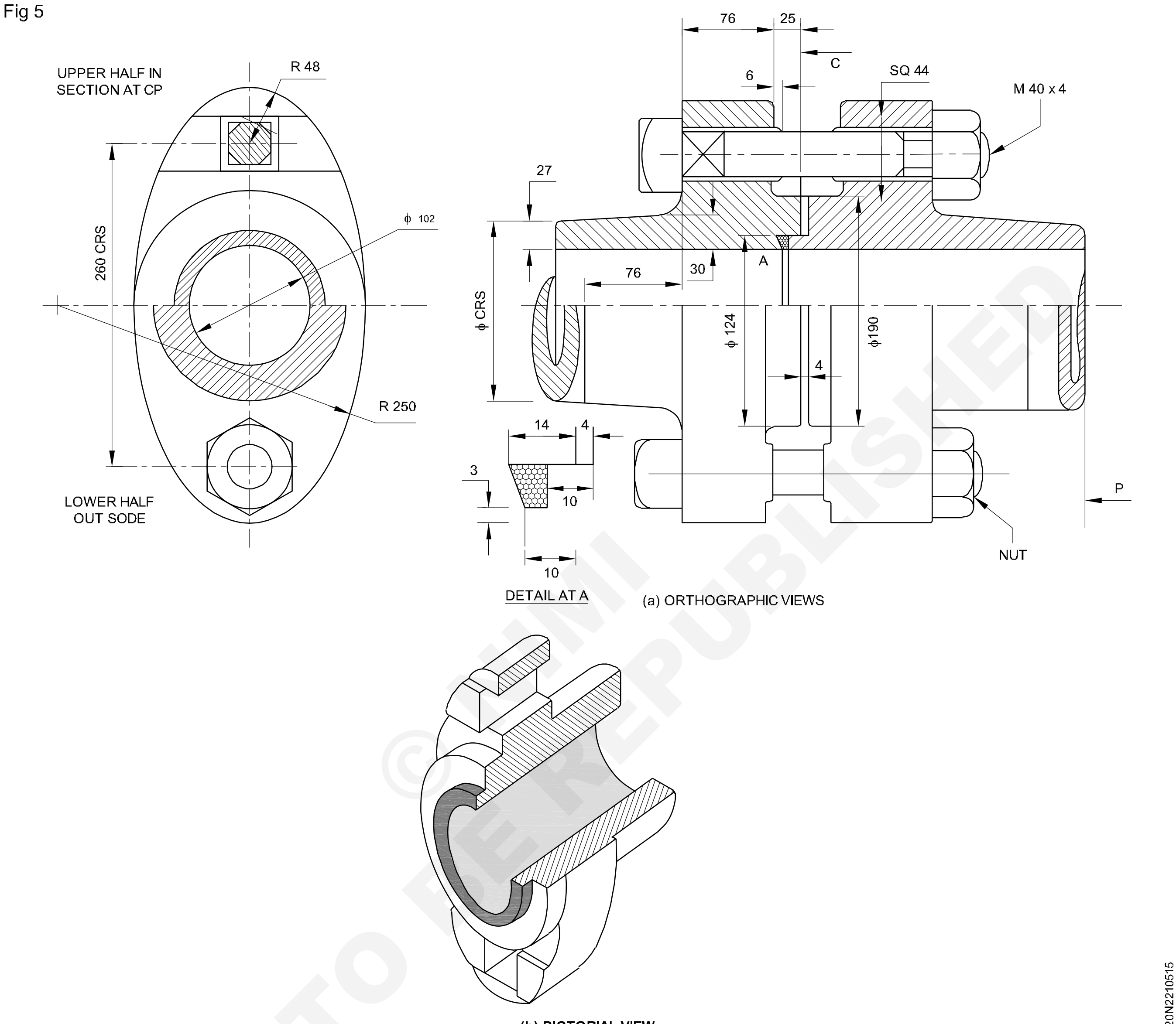
Fig 5(a) shows a flanged joint, which is used on high pressure water pipes and is called "Hydraulic pipe joint" the flanges of the joint are designed for better tightening of the joint. Fig 5(b) shows the pictorial part. When put in assembly the projected part goes into the other flange. And thus provides for better alignment. It can be noted that the flange surfaces are not wholly in contact this sieves spring action when tightened and thus helps in making the joint the joint leak proof the detail of portion 'A' of the joint illustrating the position of the packing washer, is shown or an enlarged scale.

Expansion joint

In long pipes carrying live steam, there is too much variation in temperature due to which contraction and expansion of the pipes takes places. This may result in the breakage of some joint or the building out of the pipes. To prevent it various types of expansion take up equipments are used.

Expansion bend can be used for smaller diameter pipes. For larger pipes the gland and stuffing box expansion joint show in Fig 6 is usually used. Two parts which may be called socket and sleeve are connected to the ends of the two pipes, the sleeve is free to move in and out of the turned portion of the socket and thus can accommodate any variation in the length of the pipes. Gland and packing are used to prevent the leakage ogsteam. guard bolts are provided to prevent the undesired, excessive movement of the sleeve in the socket.

Fig 5

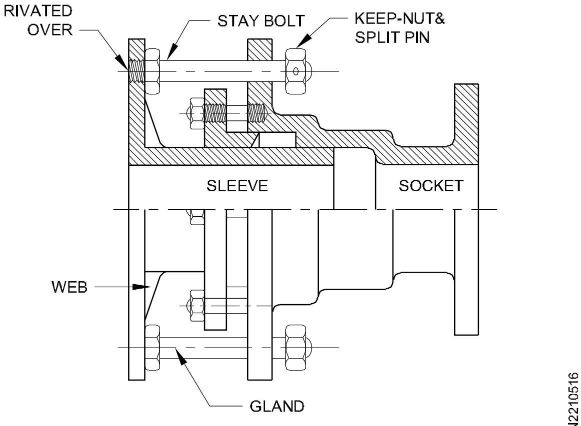


(b) PICTORIAL VIEW

Union joint

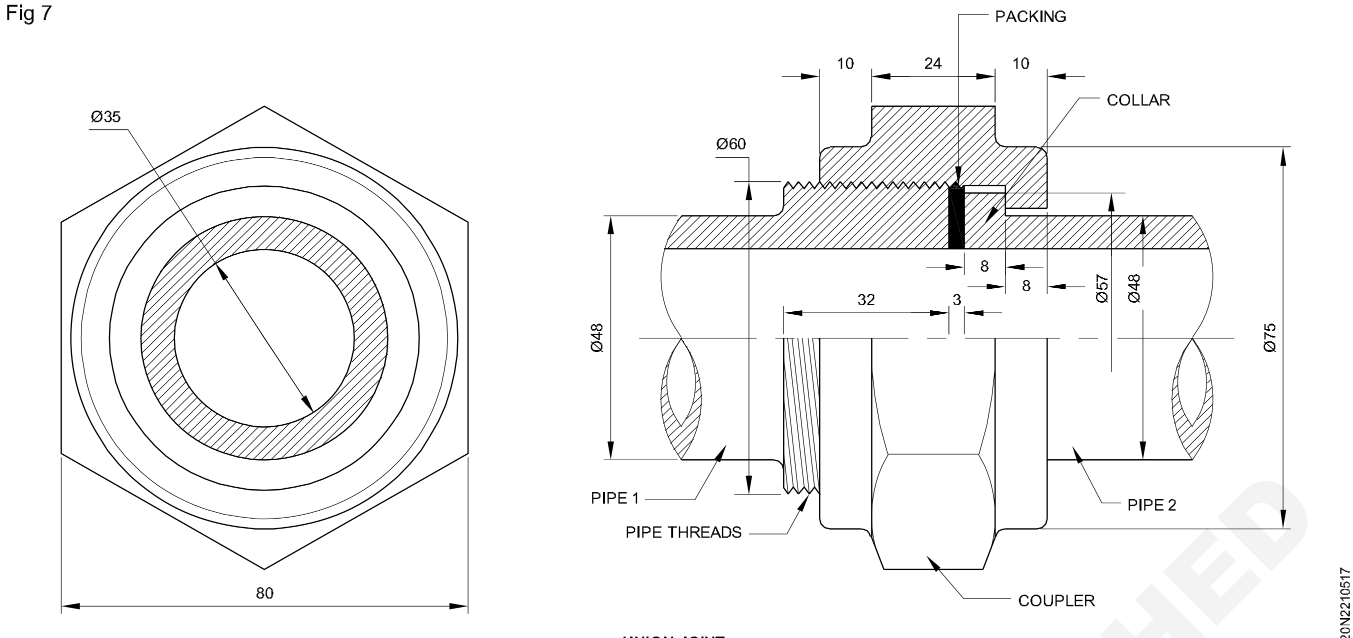
The screwed joints cannot be disassembled easily. for rapid disassembly, the joint of the type shown in Fig 7,called pipe union or union joint is used. A coupler having screw threads on one side, is used to connect the two flanged pipe. The flange on one pipe is threaded and the threaded end of the couples is screwed on to it. The outer surface of the coupler is usually made hexagonal for using a spanner to tighten the joint. Gunmetal or brass pieces, properly machined are used as packing materials.

Fig 6



GENERAL ARRANGEMENT OF EXPANSION JOINT

Fig 7

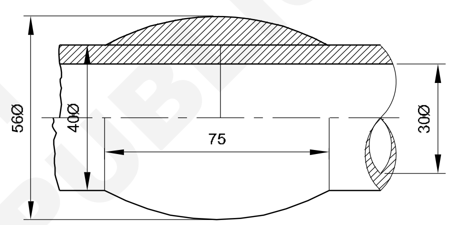


UNION JOINT

Wiped joint:

The most common form of joint for connecting lead pipes is a wiped joint. Shown in Fig 8.The end of one pipe is opened slightly wider, while that of the other is filed to a sharp edge. The ends are polished with a smooth file for a length approximately equal to the diameter of the pipes and joined together. Molten solder is then poured over the joint, which is rapidly wiped with a piece of cloth, smeared with grease. The solder sticks on to the polished surfaces of the pipes, while the outside surface of the joint is smoothened by wiping.

Fig 8



WIPED JOINT

Pipe threads

Objectives: At the end of this lesson you shall be able to
- **name the joint connected by straight pipe threads.**

Pipe threads:

Pipes are threaded on its ends for connection. Pipe threads may be straight or tapered. Taper threads are used for all purposes exception of the following 5 types of joints.

1 Pressure pipe joints for pipe couplings.

2 Pressure fight joints for grease cup fuel & oil couplings.

3 Free fitting mechanical joints for fixtures.

4 Loose fitting mechanical joints with lock nuts.

5 Loose fitting mechanical joints for loose couplings.

For the above joints straight pipe threads are used. The number of threads per inch is same in tapered and straight pipe threads. All pipe threads are assumed to be tapered, unless otherwise specified.

Pipe fittings

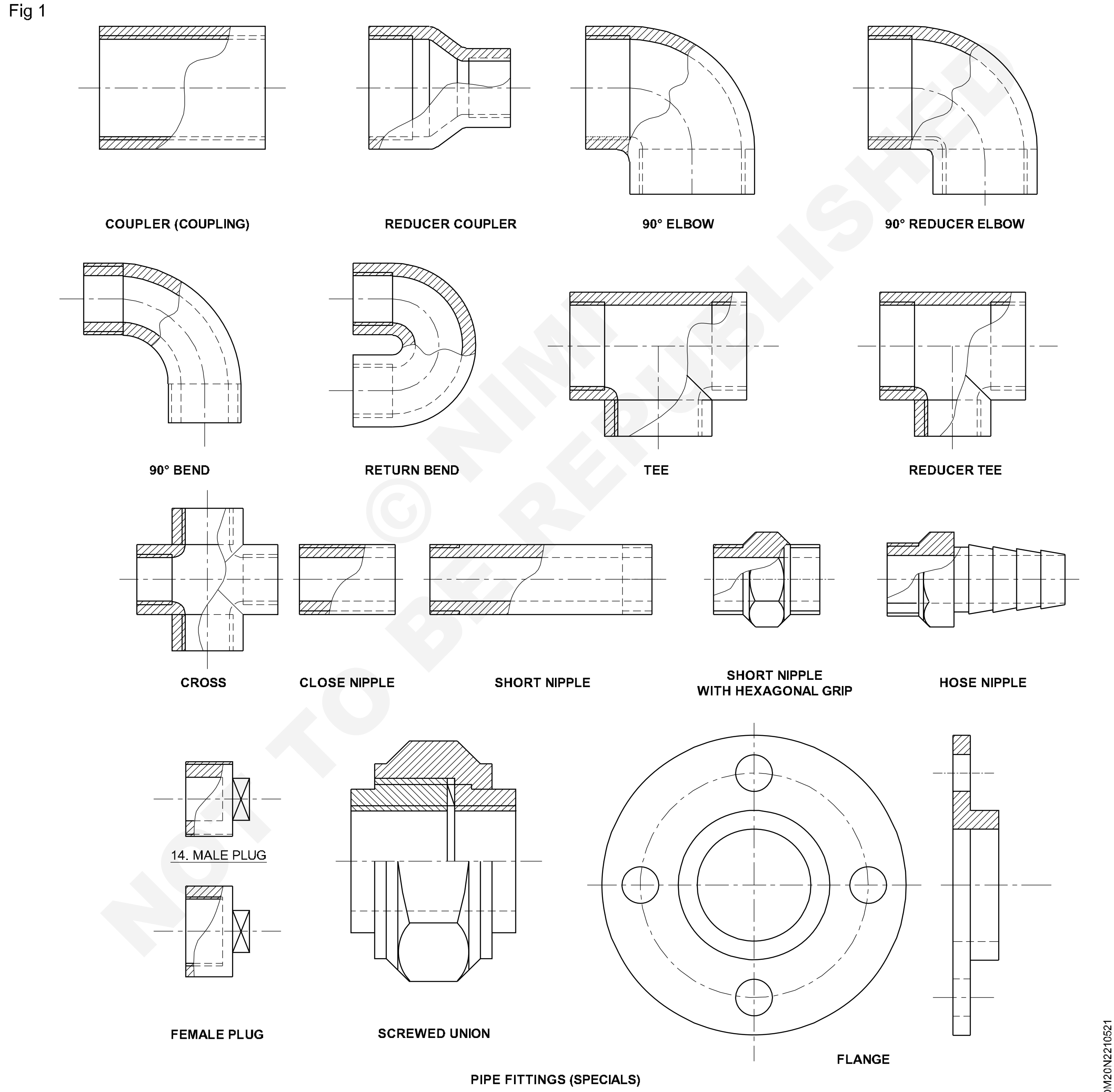
Objectives: At the end of this lesson you shall be able to
- **list the types of pipe fittings**
- **define welded pipe fittings**
- **tell about the specifications of fittings.**

Pipe fittings

To connect two pipes together and to make branches, reduction or increase of diameter, etc, different parts of a pipe line called pipe fittings or specials are used. Screwed pipe specials commonly used in plumping are shown in Fig 1. The screw threads used on pipe fittings are of fine size pitch and slightly different from the standard threads for nuts and bolts. The size values are available in engineering tables.

Depending on the shape and purpose, the joints commonly used are classified into the following categories.

Fig 1



PIPE FITTINGS (SPECIALS)

Welded pipe fittings:

Welded pipe fittings in carbon steel and stainless steel are the joining components that make possible the assemble os valves, pipes and equipment on to the piping system.

Welded fittings compliment pipe flanges in any piping system and allows, change direction of flow in a piping system.

Different Weld fittings:

- Socket Weld.
- Belt Weld.

These are quite popular in pipe line projects.

Press fitting:

Copper press fitting, also known as crimping or press connect joining, can securely connect pipe without using such heating based methods as soldering, brazing or welding. Press fitting requires hydraulic tools to press specialized fittings to standard pipe.

Press fitting connections are secure, as long as the pipe is prepared correctly according to the press tool system manufacture instructions, the connection is as strong as a welded or soldered connection.

Specifications of pipe fittings:

For getting proper pipe fittings to be used in pipes of various size, certain specifications are to be known. These specifications cover the following:

- Specifications of materials.
- Specifications of size.
- Cleaning and care tips of pipe fittings.
- Pressure and temperature ratings.

Specification of size:

To determine the usage of a pipe fitting, size is a very important criteria. Here the main consideration are inside diameter and outside diameter. Where the inside diameter (ID) has the fitting size matched to the inside diameter of connecting line. The outside diameter (OD) has the fitting size matched to the outside diameter of connecting line.

Different types of valves

Objectives: At the end of this lesson you shall be able to
- **name the different types of valves**
- **explain different.**

Valves

Fluid flow in pipe lines in controlled by different types of valves. These pipe lines are operated manually but in some cases this is done by the pressure of the fluid itself or by some outside mechanism. Valves are commonly used to regulate the flow of pressurized liquids steam gases or air and they have some common features. The opening or closing of the passage for the fluid is happened by movement of a part called valves.

Relief valve and safety valves are operated by the pressure of the fluid junction and stop valves and the cocks are operated by hand.

Materials of valves:

The material of the valves may not necessarily be the same that of the pipes to which they are connected. The most common material for a valve in smaller sizes is brass, bronze or gun metal, and in the large sizes is cast iron. The valves subjected to very high pressure are made of cast steel or cast steel alloys. Numerous types of valves are used in practice. A few of the most common types are discussed below.

Classification of valves:

1 Flap valves or swing check valves.

2 Lift check valves.

3 Gate valves

4 Globe valves

5 Ball valve

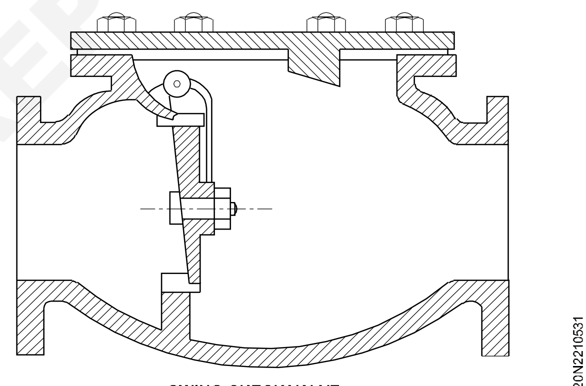
6 Junction or stop valve.

7 Non - return valve

Flap valves or swing check valves (Fig 1)

This type of valves which are bend or turn upon a hinge. The amount of swing given to the valve controls the opening for fluid.

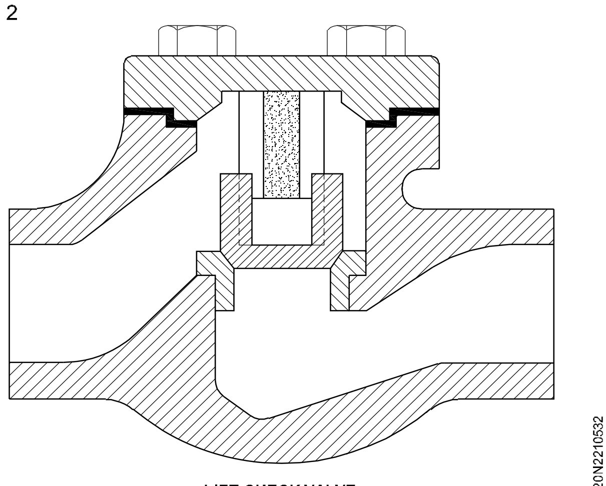
Fig 1



SWING CHECK VALVE

Lift check valves (Fig 2)

Fig 2

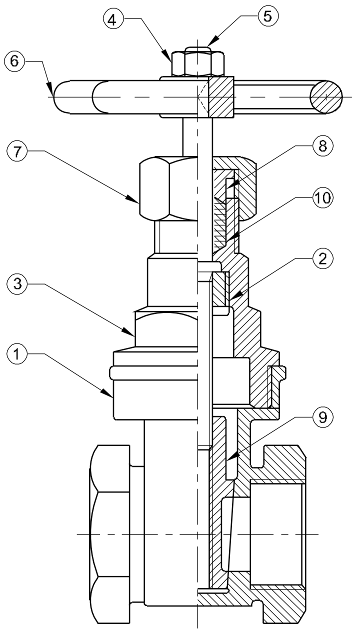


LIFT CHECK VALVE

This type of valves which rise and fall in a direction perpendicular to the seat .The lift of the valve is checked by the position of the lower end of the valve spindle or the projection provided below the cover. Such valves are used as feed check valves or hydraulic non-return valves.

Gate valve (Fig 3)

Fig 3



ELEVATION, RIGHT HALF IN SECTION

ITEM LIST

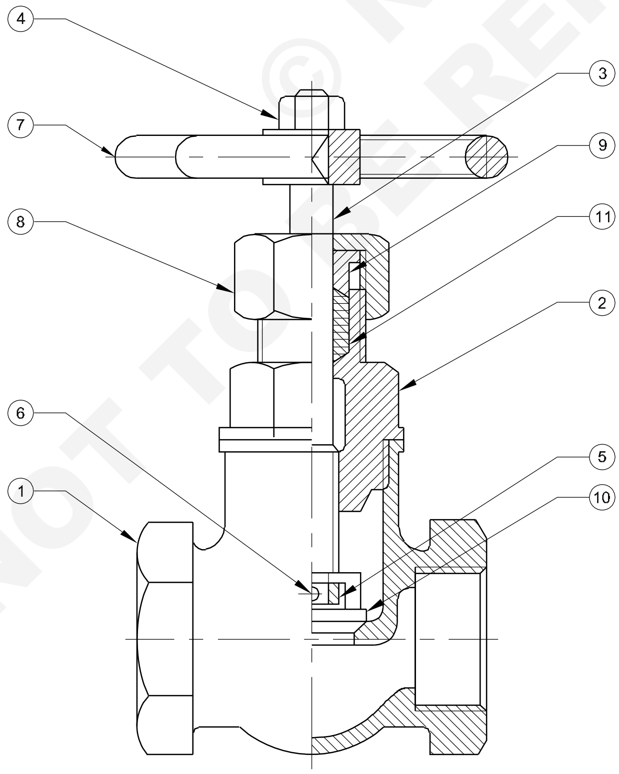
ITEM	DESCRIPTION	QTY.	MATERIAL
1	BODY	1	G.M.
2	INSIDE UNION	1	G.M.
3	UNION	1	G.M.
4	NUT	1	G.M.
5	SPINDLE	1	G.M.
6	HAND WHEEL	1	C.I.
7	GLAND NUT	1	G.M.
8	GLAND	1	G.M.
9	WEDGE VALVE	1	G.M.
10	PACKING	1	ASBESTOS

GATE VALVE (ASSEMBLY)

DM20N2210533

A gate valve is an ON or OFF type valve used commonly in liquid flow through pipe lines This type of value is used on pipes conveying water or other liquids. It offers little restriction straight -line flow. fig 2 show the assembly of gate valve for 22 mm water pipe line.

Fig 4



ITEM LIST

ITEM	DESCRIPTION	QTY.	MATERIAL
1	BODY	1	G.M.
2	COVER	1	G.M.
3	SPINDLE	1	G.M.
4	NUT	1	G.M.
5	COLLAR	1	G.M.
6	TAPER PIN	1	G.M.
7	HAND WHEEL	1	G.M.
8	GLAND NUT	1	G.M.
9	GLAND	1	G.M.
10	VALVE	1	G.M.
11	PACKING	-	ASBESTOS

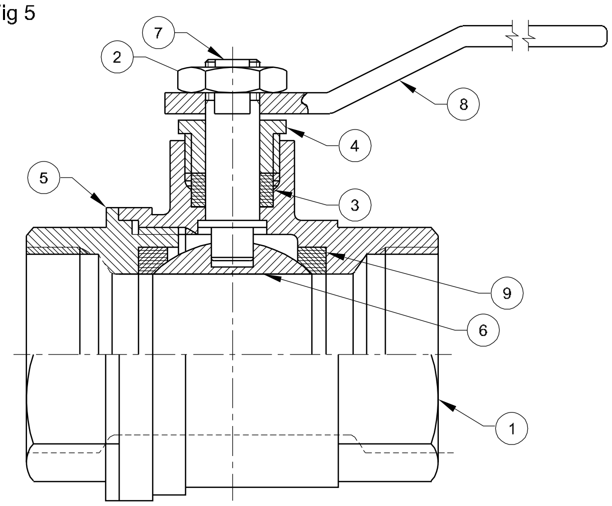
GLOBE VALVE (ASSEMBLY)

DM20N2210534

Globe valves (Fig 4)

Globe valves are used to regulate flow of liquid through pipe lines. the assembly is shown in Fig 4. This valve is lifted perpendicular to the fluid flow off its seat by rotation of the hand wheel,that intern operates the spindle. These are used to control the fluid flow for very close regulation as the throttling on the steam pipelines.

Fig 5



ITEM LIST

ITEM	DESCRIPTION	QTY.	MATERIAL
1	BODY	1	G.M.
2	NUT	1	G.M.
3	GLAND PACKING	1	P.V.C
4	GLAND	1	G.M.
5	CAP	1	G.M.
6	BALL VALVE	1	C.I.
7	SPINDLE	1	G.M.
8	HANDLE	1	M.S.
9	WASHER	1	P.V.C

BALL VALVE (ASSEMBLY)

DM20N2210535

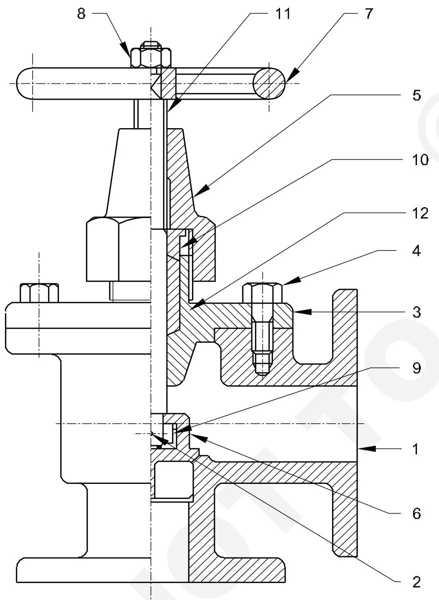
Ball valve (Fig 5)

A ball valve is a spherical shaped rotating part with a hole at the centre to keep the flow in ON or OFF position through the pipe lines.

Steam stop valve (Fig 6)

Fig 6 shows the assembly of steam stop valve. The main function of a steam stop valve is to start, regulate and stop steam flow along a pipe line. If the valve is fitted nearby a boiler, it is called junction valve and when placed near a prime mover it is called a stop valve. The gunmetal disc valve is attached to the spindle by a collar and a taper pin. The gland bush and the asbestos packing form a stuffing box arrangement to stop the leakage of steam through the side of spindle. The gland bush it tightened by screwing the gland nut. If the valve is to be operated frequently, a valve seat of gun metal is also added instead of directly placing the disc valve inside the machined hole of the body.

Fig 6



ITEM LIST

ITEM	DESCRIPTION	QTY	MATERIAL
1	BODY	1	C.I.
2	PIN	1	G.M.
3	COVER	1	C.I.
4	BOLT	4	M.S.
5	GLAND NUT	1	G.M.
6	VALVE	1	G.M.
7	HAND WHEEL	1	C.I.
8	NUT	1	M.S.
9	COLLAR	1	G.M.
10	GLAND	1	G.M.
11	SPINDLE	1	G.M.
12	PACKING	-	ASBESTOS

STEAM STOP VALVE (ASSEMBLY)

DM20N2210536

Non return valve

Objectives: At the end of this lesson you shall be able to

- **non return valve steam stop valve.**

Non return valve (Fig 1)

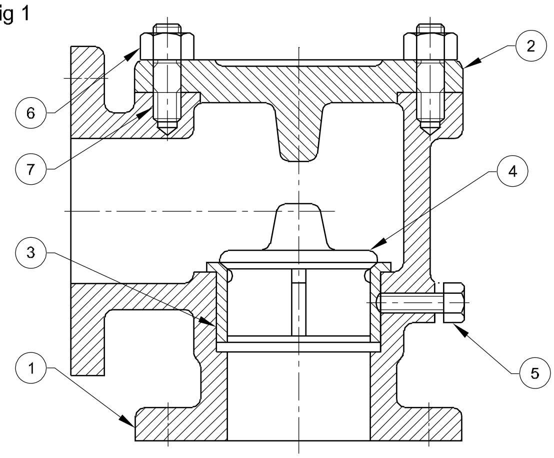
Valves which are operated by the pressure of the fluid are called non-return values as they allow the flow of fluid in one direction only and do not allow the fluid flow in the reverse direction.

The most important application of this type is the "Feed check Valve" used on boilers. It regulates the flow of water from the pump to the boiler and does not permit the back flow when the pump is stopped. The opening and closing operation of the valve is not done by spindle, but by the pressure difference on the two sides of the valve.

A non return valve used in steam pipe lines assembly is shown in Fig 1.

The disc valve at the centre is the lifted when the pressure of steam below it is greater than that of the above side, allowing the forward flow. The vertical movement of the valve is guided by the feathers inside the valve seat, at the same time the maximum lift is controlled by the metal projecting downward on the cover. When the pressure above the valve exceeds that of inlet, the valve closes automatically.

Fig 1



ITEM LIST

ITEM	DESCRIPTION	QTY.	MATERIAL
1	BODY	1	C.I.
2	COVER	1	C.I.
3	VALVE SEAT	1	BRASS
4	VALVE	1	BRASS
5	SCREW	1	M.S.
6	NUT	6	M.S.
7	STUD	6	M.S.

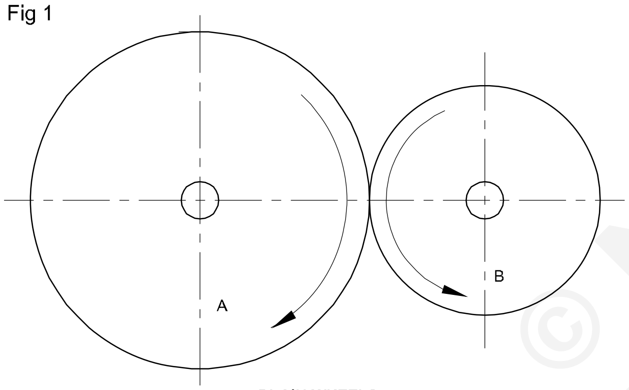
NON - RETURN VALVE (ASSEMBLY)

DM20N2210541

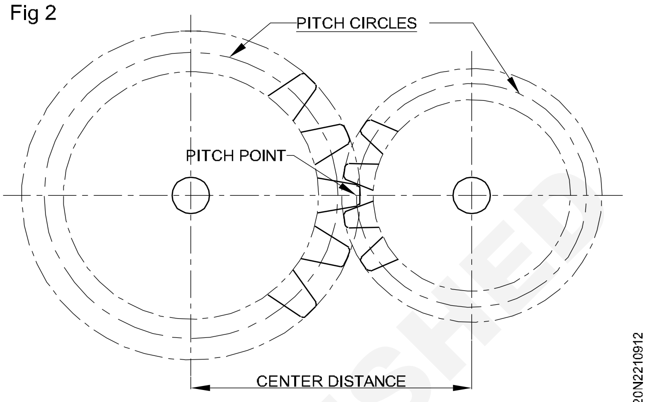
Gear drive & Different types of gears

Objectives: At the end of this lesson you shall be able to
- **explain gear drive**
- **explain types of gears.**

Imagine two plain wheels A and B (Fig 1) fixed rigidly to two parallel shafts and pressed tightly in contact with each other. If the wheel A is rotated about its axis, the wheel B will also rotate due to the friction between them. The rotary motion is thus transmitted from one shaft to another. The surfaces of the two wheels will move at the **same speed** if there is **no slipping**. It is obvious that with increase in load to be transmitted, the wheels will begin to slip on each other. To prevent slipping, grooves may be cut on the cylindrical surfaces of the wheels and projections added between them. These grooves and projections form the teeth, and wheels with such teeth become toothed wheels or gears (Fig 2)

Fig 1


PLAIN WHEELS

Fig 2


TOOTHED WHEELS

Toothed gears can be classified according to

- The mutual position of shafts,
- The relative motion of the shafts and
- Forms of teeth

The detailed classification is depicted as under :

Gear
↓
- Position of axes of shafts
  - Parallel Axes spur and helical bevel
  - Intersecting axes bevel
  - Non - Intersecting axes worm and worm wheel Spiral gear
- Relative Motion
  - Low
  - Medium
  - High
- Forms of teeth
  - Involute
  - Cycloid

Different types of gears :

1 Spur gear

2 Helical gear

3 Bevel gear

4 Worm and worm gear

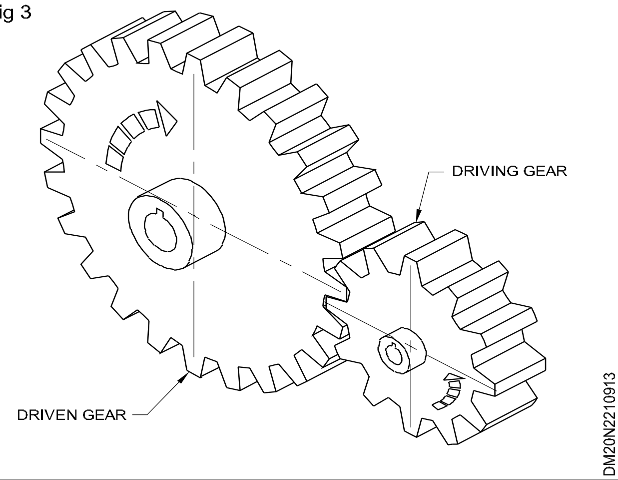
5 Spiral gear

6 Rack and pinion.

Spur gear (Fig 3)

Spur gearing is used when the two shafts are parallel to each other. This transmits power at a constant velocity ratio. This drive is compact as the distance between the two shafts are short. Speed of the driver shaft can be changed by interchanging the spur gears. Efficiency of the drive is very high,as the loss of power transmission is less than 1% The maintenance cost of this drive is less. The life of the drive is high. Spur gearing is used over a wide range of articles are from small watches, precision measuring instruments, machine tools, gear boxes fitted in motor cars and aero engines.

Fig 3



Helical gear (Fig 4)

A helical gear has its teeth in the form of helices instead of being straight lines parallel to the axis of the gear. The transverse section of a helical gear is identical with a spur gear as far as the tooth profile is concerned and is involute on this section. The mating gear must be made of the same helix angle. Helical gears are used for high pitch line velocities and heavy loads such as in automobile gear boxes and in steam and gas turbines for speed reduction.

In single helical gear the teeth makes angle to the direction of axis. In double helical (herring one) gear the opposite handed teeth are cut on the same blank to neutralize axial thrust. Such a gear has the width of a normal gear equal to two helical gears. These are used for driver of rolling mills, reciprocating machineries machine fools etc.

Advantages of helical gears:

1 Axial thrust is Zero

2 Silent operation

3 Absence of vibrations

4 High efficiency

5 High velocity ratio.

Helical gearing

Two helical gears in mesh is known as helical gearing. Out of the two gears in mesh, one gear must have a right hand helix and the other, a left hand helix as shown in Fig 1. Helical gearing is **noiseless** in operation because of the more gradual engagement of the teeth during meshing.

Bevel gear (Fig 5)

In bevel gear, the teeth are formed on conical surfaces and are used for transmitting power between **intersecting shafts.**

Fig 4

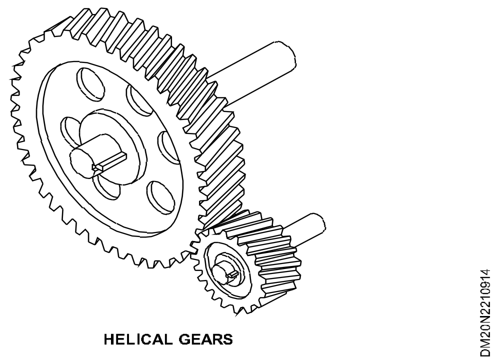
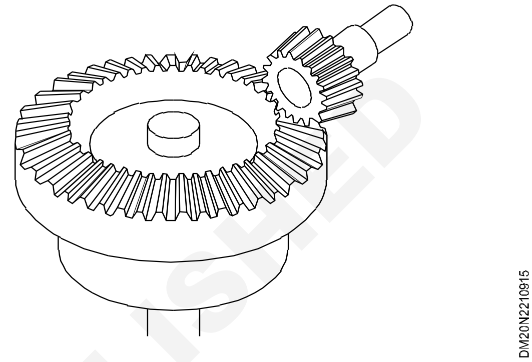


Fig 5



Classification of bevel gears

Depends upon the shapes of teeth (Figs 6 & 7)

Bevel gears may be classified as straight teeth bevel gears and spiral bevel gears. Hypoid gears are similar to spiral bevel gears, except that the shafts are offset and non - intersecting. Bevel gears may be used to connect shafts at practically any angle, 90° being the common one. Fig 5 shows the views of a bevel gear.

Fig 6

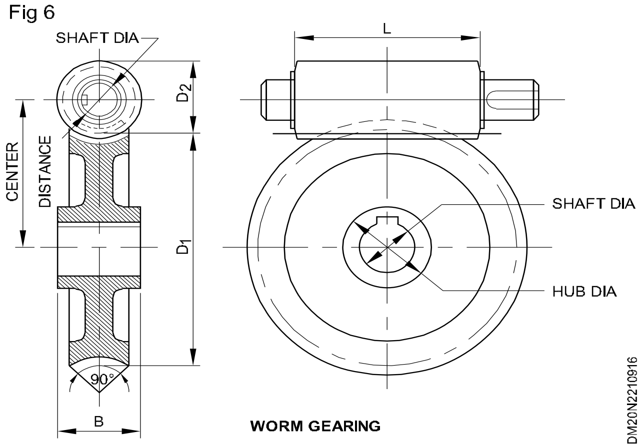
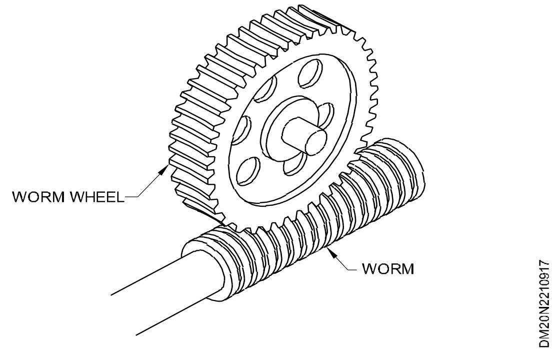


Fig 7



Depends upon the angles between the shafts and the pitch surface.

1 Miter gears (equal teeth & equal angle)

2 Angular bevel gear. (Other than right angle)

3 crown bevel gear. (greater than right angle)

4 Internal bevel gear. (teeth cut on the inside of the pitch core)

Bevel gears are used t operate the back wheels of motor vehicles, Vertical spindles of drilling machine etc.

Worm and worm gear (wheel)

Worm and worm gear in combination, i.e., in meshing is known as worm gearing and is used in **speed reducers** requiring **large reductions**. In worm gearing, the driving member is the worm, which is in the form of a screw, having trapezoidal thread. The worm may have single or multiple start threads which are left or right hand in nature. The driven member is known as the worm gear or worm wheel. In one of the designs, the worm gear is in the form of a helical gear, with teeth cut on a concave shaped periphery and thus enveloping the worm. Fig 3 shows the worm and worm gear indicates separately and Fig 4 in the same mesh.

The axes of the driving and driving and driven shafts are usually at right angels and do not intersect.

Worm gearing is commonly employed to obtain higher velocity ratios than from other forms of gearing .This velocity ratio depends upon the ratio of the number of teeth on the worm gear, To the number of threads in the worm.

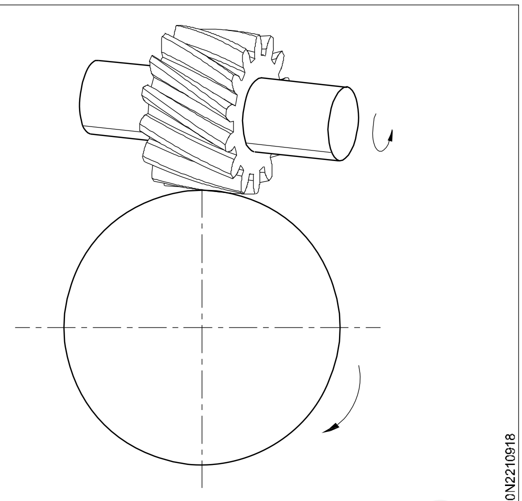
Machine tools like lathe, Drill, Milling etc. are equipped with worm gearing to get large velocity ratio.

Spiral gear (Fig 8)

Spiral gear is used to connect non-parallel and non-intersecting shafts

The pitch surfaces are cylindrical and the teeth have point contact. These gears are therefore suitable only for transmitting small power.

Fig 8

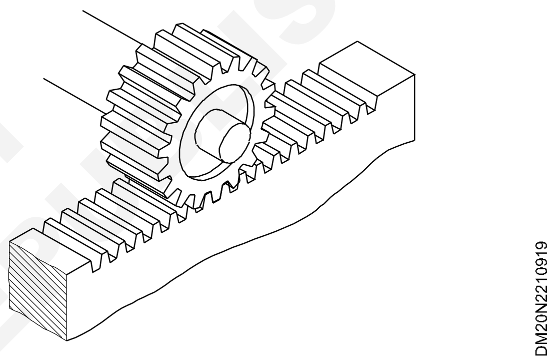


SPIRAL GEAR

The Centre distance for a pair of spiral gears is the shortest distance between the two shafts making any angle between them.

Rack and Pinion (Fig 9)

Fig 9



The function of rack and pinion is to transform circular motion to rectilinear motion. Small gear is called pinion and rack is a series of teeth on a straight line.They maybe considered as spur gears of infinite radii.

Lathe, Drill, Planner etc. are fitted with rack and pinion to convert rotary motion to straight line motion.

The rack is a gear having a pitch circle of an infinitely large radius i.e., the pitch circle is a straight line. This line is called pitch line. The teeth of the rack are straight sided. These sides are normal to the line of action and hence inclined to the vertical at the pressure angle. The crests and the bottoms of the tooth spaces are lie in straight lines parallel to the pitch line

Cast gears and machined gears

Objectives: At the end of this lesson you shall be able to
- **define gear manufacturing**
- **explain cast gears and machined gears.**

Gear manufacturing

Gear can be manufactured by a variety of processes including casting forging, extrusion, powder metallurgy and blanking .As a general rule,however, machining is applied to achieve the final dimensions,shape and surface finish in the gear.

Gear manufacturing depends on machinery available. Design specifications cost of production and type of material from which the gear is to be made.

Cast gears

Although the casting process is used most often to make blanks for gears that will have cut teeth, there are several variations of the casting process used to make toothed gears with little or no machining.

1 Forming

2 Cold drawing and Extrusion

3 Gear rolling

4 Forging

5 High energy rate forging

6 Precision forging etc

A casting process involves pouring a liquid into a mould to solidify and produce the desired shape of gear. The solidified part is ejected out of the mould and thus sent for further processing.

Machined gears:

Machining is the most common manufacturing method used .Gear machining is further classified into two categories. Gear generating and gear form cutting.

CNC (Computerized Numerical Control) machining is actually used in the manufacturing of gears with extreme precision and accuracy . This process is usually done by an experienced machinist Gear machining is used to manufacture a number of products including internal gears, worm gears, sprockets, spur and helical gears.

Manufacturing of gears in milling machine:

The tool is moved along the axis of the work piece and mills out the gear tooth space .The work piece is then rotated by distance of one tooth space and milling is repeated. The work piece is processed gradually until teeth are cut around the entire work piece.

Profile of gears

Objectives: At the end of this lesson you shall be able to
- **explain tooth profiles of gears.**

The profile of a pair of teeth in gear must be such that while the driving profile is pressing upon and moving the driven profile the relative motion of the pitch circles of the wheels shall be that of pure rolling.

To ensure this pure rolling of one pitch circle upon the other it is necessary that the common normal to the two profiles at their point of contact should always pass through the point of contact of the pitch circles.

Give almost any shape of symmetrical tooth on one wheel, it is possible to determine the necessary shape of the other tooth to satisfy the above condition of pure rolling of the pitch circles: but there are,in general, only two main types of teeth now used in wheel gearing namely, the INVOLUTE and the CYCLOIDAL. The characteristic appearance of these two types is shown in Figs.1 and 2 Cycloidal tooth were frequently used in the past as these could easily be cast in a foundry. But the cycloidal tooth is not now used to appreciable extent since the involute tooth is more easily machine-cut,and possesses many valuable advantages over the other:

1 The face and flank form one continuous curve (which may be readily ground)

2 The pressure angle is constant:

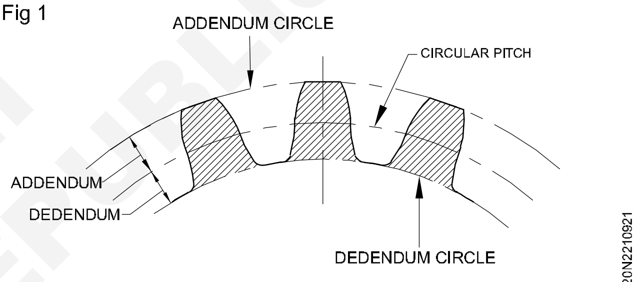
3 All gears having the same pitch and pressure angle will work together:

4 If the pitch circles do not exactly touch,the velocity ratio remains constant and the gears work equally well together.

Curves used for the profile of teeth

The cycloidal curves, portions of which go to form the profile of cycloidal teeth , are shown in Figs 3 and 4 (a) ,(b) and the involute of a circle,the early part of which forms the working profile of involute tooth is shown in Fig 5

Fig 1



INVOLUTE TEETH

The cycloid is the path traced out by a point on the circumference of a circle,which rolls on a fixed straight line in the plane of the circle.

Epicycloid And Hypocycloid: When a circle rolls on the circumference of a fixed circle,in the same plane, the path traced out by a point on the circumference of the rolling circle is called an Epicycloid or Hypocycloid according as the circle rolls on the convex or the Concave side of the fixed circle.

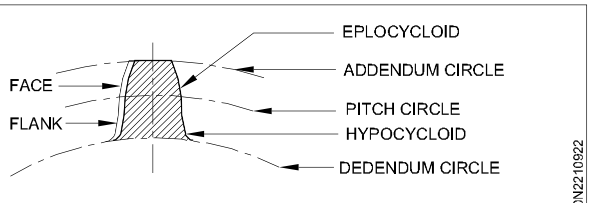
The normal through any point on any of the above curves passes through the point of contact of the corresponding portion of the rolling circle with the fixed line Fig 4

Involute

The involute of a circle is the path traced out by the end of a straight line rolling on the circumference of the circle, or it is the path traced by an inextensible cord unwound from the circumference of the circle. The straight line or chord is always a tangent to the circle and the normal to the curve at any point is the line passing through the point and tangential to the circle. The figures for these curves are self-explanatory.

When, however, only those short portions of the curves as required for the profiles to be drawn, the better method to adopt is that in which the rolling circle of straight line is drawn on tracing paper and the fixed line on drawing paper.

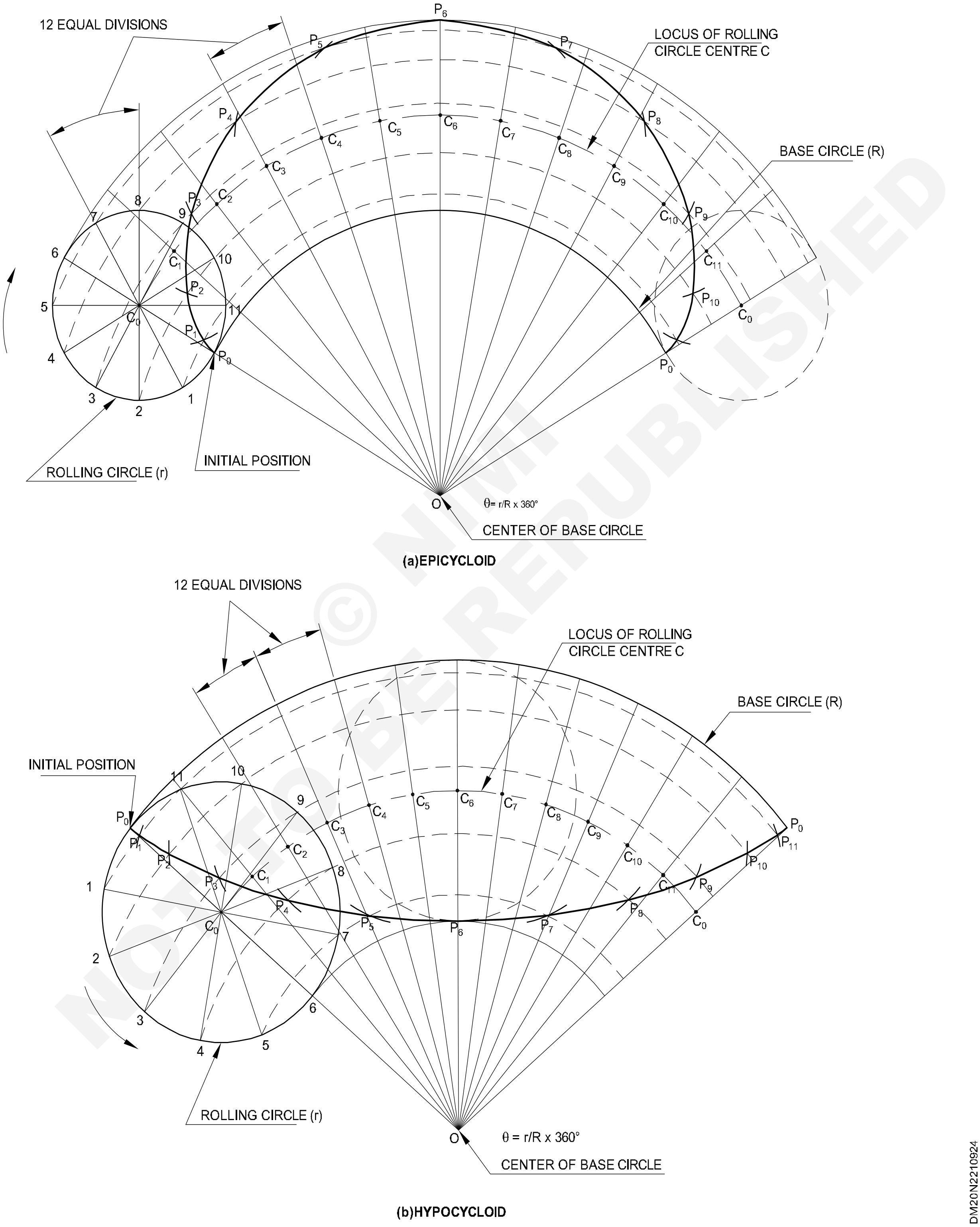
Fig 2



CYCLOIDAL TEETH

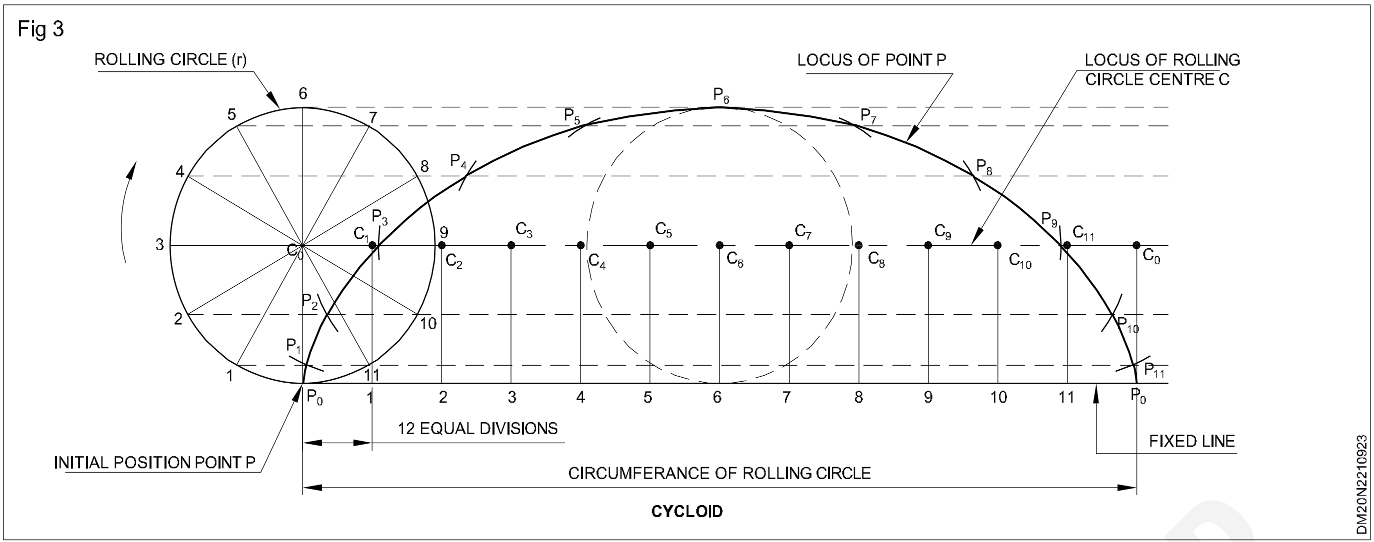
Then with the aid of a pickers the circle or straight line is rolled, in small steps, on the fixed line, and at intervals the position of the tracing point is transferred to the drawing paper below by pricking through.

Fig 4

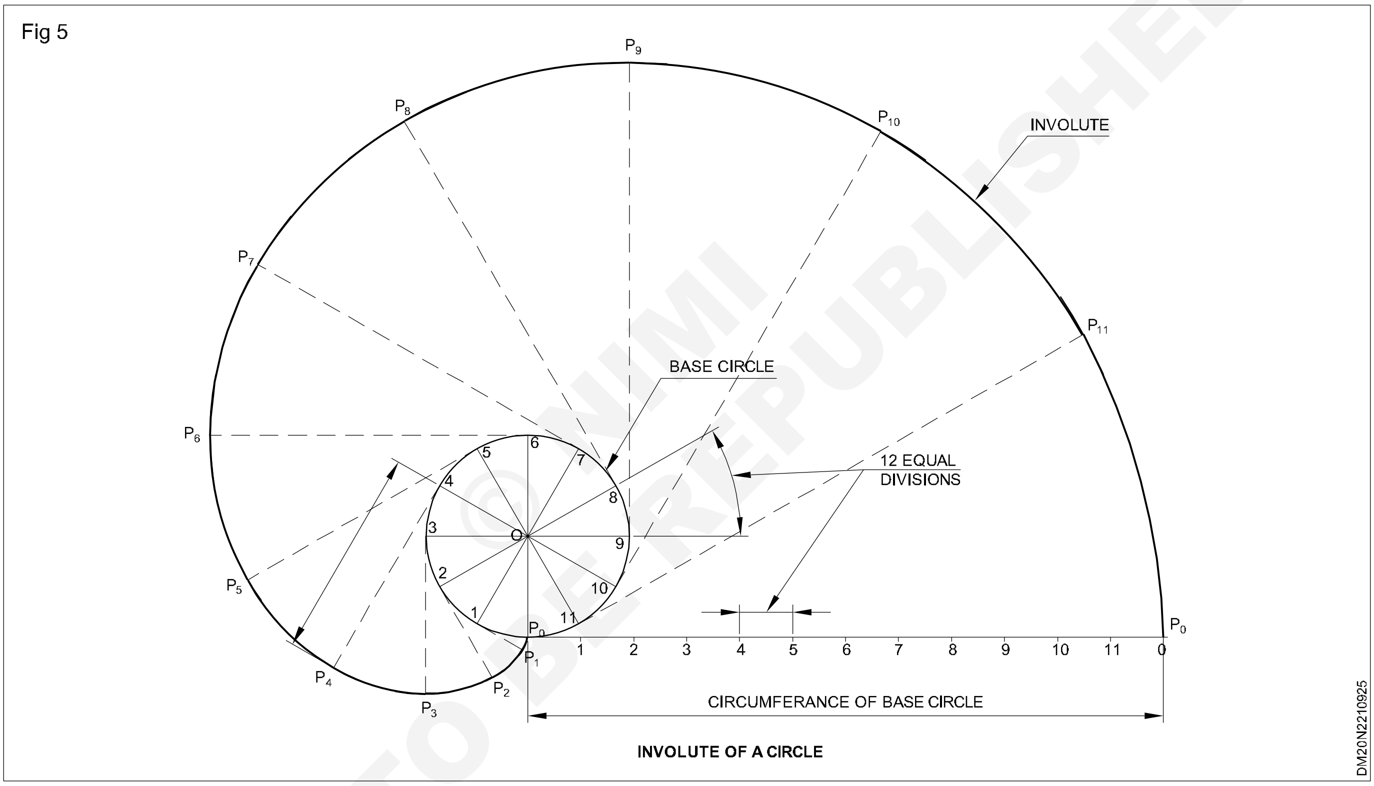


(a)EPICYCLOID

(b)HYPOCYCLOID



CYCLOID



INVOLUTE OF A CIRCLE

Cams & Types of cams

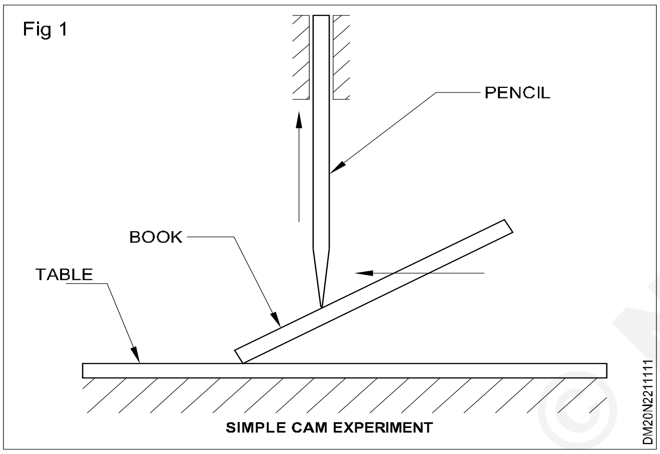
Objectives: At the end of this lesson you shall be able to
- **state about cam**
- **state the cam mechanism**
- **state the different types of cam.**

Cam

Introduction

Some parts of the machine may require an irregular motion instead of uniform motion & intermittent motion instead of continuous motion e.g the intermittest motion of the feed screw of a planner irregular motion of flame cutting nozzle along the guide. All these types of motions required for different purpose are often obtained by cams.

A simple experiment: What is a Cam? (Fig 1)



SIMPLE CAM EXPERIMENT

Take a pencil and a book to do an experiment as shown above. Make the book an inclined plane and use the pencil as a slider (use your hand as a guide). When you move the book smoothly upward, what happens to the pencil? It will be pushed up along the guide. By this method, you have transformed **one motion into another motion** by a very simple device. This is the basic idea of a cam. By rotating the cams in the Fig 1 below, the bars will have either **translation or oscillatory motion.**

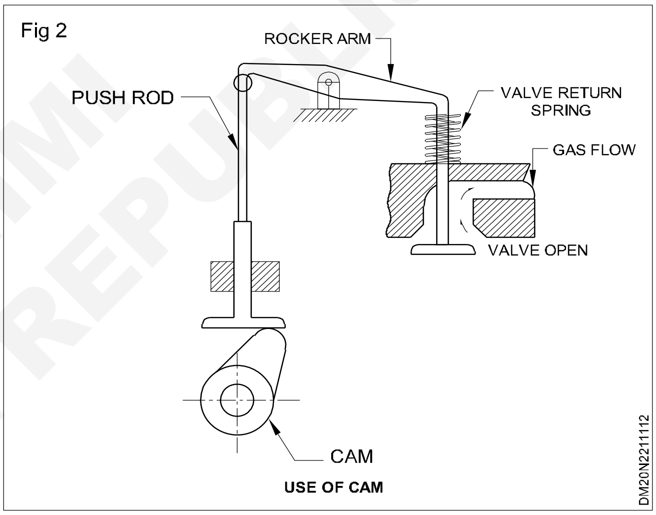
Cam Mechanism

The transformation of one of the simple motions, such as rotation, into any other motions is often conveniently accomplished by means of a cam mechanism. A cam mechanism usually consists of two moving elements, the cam and the follower, mounted on a fixed frame. Cam devices are versatile, and almost any arbitrarily - specified motion can be obtained. In some instances, they offer the simplest and most compact way to transform motions.

A cam may be defined as a machine element having a curved outline or a curved groove by which its **oscillation or rotation motion**, gives a predetermined specified motion to another element called the follower. The cam has a very important function in the operation of many classes of machines, especially those of the automatic type, such as printing presses, shoe machinery, textile machinery, gear - cutting machines, and screw cutting machines internal. In any class of machinery in which **automatic control** and **accurate timing** are paramount, the cam is an indispensable part of mechanism. The possible applications of cams are unlimited, and their shapes occur in great variety.

The transformation of one of the simple motions, such as rotation, into any other motions is often conveniently accomplished by means of a cam mechanism.

In auto motion and to change **rotational motion to linear motion cam** is very useful mechanism. In automatic machine cam's function are essential.



USE OF CAM

Classification of cams

In general, the cams may be grouped into two classes

1 Uniform motion cams.

2 Uniformly accelerated motion cams.

Uniform motion cams

A Uniform motion cam moves the follower at the same rate of speed from beginning to end of the stroke

Uniformly accelerated motion cams

The cam by which the speed of the followers is first slow and then accelerated at a uniform rate until the maximum speed is reached , is best suited for high speeds. The speed is then again uniformly related to zero when the reversal takes place. A cam constructed along these lines is called a uniformly accelerated motion cam.

Types of cams

Different types of cams are as follows depending upon their shape and applications

1 **Radial or disc cam (Edge or plate cams)**

a Reciprocating cam

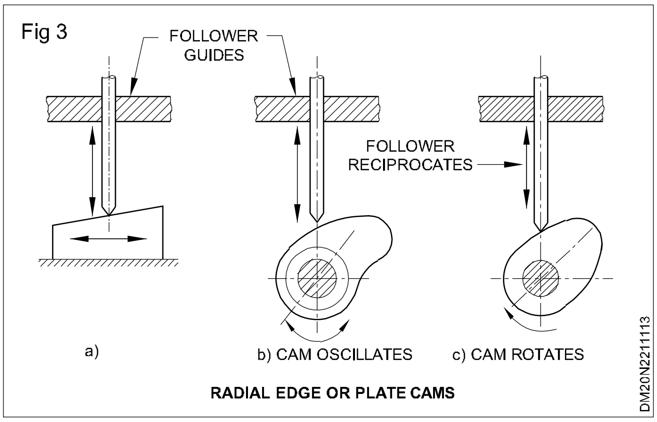
b Tangent cam

c Circular cam

2 **Cylindrical cams**

3 **End cam**

Radial or disc cams (Fig 3)



In the case of radial cams , the follower moves in a direction perpendicular to the cam axis.

Reciprocating cam:

Reciprocating cam can give reciprocating motion or oscillating motion to the follower

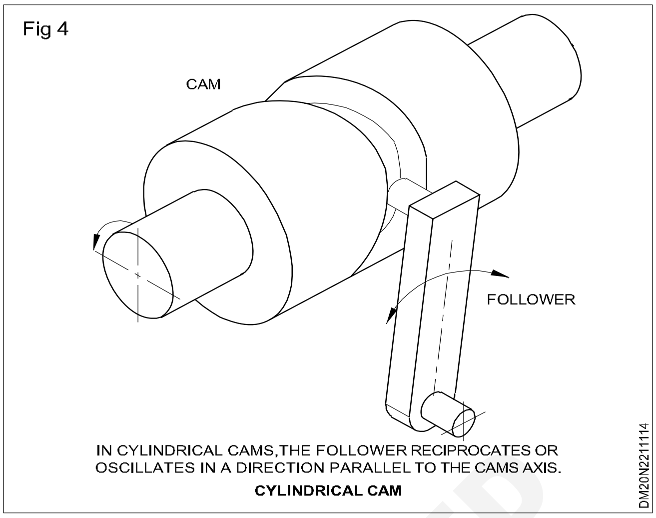
Tangent cam

Tangent cam has straight flanks and circular nose.It is mounted on a shaft. It cam give reciprocating or oscillating motion to the follower.

Circular cam:

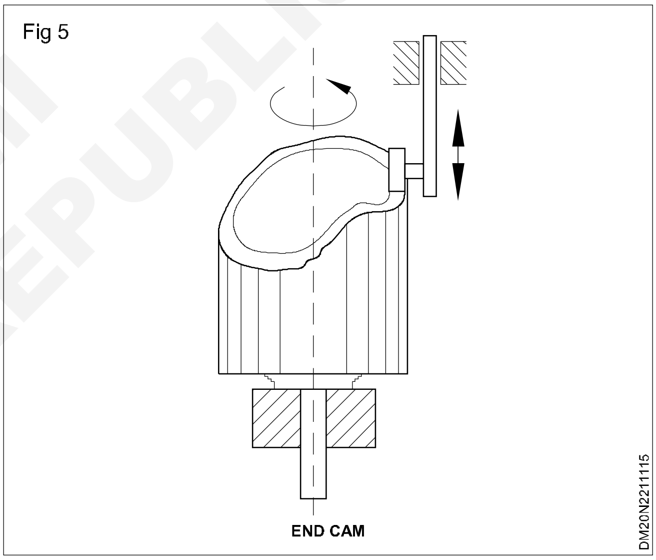
Circular cam has circular flank and circular nose. It is mounted on a shaft. It gives reciprocating motion to the follower.

Cylindrical cam (Fig 4)



In cylindrical cams the follower moves parallel to the cam axis cylindrical cams or cylindrical grooved cams is also mounted on a shaft and can give reciprocating or oscillating motion to the follower.

End cam (Fig 5)



This cam has a rotating portion of a cylinder. The follower translates or oscillators where as the cam usually rotates.The end cam is rarely used because of the cost and the difficulty in cutting its contour.

Kinds of motion in cam & Displacement diagrams

Objectives: At the end of this lesson you shall be able to
- **explain different kinds of motions**
- **draw the displacement diagrams.**

Kinds of motion in cam

Cams are designed primarily to produce the following motions

1 Uniform velocity

2 Simple harmonic motion

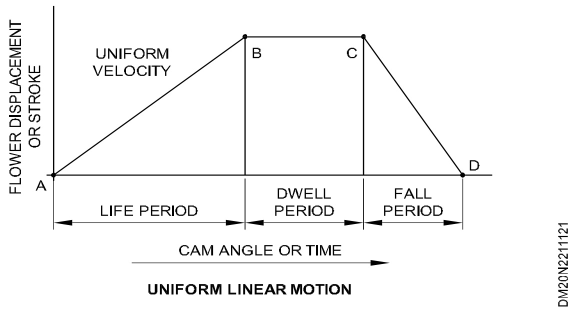
3 Uniform acceleration and Retardation or Gravity motion

4 Cycloidal motion

Uniform Velocity

The constant slope line indicates uniform velocity i.e. equal displacements in equal intervals of time for follower lift and fall periods. Fig 1 shows the displacement diagram of uniform velocity motion.

Fig 1

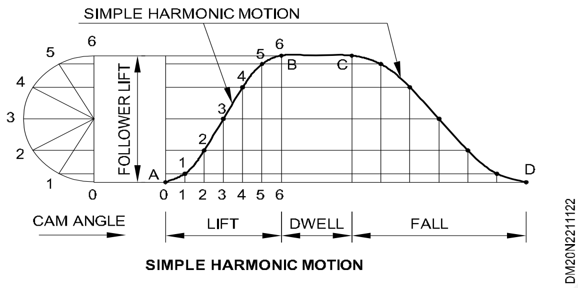


Simple harmonic motion

Harmonic motion is a sine curve and is a smooth continuous motion based on the changing of position of the points on the circumference of a circle.

At moderate speed this displacement result in a smooth operation. Fig 2 shows the displacement diagram of simple harmonic motion.

Fig 2



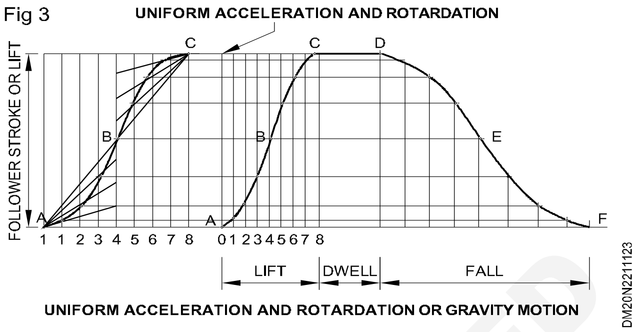
Uniform acceleration and Retardation or Gravity motion.

Gravity motion is commonly used for high speed operation. The gravity fall of the follower is designed to conform to the shape of the cam.so that its contact with the surface will provide smooth operation. Fig 3 shows the displacement diagram of gravity motion.

Cycloidal motion

Cycloid is a curve traced by a point on a circle, when the circle rolls without slipping on a straight line.

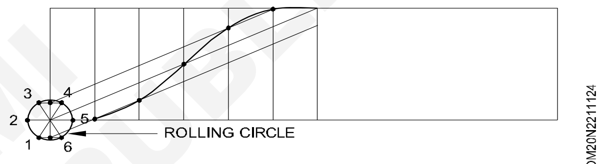
Fig 3



In case of cams, this straight line is a stroke of the follower which is translating and the circumference of the rolling circle is equal to the stroke of the follower.

Fig 4 shows the displacement diagram of cycloidal motion.

Fig 4



$2\pi r = s$ R - Radius of the rolling circle

$R = \frac{s}{2\pi}$ S - Stroke of the follower

Terms used in cam

Objectives: At the end of this lesson you shall be able to
- **explain the terms used in cam.**

Terms used in cam (Fig1)

Base circle

The circle of the least radius of the cam.

Lift

Difference between maximum distance of the lowest point of the follower from the axis of rotation of the cam and least radius is known as the lift of the follower.

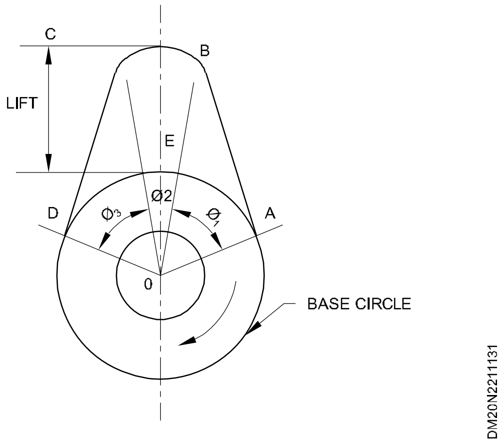
Angle of ascent

Angle moved by the cam,from the instant the follower begins to rise till it reached its highest position, is known as angle of ascent and it is equal to the angle AOB (Fig -1)

Angle of dwell:

Angle through which the cam rotates during the period in which the follower remains in its highest position is known as angle of dwell. This angle is equal to the angle BOC in fig 1.

Fig 1



Dwell:

Profile of the cam on which the follower neither reciprocates nor oscillates

Angle of descent

Angle moved by the cam from the instant the follower begins to fall, till it reached its lowest position is known as angle of descent. This angle is equal to angle COD in Fig 1

Angle of action

Total angle moved by the cam from the beginning of ascent to the termination of descent is termed as angle of action.

Types of follower

Objectives: At the end of this lesson you shall be able to
- **name the different types of follower**
- **explain the different types of follower.**

Types of follower (Fig 1)

Three basic types of cam follower are

1 Knife edge follower

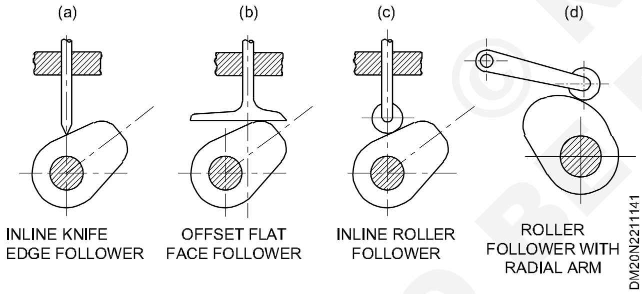
2 Flat face follower

3 Roller follower

Knife edge and the flat face followers are limited to use with slow moving cams where the minimum of force will be excerpted by the friction that is caused during rotation.

The roller is the most often used form of followers since it can withstand higher speeds and can transmit greater forces and also used for any application where heat and wear require careful consideration but they are most expensive.

Fig 1

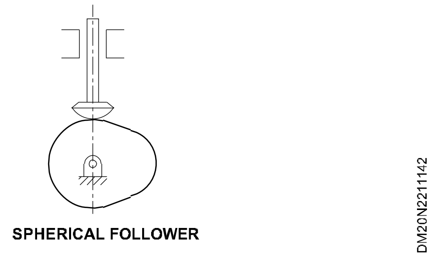


Spherical follower (Fig 2)

In a spherical follower, the spherical surface is in contact with the cam.In order to minimize the surface stress produced in the flat follower, a spherical shape having a surface of a large sphere radius is given to the flat end. The spherical follower are also used in automobile engineers.

Followers may oscillate in a straight line or radially and they may be offset from the cam centre of rotation. All these variations give the designs a wide choice for the most suitable arrangement for a given engine or mechanism.

Fig 2



Reciprocating steam engine mechanism

Objectives: At the end of this lesson you shall be able to
- **define steam engine**
- **explain steam engine driving mechanism.**

Introduction

A steam power plant consists of a steam generating unit i.e. boiler in which the steam is generated, a prime mover in which the energy of the steam is converted into mechanical work, and a condenser in which the steam is condensed. The prime mover used in a steam power plant is classified as a reciprocating steam engine and a steam turbine.

The reciprocating steam engine is a form of heat engine in which the work is done by the pressure of the steam acting on a moving piston. Although it has been used as a prime mover successfully for many years, it is now practically replaced by the steam turbine for larger powers, and by the internal, combustion engine for small powers.

The main advantages in favor of the use of steam engines are:

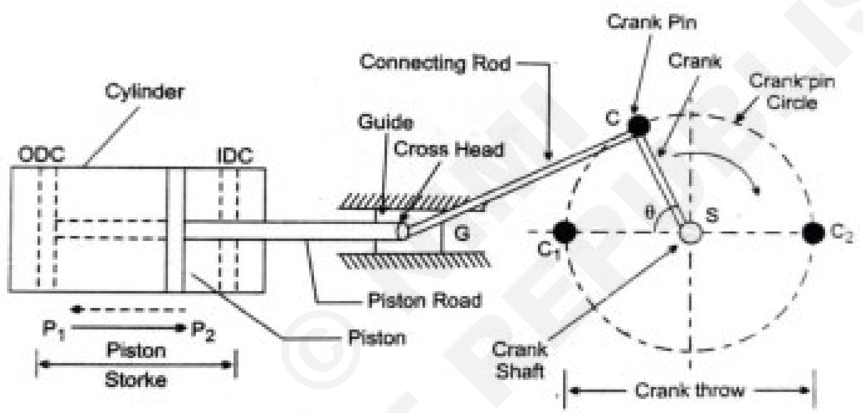
1 It is more efficient for small powers

2 The rotation of the crank shaft may be reversed

3 It is easily repairable.

The line diagram of a steam engine mechanism is shown in fig 1.

Fig 1



Classification

A reciprocating steam engine may be classified as follows:

i **Single acting and double acting:** When steam acts only on one side of the piston, it is called a single acting steam engine, where as in a double acting steam engine steam acts on both sides of the piston alternately.

ii **Condensing and non-condensing:** In a condensing steam engine, the exhaust steam is discharged and condensed into a chamber called the condenser and the expansion of the steam is done much below the atmospheric pressure. In a non-condensing steam engine, however, the exhaust steam is discharged into the atmosphere and the expansion of steam is done above the atmospheric pressure,

iii **Simple and compound:** In a simple steam engine, the expansion of steam is done in a single cylinder, where as in a compound steam engine, the total expansion of steam takes place in more than one cylinders.

Reciprocating steam engines

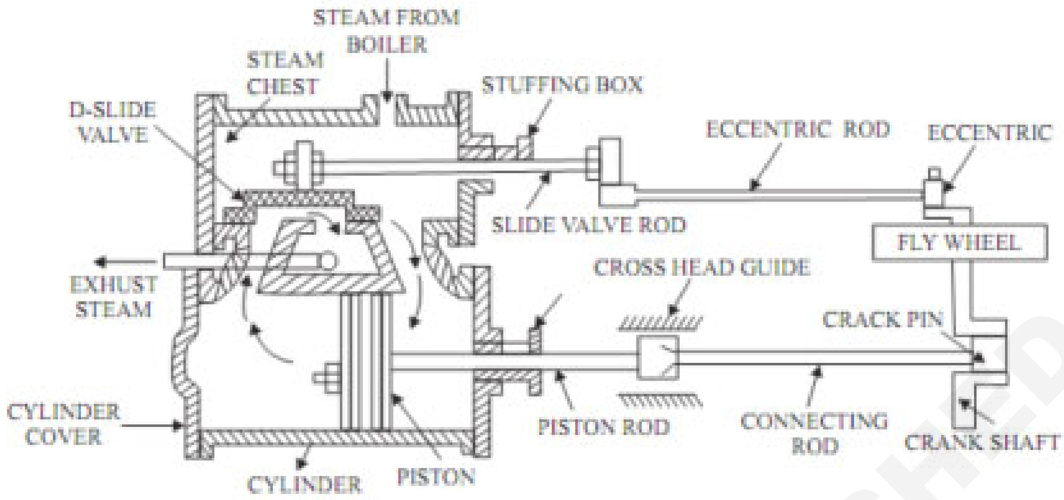
Engine Details (Fig 2)

The engine being a reciprocating one the piston reciprocates inside the cylinder and the movement is transmitted to the crankshaft through a piston and a connecting rod. To control the admission and exhaust of steam usually a slide valve rec procares inside the valve chamber and its motion is received from the eccentric through an eccentric rod and a slide valve rod.

Cylinder: The steam engine cylinder consists of two chambers-one cylinder chamber and the other valve chamber or valve chest. The piston moves inside the cylinder chamber and the slide valve moves inside the valve chamber. There are two openings or ports at the cylinder chamber through which steam passes to and from the cylinder. There is a third passage between the steam ports, called the exhaust port, which leads steam either into the atmosphere or to the condenser.

Piston: The piston is a movable plug which reciprocates from one to the other end of the cylinder due to the pressure of steam. It is fitted with piston rings generally made of rectangular cross-section inside the ring grooves and they are used to prevent the leakage of steam from one to the other side of the piston. At least two rings should be fitted. The movement of the piston from one to the other end of the cylinder is called the stroke of the piston and the volume swept through by the piston in one stroke is called the stroke volume, and the volume left by the piston at the end of the stroke is called the clearance volume.

Fig 2



Crosshead and guide: The crosshead is a block where the outer end of the piston rod is forged or attached by means of bolts and nuts. The connecting rod end is also connected with the block by means of a pin called crosshead pin or gudgeon pin. The outer part of the crosshead is called the slipper, which is controlled by a guide bar. This makes the crosshead to get only the sliding motion.

Connecting rod and crank shaft: The connecting rod is connected with the crank shaft by a crank pin. The reciprocating motion of the piston is converted into circular motion of the crank shaft through the connecting rod and two strokes of the piston make one revolution of the crank shaft. The flywheel and the eccentric are also connected to the crank shaft. The distance between the axes of the crank pin and the crank shaft is called the radius of the crank. The throw of the crank is equal to the diameter of the crank pin path which is again equal to the stroke of the piston.

If the speed of the crank shaft is N r.p.m., the piston speed will be equal to 2 NL m/min., where L is the stroke length in metres.

Engine crankshaft

The crankshaft transforms the linear motion of the pistons into a rotational motion that is transmitted to the load. A crankshaft has three main functions:

- To convert the reciprocating motion of the pistons into rotational motion.
- To transmit the power of an engine to the load.
- To balance the forces acting on the engine.

Crankshaft Parts

Crankshafts are usually manufactured from forged steel. The forged crankshaft is machined to produce the crankshaft bearing and connecting rod bearing surfaces. The rod bearings are eccentric, or offset, from the centre of the crankshaft. This offset converts the reciprocating (up and down) motion of the piston into the rotary motion of the crankshaft. The amount of offset determines the stroke (distance the piston travels from bottom dead centre (BDC) to top dead centre (TDC)) of the engine.

TDC and BDC Indicated

The crankshaft does not ride directly on the cast iron block crankshaft supports, but rides on special bearing material. The connecting rods also have bearings inserted between the crankshaft and the connecting rods. The bearing material is a soft alloy of metals that provides a replaceable wear surface and prevents galling between two similar metals i.e. between the crankshaft and connecting rod. Each bearing is split into halves to allow assembly of the engine. The crankshaft is drilled with oil passages that allow the engine to feed oil to each of the crankshaft bearings and connection rod bearings and up into the connecting rod itself.

Plain Bearing

The crankshaft has large weights, called counterweights (crank webs), that balance the weight of the connecting rods. These weights ensure an even (balance) force during the rotation of the moving parts.

Crankshaft and Bearing Lubrication

Tip 1: Crankshaft counterweights are also referred to as the crank webs.

Tip 2: Single piece bearings and bearings split into multiple parts, are known as plain bearings (journal bearings).

Tip 3: Soft metal bearings have a shiny white/grey appearance and are sometimes referred to as white metal bearings, or, Babbitt bearings (Babbitt was the inventor of the soft alloy).

Valve gears: The valve gear of a steam engine is a mechanism which controls the admission of steam into the cylinder and the discharge of steam from the cylinder. This arrangements is different for different types of valves. A simple valve gear consists of an eccentric and a slide valve.

Valves

The function of a steam engine valve is to control the flow of steam from the steam chest to the cylinder or from the cylinder to the outside so as to perform the following four operations

a admission, b cut off, c release and d compression.

Valve Driving Mechanisms (Fig 3)

A slide valve is generally driven by means of an eccentric which is nothing but a small crank where the crank pin diameter is large enough to embrace the crank shaft. The circular motion of the crank shaft is converted into the reciprocating motion of the slide valve by the eccentric which is fitted at the crank shaft. An eccentric is therefore used to get a very small reciprocating motion from a circular motion.

The eccentric consists of a circular disc E called an eccentric sheave. There is an opening inside the sheave at a short distance from its centre for the passage of the crank shaft. The sheave is

Covered by two straps ES called eccentric straps. One end of the eccentric rod ER is connected with one of the straps while the other end is connected with the slide valve rod SVR. The other end of the slide valve rod is connected with the slide valve.

If the slide valve has lap and lead, the angle between crank and eccentric will be (90+a), where a is called the angle of advance.

Transmission of motion through eccentric, crank and connecting rod

Objectives: At the end of this lesson you shall be able to
- **function of connecting rod.**

Eccentric

Eccentric is used to provided **a short reciprocating motion,** actuated by the rotation of a shaft eccentrics are used for operating steam valves small pump plungers, shaking screens etc. The components parts and assembly of an eccentric are shown in Figs 1 & 2 for easy understanding of their shapes. **Rotary motion can be converted into a reciprocating motion** with an eccentric but the reverse conversion is not possible due to, excessive friction between the sheave and the strap.

Crank

Crank in mechanics, arm secured at right angle to a shaft with which it can rotate or oscillate next to the wheel, the crank is the most important motion-transmitting device. Since with the connecting rod, it provides means for converting linear to rotary motion and vice-versa.

Connecting Rod

A connecting rod is a mechanical part that connects the piston to the crankshaft in a reciprocating engine. Connecting rod are commonly found in internal combustion engines, such as those used in cars and trucks. The connecting rod transfers the motion of the piston, which is driven by the combustion of fuel, to the crankshaft. The crankshaft then converts this into rotational motion, which drives the vehicle's wheels.

Connecting Rod Diagram

A connecting rod diagram is a visual representation of a connecting rod, which is a critical component in an engine. The diagram typically shows the connecting rod in relation to other parts of the engine, such as the piston, crankshaft, and cylinder. It may also include labels and other annotations to help explain the function and operation of the connecting rod. The diagram is often used to study and understand an engine's design and operation.

Connecting Rod Material

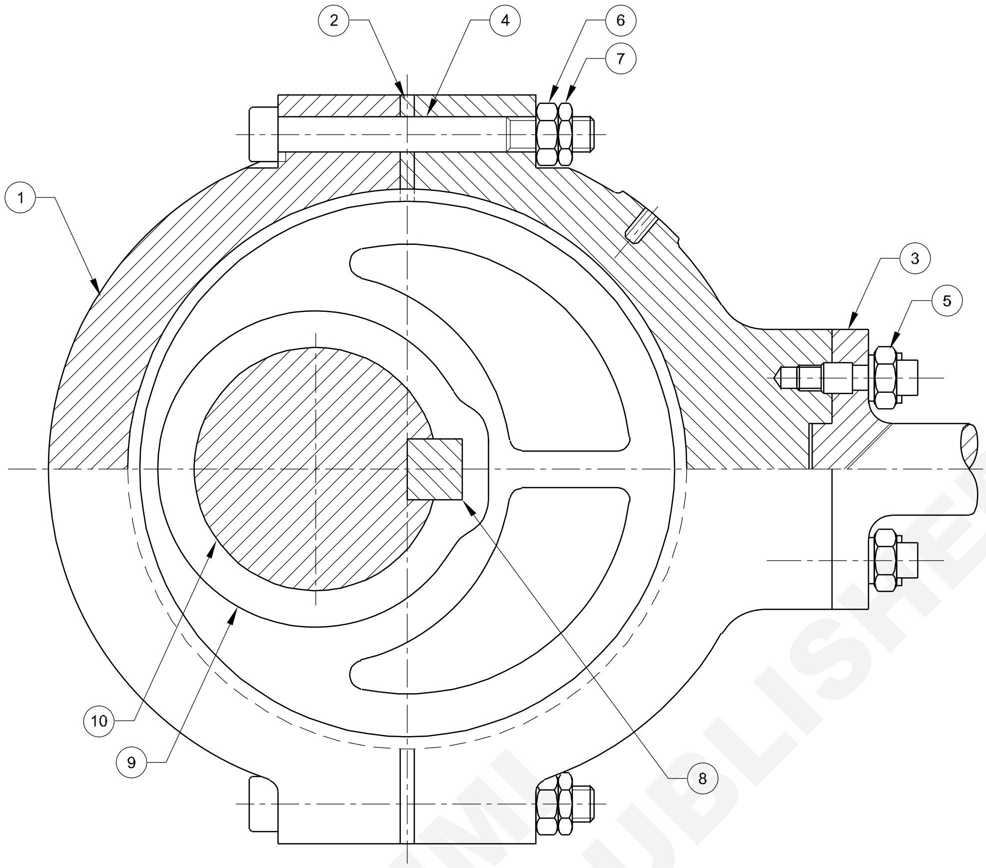
The material used for engine connecting rods can vary depending on the intended application and the engine's design. Common materials for connecting rods include steel, aluminum, and titanium. Each of these materials has unique properties that make it suitable for a connecting rod. For example, steel is known for its strength and durability, while aluminum is lightweight and has good thermal conductivity. On the other hand, Titanium is very strong and lightweight but also very expensive

Functions of Connecting Rod

The connecting rod is a critical component in an engine, as it connects the piston to the crankshaft and transfers the motion of the piston to the crankshaft. This motion is what drives the engine and allows it to generate power. There are several key functions of the connecting rod in an engine, including:

- Transferring the motion of the piston to the crankshaft: The connecting rod converts the piston's up-and-down motion into the rotational motion of the crankshaft.
- Supporting the weight of the piston: The connecting rod must be strong enough to support the weight of the piston and any other loads placed on it, such as the pressure of the combustion gases in the cylinder.
- Allowing the piston to move freely: The connecting rod must be able to move freely within the cylinder so that the piston can travel up and down without any obstruction.
- Absorbing the forces generated by the piston: The connecting rod must be able to withstand the forces generated by the piston as it moves up and down, such as the pressure of the combustion gases and the impact of the piston hitting the cylinder head.

Fig 2



PART NO.	NAME	MATL.	QTY.
1	STRAPS (SET)	C.I.	1
2	SHIM	G.M.	2
3	END ROD	STEEL	1
4	BOLT (M10 x 100)	M.S.	2
5	BOLT (M10 x 28)	M.S.	2
6	NUT	M.S.	2
7	LOCK NUT	M.S.	2
8	PARALLEL KEY	M.S.	1
9	SHEAVE	C.I.	1
10	SHAFT	STEEL	1

ELEVATION, TOP HALF IN SECTION
ECCENTRIC (ASSEMBLY)

DM20N2311312

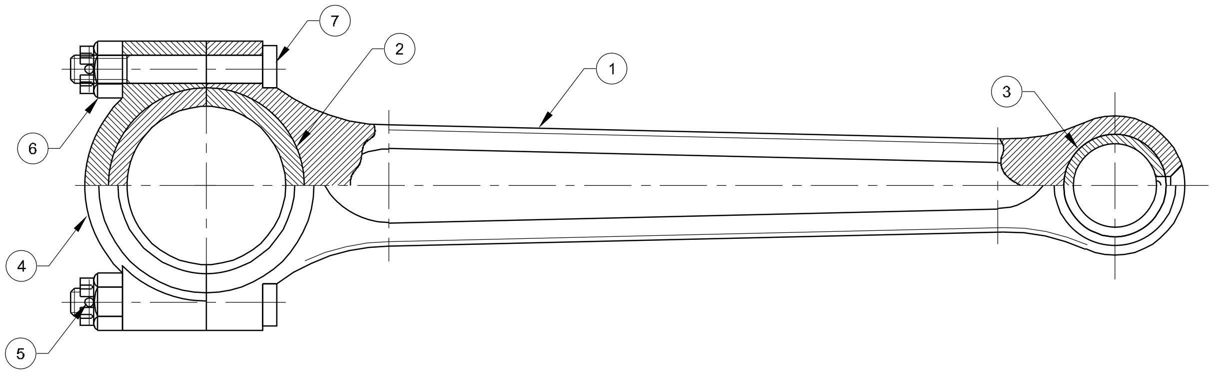
Parts of Connecting Rod

A connecting rod is a mechanical component that connects together two other mechanical parts, such as a piston and a crankshaft. It typically consists of several different parts, including the following:

- **Rod body:** This is the main part of the connecting rod and is typically made from strong, durable steel. It has a cylindrical shape with rounded ends and is designed to withstand the stresses and forces applied to it during operation.
- **The big end and small end:** The big end is the larger, rounded end of the connecting rod, which is attached to the crankshaft. The small end is the smaller, rounded end, which is attached to the piston. The rod body connects the big and small ends, designed to pivot and rotate relative to each other.
- **Crank pin:** The crank pin is a cylindrical component attached to the crankshaft and extends into the big end of the connecting rod. The crank pin allows the connecting rod to pivot and rotate relative to the crankshaft as the piston moves up and down in the cylinder.
- **Gudgeon pin:** The gudgeon pin, also known as a wrist pin or piston pin, is a small cylindrical component attached to the piston and extends into the small end of the connecting rod. The gudgeon pin allows the connecting rod to pivot and rotate relative to the piston as the crankshaft rotates.
- **Bearings:** Connecting rods typically have bearings at both the big and small ends, allowing them to pivot and rotate smoothly. These bearings may be made from various materials, such as bronze or a low-friction synthetic polymer.
- **Bolts and nuts:** Connecting rods are often held together with bolts and nuts, which allow them to be easily disassembled and reassembled for maintenance or repair. These bolts and nuts may be made from various materials, such as steel or an alloy.

Connecting - rods (Fig 1)

Fig 1



IC ENGINE CONNECTING ROD (ASSEMBLY)

It is fitted in between the **piston and crankshaft**. It converts the **reciprocating motion** of the piston to the **rotary motion** in the crankshaft. It must be light and strong enough to withstand stress and twisting forces.

The connecting rod is made of **high grade alloy steel**. It is drop-forged to 'I' shape. In some engines **aluminium alloy** connecting rods are also used. The upper end of the connecting rod has a hole for the piston pin. The lower end of the connecting rod is split, so that the connecting rod can be installed on the crankshaft. The top and bottom halves of the lower end of the connecting rod are bolted together on the crankshaft big end journal by bolt and nut.

A large bearing area is provided to take the load, heat and wear. The split halves are usually fitted with **babbitt**. In the upper end of the connecting rod a **bronze bush** is fixed. The small end of the connecting rod is connected to the piston by means of a piston pin.

In some engines a hole is drilled in the connecting rods from the big end to the small end. It allows **oil to flow** from the big end to the small end bush.

Stuffing Box: The function of the stuffing box (Fig 1) is to allow the piston rod or the slide valve rod to move in the cylinder or valve chamber without any leakage of steam. It may be a part of the cylinder C or the valve chest end. Necessary packings P Usually made of asbestos, canvas etc., are placed between the sliding rod R and the stuffing box and they are compressed by means of a gland G which is fitted with the stuffing box by studs and nuts.

I.C Engine mechanism

Objectives: At the end of this lesson you shall be able to
- **construction of IC engines.**

An engine is defined as the machine that converts the chemical energy liberated through combustion of a certain fuel, into a mechanical energy that is used to derive a certain vehicle. The definition highlights two important facts about the engines. First, an engine is a machine, hence a mechanism exists. This mechanism can vary, and thus we can have more than one mechanism of operation. The two most famous mechanism of actions are the two-stroke and four-stroke engines.

The second point in the definition is the conversion of chemical energy that results from combustion of a certain fuel. Based on the type of the fuel and the method of conversion of chemical energy to mechanical energy, one can distinguish two main types of engines, which are: Diesel engine and Gasoline engines. The first engine is based on a thermodynamic cycle called Diesel cycle, while the second is based on a cycle called Otto cycle. Due to the difference in the thermodynamic cycle that is used to burn the used fuel, a certain fuel was selected to suit the process. In Otto cycle engines, gasoline is the fuel. In Diesel cycle engine engines, diesel oil is the fuel.

There are two types of internal combustion engines:

(1) Reciprocating engines and

(2) Rotary engines or gas turbine.

Basic Operation of IC Engine:

The reciprocating internal combustion engines are mainly using slider crank mechanism for generation of power. The piston is reciprocating in the cylinder and it is connected to the connecting rod and crankshaft. The slider crank mechanism converts reciprocating motion into rotary motion.

The fuel is burned in the engine cylinder either by self-ignition or by external aid such as spark plug. The air and fuel mixture is supplied to the engine cylinder. The combustion of fuel occurs due to its reaction with the oxygen in the air. This produces hot gases in the engine cylinder which applies the force on the piston and the reciprocating motion of the piston is converted to rotary motion. Fig 13-2 shows basis operation of I.C. engine.

Construction of IC Engines:

The mechanical elements of the reciprocating I.C. engine. The piston which reciprocates in the cylinder is made a very close fit in the cylinder. In order to prevent the leakage of gas from one side of the piston to other side of it, piston rings are inserted in the circumferential grooves of the piston.

The cylinder is bored in the cylinder block may be bolted to the top of the crank case. The top of the cylinder is sealed down by bolting on to it the cylinder head. Generally gasket made of copper sheets and asbestos is inserted between the cylinder and cylinder head. The combustion space is provided in the top of cylinder head.

The reciprocating motion of the piston is converted into the rotary motion of the crankshaft by means of connecting rod and crank. The connecting rod connects the piston and the crank, which is mounted on the crankshaft. The pin which connects the piston and the connecting rod is known as the gudgeon pin or piston pin.

The bottom of the engine is closed by means of a sump. This sump often contains the oil, which is pumped round the engine for lubrication.

A mechanical cycle for an internal combustion engine can be completed in one revolution (two stroke cycle) of the crankshaft or in two revolutions (four stroke cycle) of the crankshaft.

In an engine running on four stroke cycle principle, there are mechanically operated valves which control admission and exhaust to and from the engine cylinder. The opening and closing of the valves is controlled by means of cams which are fixed to the camshaft.

The camshaft is operated by means of a gear drive or chain drive from the crankshaft. The camshaft runs at half the speed of the crankshaft. The valves, which are known as poppet valves, are held down in closed position by means of valve springs.

Injection systems - petrol and diesel engines

Objectives: At the end of this lesson you shall be able to
- **state functional requirements of an injection system**
- **classify injection systems**
- **define injection in SI engine.**

Introduction

The fuel-injection system is the most vital component in the working of CI Engines. The engine performance viz., power output, economy etc. Is greatly dependent on the effectiveness of the fuel-injection system. The injection system has to perform the important duty of initiating and controlling the combustion process.

Basically, the purpose of carburetion and fuel-injection is the same viz., preparation of the combustible charge. But in case of carburetion fuel is atomized by processes relying on the air speed greater than fuel speed at the

Fuel nozzle, whereas, in fuel-injection the fuel speed at the point of delivery is greater than the air speed to atomize the fuel. In carburetors, as explained in chapter 7, air flowing through a venturi picks up fuel from a nozzle located there. The amount of fuel drawn into the engine depends upon the air velocity In the venturi. In a fuel-injection system, the amount of fuel delivered into the air stream going to the engine is controlled by a pump which forces the fuel under pressure.

When the fuel is injected into the combustion chamber towards the end of compression stroke, it is atomized into very fine droplets. These droplets vaporize due to heat transfer from the compressed air and form a fuel-air mixture. Due to continued heat transfer from hot air to the fuel, the temperature reaches a value higher than its self-ignition temperature. This causes the fuel to ignite spontaneously initiating the combustion process.

Functional requirements of an injection system

For a proper running and good performance from the engine, the following requirements must be met by the injection system:

i Accurate metering of the fuel injected per cycle. This is very critical due to the fact that very small quantities of fuel being handled. Metering errors may cause drastic variation from the desired output. The quantity of the fuel metered should vary to meet changing speed and load requirements of the engine.

ii Timing the injection of the fuel correctly in the cycle so that maximum power is obtained ensuring fuel economy and clean burning.

iii Proper control of rate of injection so that the desired heat-release pattern is achieved during combustion.

iv Proper atomization of fuel into very fine droplets.

v Proper spray pattern to ensure rapid mixing of fuel and air.

vi Uniform distribution of fuel droplets in the combustion chamber.

vii To supply equal quantities of metered fuel to all cylinders in case of multi cylinder engines.

viii No lag during beginning and end of injection i.e., to eliminate dribbling of fuel droplets into the cylinder.

Classification of injection systems

In a constant-pressure cycle or diesel engine, only air is compressed in the cylinder and then fuel is injected into the cylinder by means of a fuel-injection system. For producing the required pressure for atomizing the fuel either air or a mechanical means is used. Accordingly the injection systems can be Classified as:

i Air injection systems

ii Solid injection systems

Air injection system

In this system, fuel is forced into the cylinder by means of compressed air. This system is little used nowadays, because it requires a bulky multi-stage air compressor. This causes an increase in engine weight and reduces the brake power output further. One advantage that is claimed for the air injection system is good mixing of fuel with the air with resultant higher mean effective pressure. Another is the ability to utilize fuels of high viscosity which are less expensive than those used by the engines with solid injection systems. These advantages are off-set by the requirement of a multistage compressor thereby making the air-injection system obsolete.

Solid injection system

In this system the liquid fuel is injected directly into the combustion chamber without the aid of compressed air. Hence, it is also called airless mechanical injection or solid injection system. Solid injection systems can be classified as:

i Individual pump and nozzle system

ii Unit injector system

iii Common rail system

iv Distributor system

All the above systems comprise mainly of the following components.

i Fuel tank,

ii Fuel feed pump to supply fuel from the main fuel tank to the injection system,

iii Injection pump to meter and pressurize the fuel for injection,

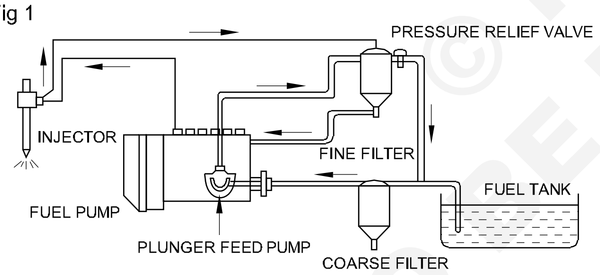
iv Governor to ensure that the amount of fuel injected is in accordance with variation in load,

v Injector to take the fuel from the pump and distribute it in the combustion chamber by atomizing it into fine droplets,

vi Fuel filters to prevent dust and abrasive particles from entering the pump and injectors thereby minimizing the wear and tear of the components.

A typical arrangement of various components for the solid injection system used in a ci engine. Fuel from the fuel tank first enters the coarse filter from which is drawn into the plunger feed pump where the pressure is raised very slightly. Then the fuel enters the fine filter where all the dust and dirt particles are removed. From the fine filter the fuel enters the fuel pump where it is pressurized to about 200 bar and injected into the engine cylinder by means of the injector. Any spill over in the injector is returned to the fine filter. A pressure relief valve is also provided for the safety of the system. The above functions are achieved with the components listed above. The types of solid injection system described in the following sections differ only in the manner of operation and control of the components mentioned above. (Fig 1)

Fig 1



TYPICAL FUEL FEED SYSTEM FOR A CI ENGINE

Injection in SI engine

Fuel-injection systems are commonly used in ci engines. Presently gasoline injection system is coming into vogue in SI engines because of the following drawbacks of the carburetion.

i Non uniform distribution of mixture in multicylinder engines.

ii Loss of volumetric efficiency due to restrictions for the mixture flow and the possibility of back firing.

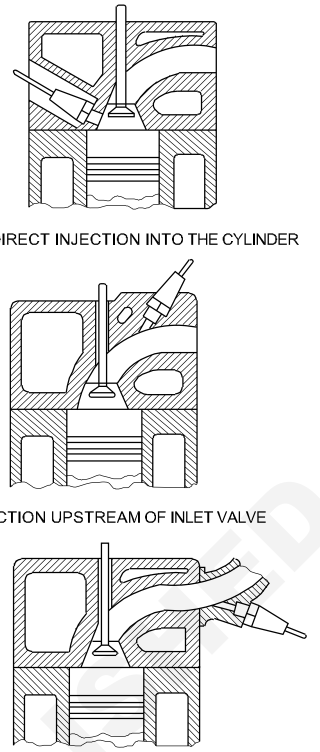
A gasoline injection system eliminates all these drawbacks. The injection of fuel into an SI engine can be done by employing any of the following methods. (Fig 2)

a Direct injection of fuel into the cylinder

b Injection of fuel close to the inlet valve

c Injection of fuel into the inlet manifold

Fig 2



(a) DIRECT INJECTION INTO THE CYLINDER

(b) INJECTION UPSTREAM OF INLET VALVE

(b) INJECTION INTO THE INLET MANIFOLD

LOCATION OF INJRCTION NOZZLE

There are two types of gasoline injection systems, viz.,

i **Continuous injection :** Fuel is continuously injected. It is adopted when manifold injection is contemplated.

ii **Timed injection :** Fuel is injected only during induction stroke over a limited period. Injection timing is not a critical factor in SI engines.

Major advantages of fuel-injection in an SI engine are:

i Increased volumetric efficiency

ii Better thermal efficiency

iii Lower exhaust emissions

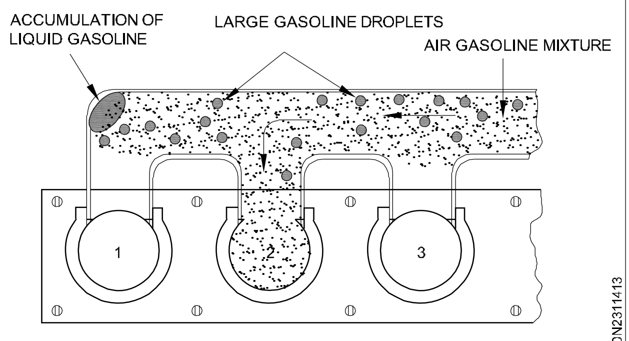
iv High quality fuel distribution

The use of petrol injection is limited by its high initial cost, complex design and increased maintenance requirements. It is believed that the petrol injection has a promising future compared to carburetion and may replace carburetor in the near future.

Gasoline injection

In a carburettor engine, uniformity of mixture strength is difficult to realize in Each cylinder of a multicylinder engine. Figure 9.1 shows a typical pattern of mixture distribution in an intake manifold of a multicylinder engine. As may be noticed that the intake valve is open in cylinder 2. As can also be observed the gasoline moves to the end of the manifold and accumulates there. This enriches the mixture going to the end cylinders. However, the central cylinders, which are very close to the carburetor, get the leanest mixture. Thus the various cylinders receive the air-gasoline mixture in varying quantities and richness. This problem is called the maldistribution and can be solved by the port injection system by having the same amount of gasoline injected at each intake manifold. Therefore, there is an urgent need to develop injection systems for gasoline engines. By adopting gasoline injection each cylinder can get the same richness of the air-gasoline mixture and the maldistribution can be avoided to a great extent. (Fig 3)

Fig 3



TYPICAL PATTERN OF MIXTURE DISTRIBUTION IN A MULTI-CYLINDER ENGINE

As already mentioned, some of the recent automotive engines are equipped with gasoline injection system, instead of a carburetion for one or more of the following reasons:

i To have uniform distribution of fuel in a multicylinder engine.

ii To improve breathing capacity i.e. Volumetric efficiency.

iii To reduce or eliminate detonation.

iv To prevent fuel loss during scavenging in case of two-stroke engines.

Types of injection systems

The fuel injection system can be classified as:

i Gasoline direct injection into the cylinder (GDI)

ii Port injection

a Timed, and b Continuous

iii Manifold injection

The above fuel injection systems can be grouped under two heads, viz., single-point and multi-point injection. In the single point injection system, one or two injectors are mounted inside the throttle body assembly. Fuel sprays are directed at one point or at the center of the intake manifold. Another name of the single point injection is throttle body injection. Multipoint injection has one injector for each engine cylinder. In this system, fuel is injected in more than one location. This is more common and is often called port injection system.

As already mentioned the gasoline fuel injection system used in a spark ignition engine can be either of continuous injection or timed injection.

i Continuous injection systems: this system usually has a rotary pump. The pump maintains a fuel line gauge pressure of about 0.75 to 1.5 bar. The system injects the fuel through a nozzle located in the manifold immediately downstream of the throttle plate. In a supercharged engine, fuel is injected at the entrance of the supercharger. The timing and duration of the fuel injection is determined by electronic control unit (ECU) depending upon the load and speed.

ii Timed fuel injection system: this system has a fuel supply pump which sends fuel at a low pressure of about 2 bar when the engine is running at maximum speed. A fuel metering or injection pump and a nozzle are the Other parts of the system. The nozzle injects the fuel in the manifold or the cylinder head port at about 6.5 bar or into the combustion chamber at pressures that range from 16 to 35 bar. Timed injection system injects fuel usually during the early part of the suction stroke. During maximum power operation injection begins after the closure of the exhaust valve and ends usually after BDC. Direct in-cylinder injection is superior and always desirable and better compared to manifold injection. In this case both low and high volatile fuels can be used and higher volumetric efficiencies can be achieved. However, it was noticed that direct injection caused oil dilution in the frequent warm up phases if the car is used for daily transportation.

Typical fuel injection methods used in four stroke and two stroke gasoline engines.

Components of injection system

The objectives of the fuel injection system are to meter, atomize and uniformly distribute the fuel throughout the air mass in the cylinder. At the same time it must maintain the required air-fuel ratio as per the load and speed requirement of the engine. To achieve all the above tasks, a number of components are required in the fuel injection system, the functions of which are mentioned below.

i Pumping element - moves the fuel from the fuel tank to the injector. This includes necessary piping, filter etc.

ii Metering element - measures and supplies the fuel at the rate demanded by load and speed conditions of the engine.

iii Mixing element - atomizes the fuel and mixes it with air to form a homogenous mixture.

iv Metering control - adjusts the rate of metering in accordance with load and speed of the engine.

v Mixture control - adjusts fuel-air ratio as demanded by the load and speed.

vi Distributing element - divides the metered fuel equally among the cylinders.

Multi-point fuel injection (MPFI) system

The main purpose of the multi-point fuel injection (MPFI) system is to supply a proper ratio of gasoline and air to the cylinders. These systems function under two basic arrangements, namely

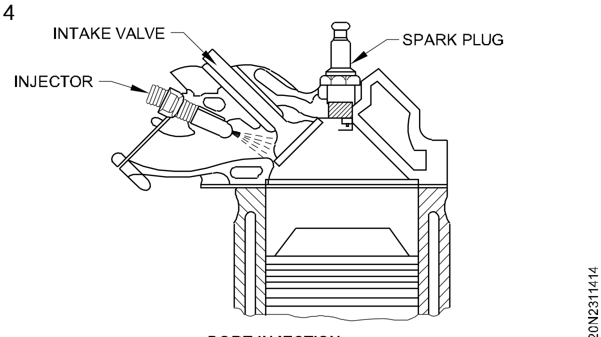
i Port injection

ii Throttle body injection

Port injection

In the port injection arrangement, the injector is placed on the side of the intake manifold near the intake port, the injector sprays gasoline into the air, inside the intake manifold. The gasoline mixes with the air in a reasonably uniform manner. This mixture of gasoline and air then passes through the intake valve and enters into the cylinder. (Fig 4)

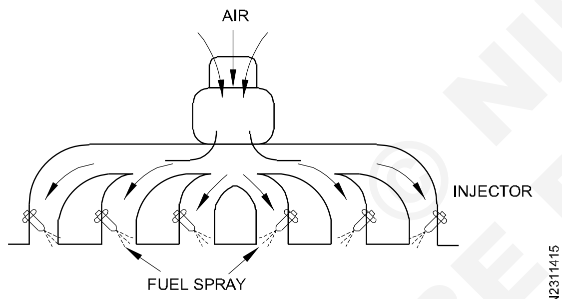
Fig 4



PORT INJECTION

Every cylinder is provided with an injector in its intake manifold. If there are six cylinders, there will be six injectors. A simplified view of a port or multi point fuel injection (mpfi) system. (Fig 5)

Fig 5

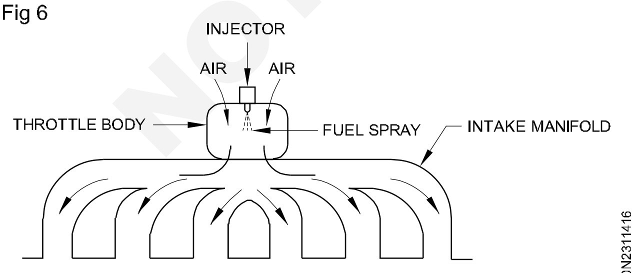


MULTI-POINT FUEL INJECTION (MPFI) NEAR PORT

Throttle body injection system (Fig 6)

Illustrates the simplified sketch of throttle body injection system (single point injection). This throttle body is similar to the carburettor throttle body, with the throttle valve controlling the amount of air entering the Intake manifold.

Fig 6



THROTTLE BODY INJECTION (SINGLE POINT)

An injector is placed slightly above the throat of the throttle body. The injector sprays gasoline into the air in the intake manifold where the gasoline mixes with air. This mixture then passes through the throttle valve and enters into the intake manifold.

As already mentioned, fuel-injection systems can be either timed or continuous. In the timed injection system, gasoline is sprayed from the injectors in pulses. In the continuous injection system, gasoline is sprayed continuously from the injectors. The port injection system and the throttle-body injection system may be either pulsed systems or continuous systems. In both systems, The amount of gasoline injected depends upon the engine speed and power demands. In some literature MPFI systems are classified into two types: DMPFI and I-MPFI.

Functional divisions of MPFI system

The MPFI system can be functionally divided into

i Electronic control system,

ii Fuel system, and

iii Air induction system.

These functional divisions are described in the following sections.

MPFI -electronic control system

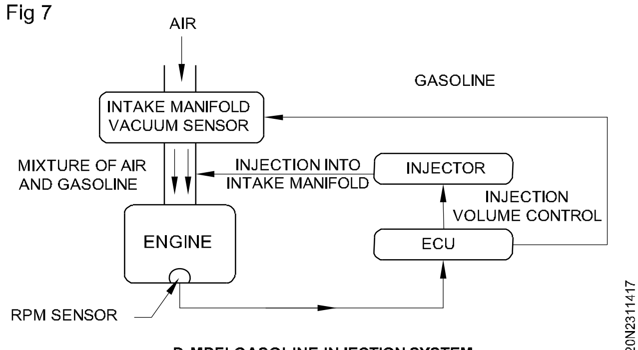
The MPFI -electronic control system is shown in the form of block diagram in fig.9.8. The sensors that monitor intake air temperature, the oxygen, the water temperature, the starter signal and the throttle position send signals to the ECU. The air-flow sensor sends signals to the ECU regarding the intake air volume. The ignition sensor sends information about the engine speed. The ECU processes all these signals and sends appropriate commands to the injectors, to control the volume of the fuel for injection. When necessary the cold-start injector timing switch off the ECU operates the cold start injector which is a part of the fuel system.

MPFI-fuel system

The MPFI -fuel system is shown in the form of block diagrams. In this system, fuel is supplied by the fuel pump. At the time of starting, the cold start injector is operated by the cold start injector time switch. The cold start injector injects fuel into the air intake chamber, thus enriching the air-fuel mixture. The pressure regulator regulates the pressure of the fuel. The injectors receive signals from the ECU and inject the fuel into the intake manifold.

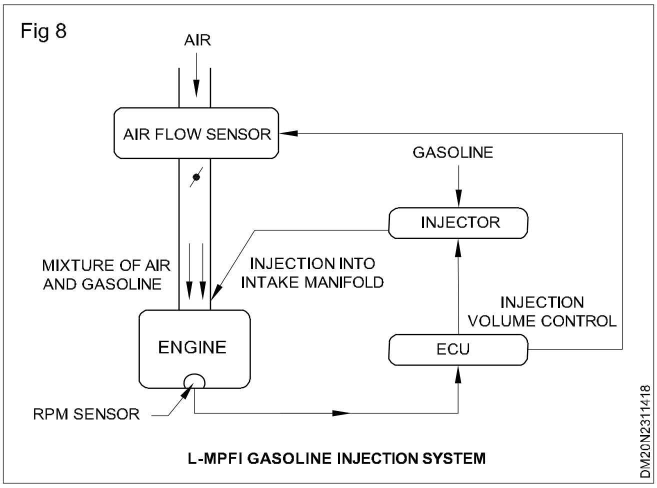
MPFI -air induction system (Fig 7)

Fig 7

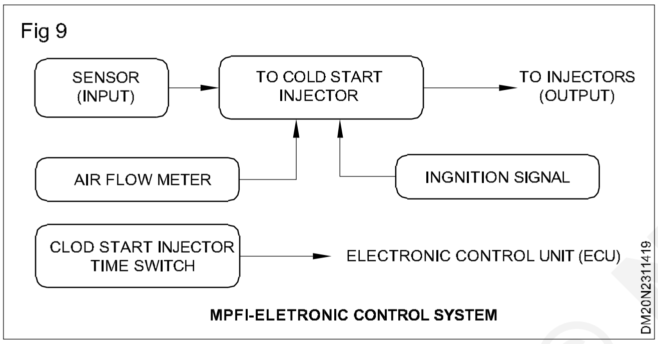


D-MPFI GASOLINE INJECTION SYSTEM

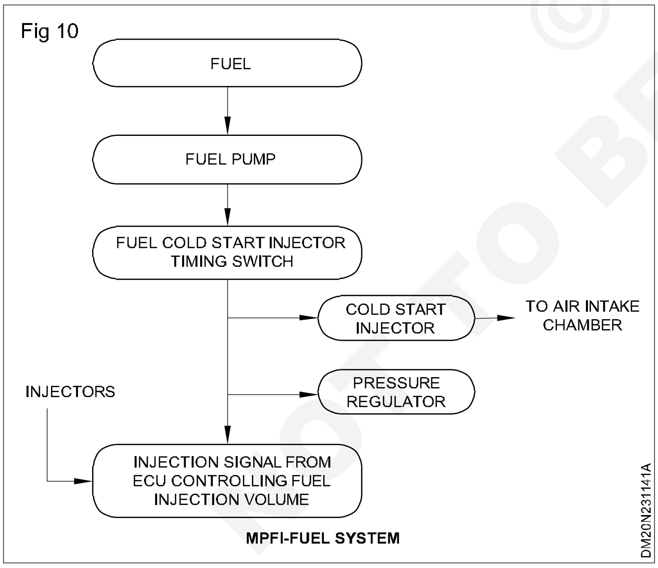
The MPFI -air induction system is shown in the block diagram. The air cleaner, the air-flow meter, the throttle body and the air valve supply a proper amount of air to the air intake chamber and intake manifold. The quantity of air supplied is just what is necessary for complete combustion. (Fig 8-10)



L-MPFI GASOLINE INJECTION SYSTEM



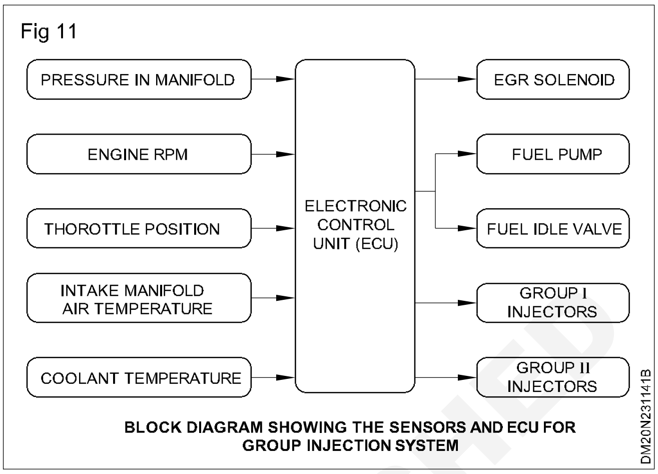
MPFI-ELETRONIC CONTROL SYSTEM



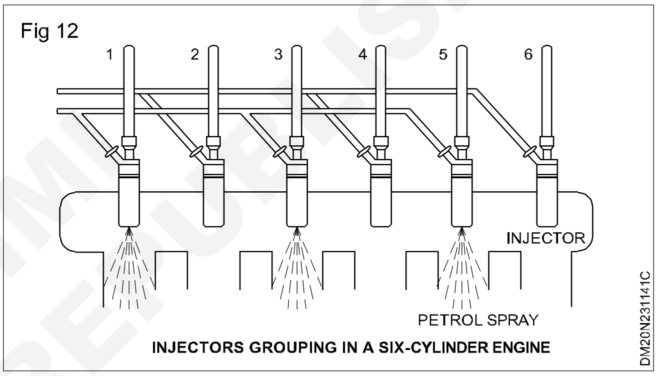
MPFI-FUEL SYSTEM

Group gasoline injection system

In an engine having group gasoline injection system, the injectors are not activated individually, but are activated in groups. In a four-cylinder engine also there are two groups, each group having two injectors. In a six-cylinder engine, there are two groups, each group having 3 injectors. Block diagram with sensors and the electronic control unit (ECU), for a group injection system. Sensors for detecting pressure in the manifold, engine speed in rpm, throttle position, intake manifold air temperature and the coolant temperature send information to the ECU. With this information, the ECU computes the amount of gasoline that the engine needs. The ECU then sends signals to the injectors and other parts of the system. The timing of the injectors is decided by the engine-speed sensor. (Fig 11&12)

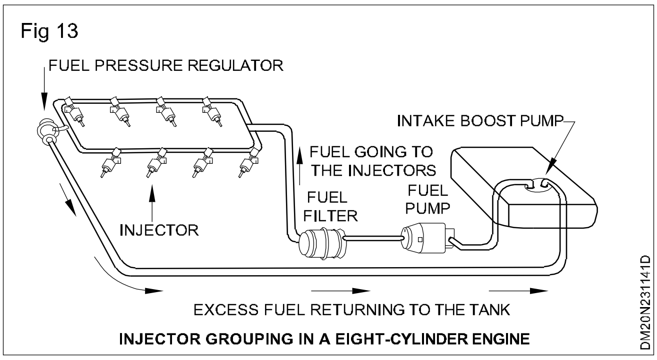


BLOCK DIAGRAM SHOWING THE SENSORS AND ECU FOR GROUP INJECTION SYSTEM



INJECTORS GROUPING IN A SIX-CYLINDER ENGINE

The injectors are divided into two groups. Based on the signals from The speed sensor, the ECU activates one group of injectors. Subsequently, the ECU activates the other group of injectors. For example, the injector grouping for a six-cylinder engine. Injectors for cylinders 1, 3 and 5 open at the same time and inject gasoline into the intake manifold. After these injectors close, the injectors for the cylinders 2, 4 and 6 open and inject gasoline. (Fig 13)



INJECTOR GROUPING IN A EIGHT-CYLINDER ENGINE

Injection using the electronic group fuel-injection system for an eight-cylinder engine. Eight injectors are connected to a fuel system and are divided into two groups, each group having four injectors. Each group of injectors is alternately turned on by the ECU. When the crankshaft makes two revolutions, the injectors are turned on once. Thus it is seen that the modern engines are controlled more and more by electronics and the days are not far off when electronics may completely take over leaving bare minimum room for any mechanical or manual control.

Electronic diesel injection system (Fig 14)

It may be noted that meeting future emission and other norms puts a large stress on the fuel injection system of a diesel engine. A conventional fuel injection pump with variable delivery capability is already seen.

All parameters related to the injection process like, timing, rate of injection, end of injection, quantity of injected fuel etc. Have to be precisely controlled if the engine has to operate with a high efficiency and low emission levels. Such a control is difficult with conventional mechanical systems. Mechanical systems only sense a few parameters and meter the fuel quantity or adjust the injection timing. They seldom change the injection rate or the injection pressure.

Use of pilot injection systems can lead to significant advantages. Here, a small quantity of fuel is first injected and allowed to undergo the ignition delay and burn. Subsequently the main injection takes place into gases, which are already hot. Thus the amount of fuel taking part in the premixed or the uncontrolled combustion phase is minimized and this leads to a reduction in noise and NOx levels. Such a system will need an injection rate variation with time which is rather difficult to achieve precisely in mechanical systems. Hence, different types of injection systems with electronic controls have been developed.

By means of EFI systems one can achieve the precise control of:

i Injection timing,

ii Fuel injection quantity,

iii Injection rate during various stages of injection,

iv Injection pressure during injection,

v Nozzle opening speed and

vi Pilot injection timing and its quantity,

The following are easy to obtain with such systems:

i Very high injection pressure,

ii Sharp start and stop of injection,

iii Cylinder cut off,

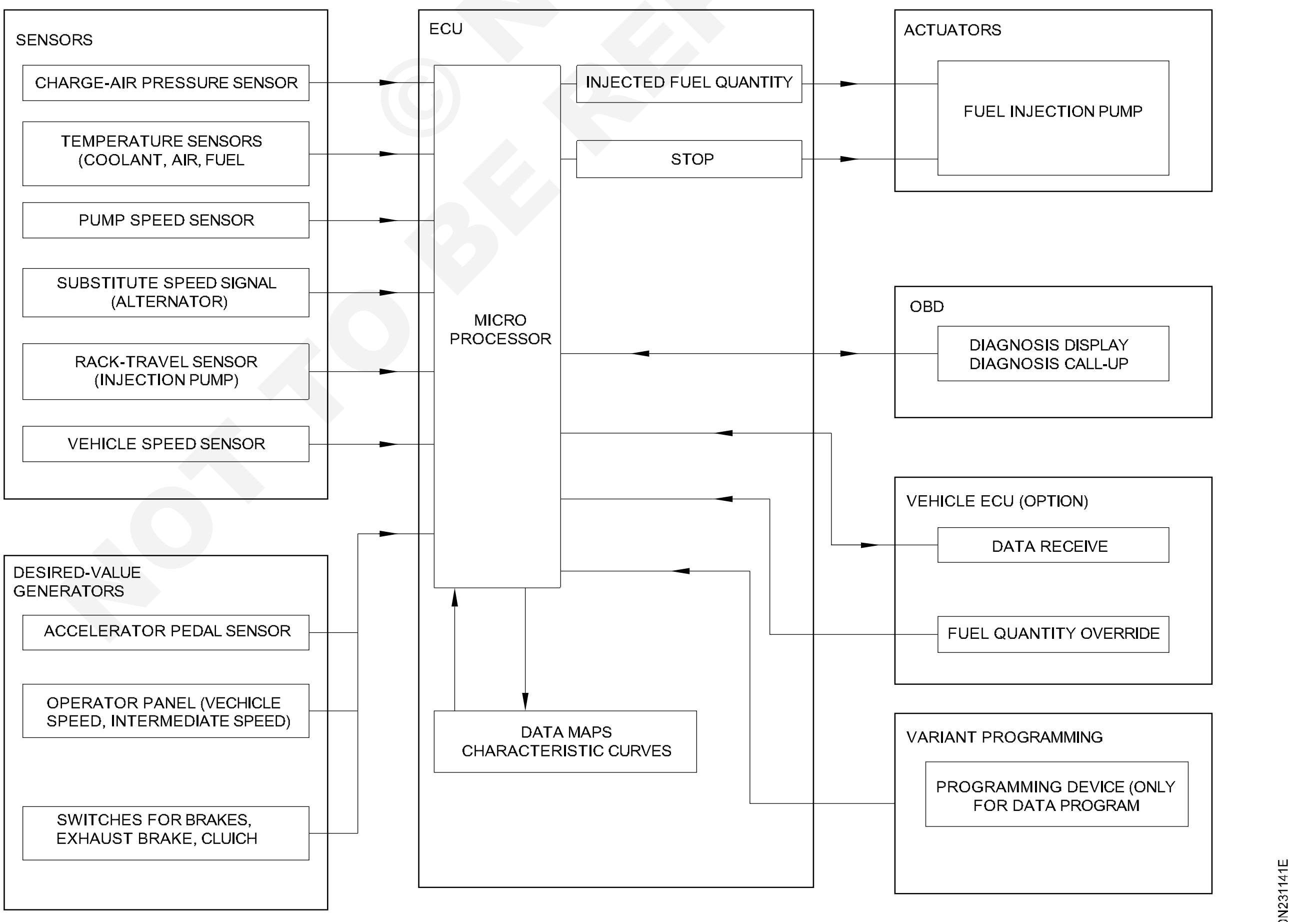
iv Diagnostic capability,

v Turbocharger control and

vi Two stage injection

The ECU can also regulate the fuel quantity depending on other conditions like braking. The ECU also protects the engine against overheating by regulating the maximum quantity of fuel delivered.

Fig 14



SYSTEM BLOCKS FOR ELECTRONIC DIESEL CONTROL (EDC)

Common-rail fuel injection system

The common rail fuel injection system is finding increasing use in diesel engines as it has the potential to drastically cut emissions and fuel consumption. This system provides control of many important parameters linked to the injection system (refer chapter 20). It has a wide range of application, from small to heavy duty engines. Some important features are:

i Very high injection pressures of the order of 1500 bar.

ii Vomplete control over start, and end of injection

iii Injection pressure is independent of engine speed

iv Ability to have pilot, main and post injection

v Variable injection pressure.

The common rail injection system has a high pressure pump which operates continuously and charges a high pressure rail or reservoir or accumulator. Fuel is led from this rail to the injector mounted on the cylinder head through lines. The injector is solenoid operated. It received pulses from the ECU to open the same.

The engine directly drives the pump of the common rail system. It is generally of the multi-cylinder radial piston type. The generated pressure is independent of the injection process unlike conventional injection systems. The rail pressure pump is generally much smaller than conventional pumps and also is subjected to lesser pressure pulsations. The injection occurs when the solenoid is energized. The quantity of fuel injected is directly dependent on the duration of the pulse when the injection pressure is constant. Sensors on the crankshaft indicate its position and speed and so the timing of injection and its frequency can be controlled. A typical layout of the common rail fuel injection system is indicated. (Fig 15)

1 High pressure pump

2 Element shutoff valve

3 Pressure control valve

4 Fuel filter

5 Fuel temperature sensor

6 Battery

7 High pressure accumulator

8 Rail pressure sensor

9 ECU

10 Turbocharger

11 Coolant temperature sensor

12 Crankshaft speed

13 Accelerator pedal sensor

14 Injector

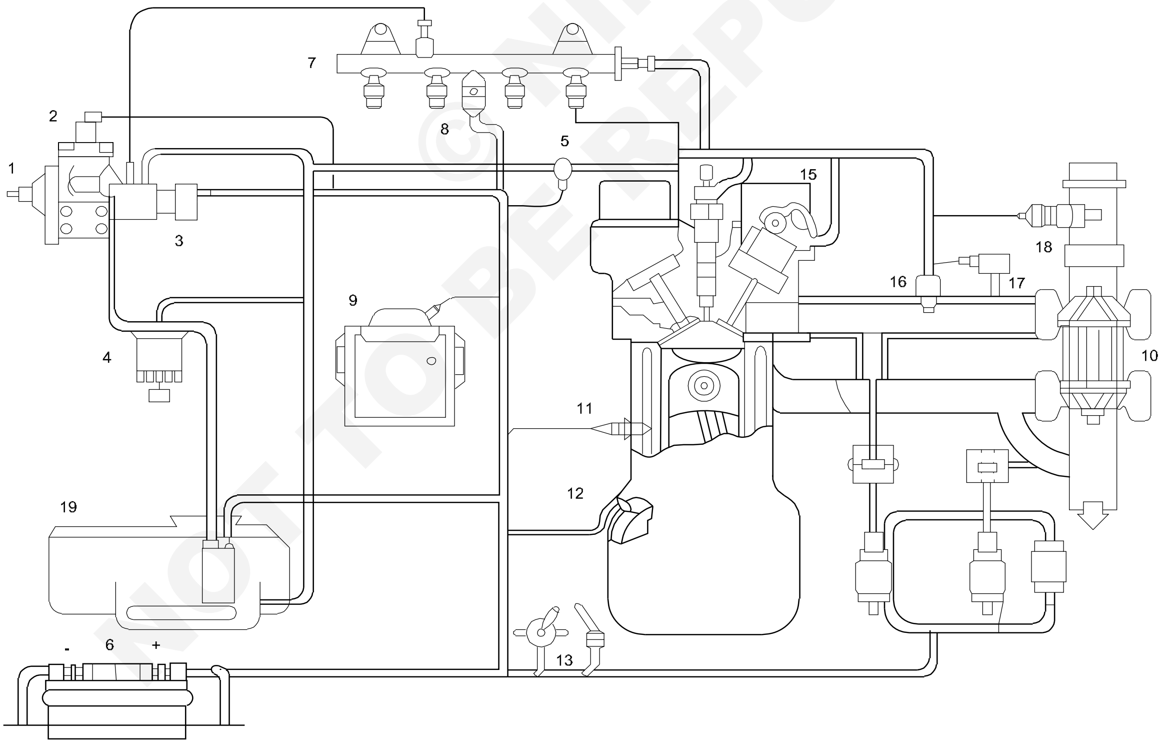
15 Camshaft speed sensor

16 Intake air temperature sensor

17 Boost pressure sensor

18 Air mass meter

Fig 15



1. HIGH PRESSURE PUMP
2. ELEMENT SHUTOFF VALVE
3. PRESSURE CONTROL VALVE
4. FUEL FILTER
5. FUEL TEMPERATURE SENSOR
6. BATTERY
7. HIGH PRESSURE ACCUMULATOR
8. RAIL PRESSURE SENSOR
9. ECU
10. TURBOCHARGER
11. COOLANT TEMPERATURE SENSOR
12. CRANKSHAFT SPEED
13. ACCELERATOR PEDAL SENSOR
14. INJECTOR
15. CAMSHAFT SPEED SENSOR
16. INTAKE AIR TEMPERATURE SENSOR
17. BOOST PRESSURE SENSOR
18. AIR MASS METER

FUEL TANK WITH PREFILTER AND PRESUPPLY PUMP

DM20N231141F

Introduction to 3D modeling & 3D primitives

Objectives: At the end of this lesson you shall be able to
- **define 3D modeling**
- **list the 3D primitives in the modeling tool panel.**

Introduction

3D modeling is the process of creating three-dimensional representations of an object or a surface. 3D models are made within computer-based 3D modeling software, which we'll explore a little later. During the 3D modeling process, you can determine an object's size, shape, and texture.

3D modeling is used to shape many of the things we see in our everyday lives. From video games to Engineering, we've all likely benefited from 3D modeling technology.

Many industries utilize 3D modeling for a range of projects; there are likely loads of 3D modeled items we use without even realizing its involvement. With 3D modeling, the opportunities are endless. It's a truly versatile medium that can be used for an array of different areas. Let's explore some common uses of 3D modeling:

3D Primitives

Primitives are the most basic elements in the world of 3D modeling and design. They're used either in tandem with one another, forming much more interesting compound shapes, or as the foundation for something that you would like to sculpt. They're your standard shapes, only rendered in three dimensions instead of two.

A primitive solid is a 'building block' that you can use to work with in 3D. Rather than extruding or revolving an object, AutoCAD has some basic 3D shape commands at your disposal. From these basic primitives, you can start building your 3D models. In many cases, you get the same result from drawing circles and rectangles and then extruding them, but doing it one command is generally faster. Using these with Boolean operations can be a very effective way of drawing in 3D.

There are eight different primitives that you can choose from and are on the

Home > Modeling Tool Panel (when in the 3D workspace).

Shape	Command	Icon	Description
BOX	BOX		Creates a solid box after you provide 2 opposite corners and a height.
SPHERE	SPHERE / SPH		Creates a solid sphere from a center point and radius.
CYLINDER	CYLINDER / CYL		Creates a straight cylinder from a center point, radius and height.
CONE	CONE		Creates a tapered cone from a center point, radius and height.
WEDGE	WEDGE / WED		Creates a triangular wedge from 2 opposite points.
TORUS	TORUS / TOR		Creates a torus (donut shape) based on center point, radius and tube radius.
PYRAMID	PYRAMID / PYR		Draws a solid object with a polygon (3-32 sides) base that rises to a central point.
POLYSOLID	PSOLID		Draws a solid object with width and height as you would draw a polyline.

3D Solid figures & solid editing commands

Objectives: At the end of this lesson you shall be able to
- **state the use of extrude revolve, sweep and loft commands**
- **state the use of fillet offset, shell and slice commands.**

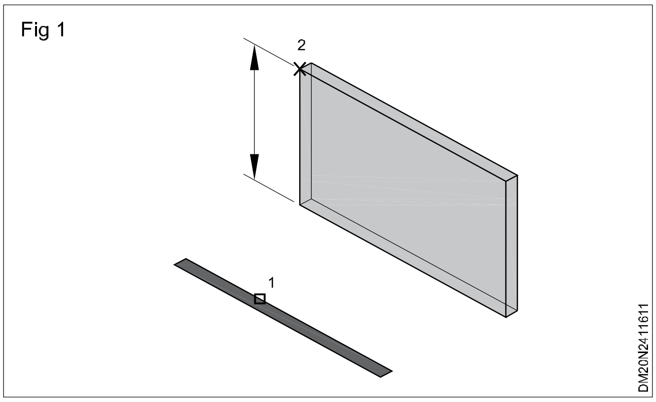
Solid Figures

Extrude:

Creates a 3D solid from an object that encloses an area, or a 3D surface from an object with open ends.

The DELOBJ system variable controls whether the source objects or selected path are automatically deleted when the solid or surface is created, or whether you are prompted. (Fig 1)

You can use the following objects and sub objects



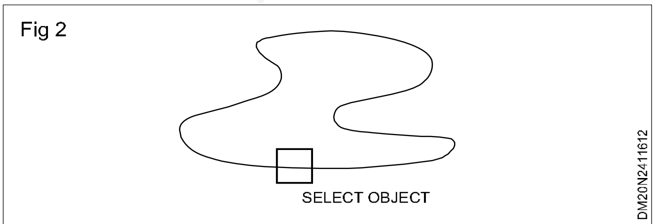
Objects That Can Be Extruded or Used as Paths

Object type	Can be extruded?	Can be extrusion path?	Comments
3D faces	X		
Arcs	X	X	
Circles	X	X	
Ellipses	X	X	
Elliptical arcs	X	X	
Helixes	X	X	
Lines	X	X	
Meshes: faces			Use the MESHEXTRUDE command.
Meshes: edges			Press Ctrl and use the gizmo to change the location of the edge.
2D Polylines	X	X	2D polylines with crossing segments cannot be extruded.
3D Polylines	X	X	Thickness and width are ignored.
Regions	X		The extrusion extends from the center line.
2D Solids	X		
3D Solids: edges	X	X	
3D Solids: faces	X		
Splines: 2D and 3D	X	X	
Surfaces: edges	X	X	
Surfaces: planar and non-planar	X		

The following prompts are displayed.

Objects to Extrude (Fig 2)

Specifies the objects to extrude.



Note: Select face and edge sub objects by pressing Ctrl while you select them.

Mode

Controls whether the extruded object is a solid or a surface.

Surfaces are extruded as either NURBS surfaces or procedural surfaces, depending on the SURFACEMODELINGMODE system variable.

Height of extrusion

Extrudes selected objects along the positive or negative Z axis. The direction is based on the UCS that was current when the object was created, or (for multiple selections) on the original UCS of the most recently created object.

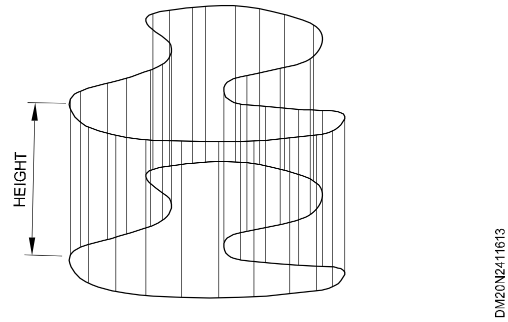
Direction

Specifies the length and direction of the extrusion with two specified points. (The direction cannot be parallel to the plane of the sweep curve created by the extrusion.)

Path (Fig 3&4)

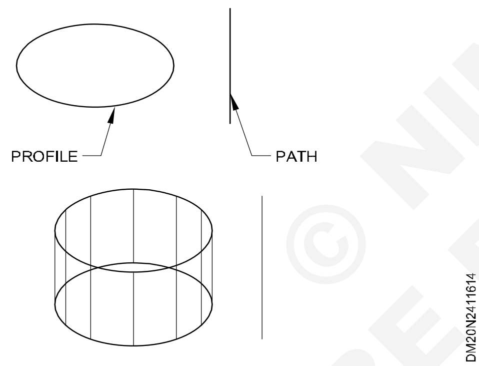
Specifies the extrusion path based on a selected object. The path is moved to the centroid of the profile. Then the profile of the selected object is extruded along the chosen path to create solids or surfaces.

Fig 3



Note: Select face and edge sub objects by pressing Ctrl while you select them.

Fig 4



The path should not lie on the same plane as the object, nor should the path have areas of high curvature.

The extrusion starts from the plane of the object and maintains its orientation relative to the path.

If the path contains segments that are not tangent, the program extrudes the object along each segment and then miters the joint along the plane bisecting the angle formed by the segments. If the path is closed, the object should lie on the miter plane. This allows the start and end sections of the solid to match up. If the object is not on the miter plane, the object is rotated until it is on the miter plane.

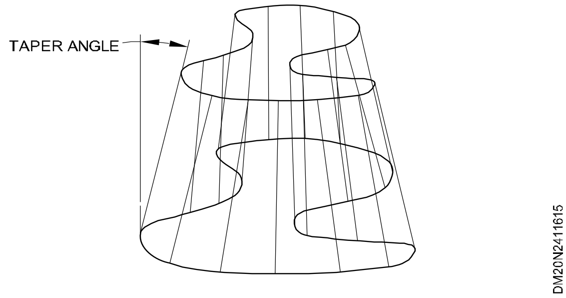
Objects with multiple loops are extruded so that all of the loops appear on the same plane at the end section of the extruded solid.

Taper angle (Fig 5)

Specifies the taper angler for the extrusion.

Positive angles taper in from the base object. Negative angles taper out. The default angle, 0, extrudes a 2D object perpendicular to its 2D plane. All selected objects and loops are tapered to the same value.

Fig 5



Specifying a large taper angle or a long extrusion height can cause the object or portions of the object to taper to a point before reaching the extrusion height.

Individual loops of a region are always extruded to the same height.

When an arc is part of a tapered extrusion, the angle of the arc remains constant, and the radius of the arc changes.

- Angle of taper. Specifies the taper between -90 and +90 degrees.
- Specify two points. Specifies the taper angle based on two specified points. The taper angle is the distance between the two specified points.

Drag the cursor horizontally to specify and preview the taper angle. You can also drag the cursor to adjust and preview the height of the extrusion. The dynamic input origin should be placed on the extruded shape, on the projection of the point to the shape.

When you select the extruded object, the position of the taper grip is the correspondent point of the dynamic input origin on the top face of the extrusion.

Revolve

Creates a 3D solid or surface by sweeping an object around an axis.

Open profiles create surfaces and closed profiles can create either a solid or a surface. The Mode option controls is a solid of surface is created. When creating a surface, SURFACEMODELINGMODE system variable controls if a procedural or NURBS surface is created.

Revolve path and profile curves can be:

- Open or closed
- Planar or non-planar
- Solid and surface edges
- A single object (to extrude multiple lines, convert them to a single object with the JOIN command)
- A single region (to extrude multiple regions, first convert them to a single object with the UNION command)

To automatically delete the profile, use the DELOBJ system variable. If associativity is on, the DELOBJ system variable is ignored and the originating geometry is not deleted.

Objects that can be revolved

Surfaces	Elliptical arcs	2D solids
Solids	2D and 3D splines	Traces
Arcs	2D and 3D polylines	Ellipses
Circles	Regions	

> **Note: Select face and edge sub objects by pressing Ctrl while you select them.**

You cannot revolve objects contained within a block or objects that will self-intersect. REVOLVE ignores the width of a polyline and revolves from the center of the path of the polyline.

The right-hand rule determines the positive direction of rotation.

The following prompts are displayed.

Objects to Revolve

Specifies the objects to be revolved about an axis.

Mode

Controls whether the revolve action creates a solid or a surface. Surfaces are extended as either NURBS surfaces or procedural surfaces, depending on the SURFACEMODELINGMODE system variable.

Axis Start Point

Specifies the first point of the axis of revolution. The positive axis direction is from the first to the second point.

Axis Endpoint

Sets the endpoint for the axis of revolution.

Start Angle

Specifies an offset for the revolution from the plane of the object being revolved.

Drag your cursor to specify and preview the start angle of the object.

Angle of Revolution (Fig 6)

Fig 6

Specifies how far the selected object revolves about the axis.

A positive angle revolves the objects in a counterclockwise direction. A negative angle revolves the objects in a clockwise direction. You can also drag the cursor to specify and preview the angle of revolution.

Specifies an existing object to be used as an axis. The positive axis direction is from the closest to the farthest endpoint of this object.

Object

Specifies an existing object to be used as an axis. The positive axis direction is from the closest to the farthest endpoint of this object.

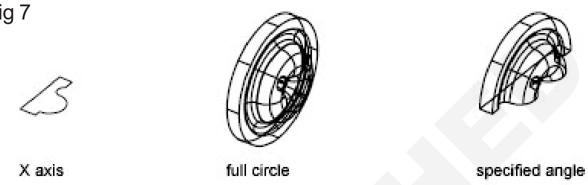
You can use lines, linear polyline segments, and linear edges of solids or surfaces as an axis.

> **Note: Select an edge sub object by pressing Ctrl while you select an edge.**

X (Axis) (Fig 7)

Sets the positive X axis of the current UCS as the positive axis direction.

Fig 7



Y (Axis) (Fig 8)

Sets the positive Y axis of the current UCS as the positive axis direction.

Fig 8

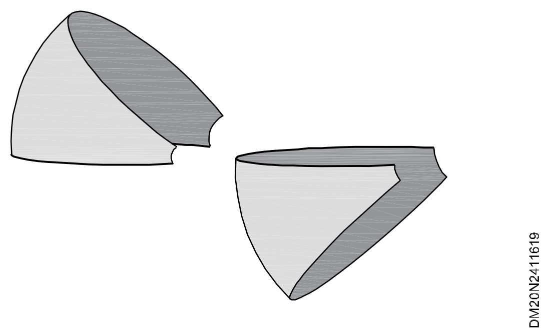
Z (Axis) (Fig 9)

Sets the positive Z axis of the current UCS as the positive axis direction.

Reverse

Changes the direction of the revolve; similar to entering a - (minus) angle value. The revolved object on the right shows a spline revolved at the same angle as the object on the left, but using the reverse option.

Fig 9



> **Note: You can also extrude directly from rectangles, circles and closed polylines, but I wanted to show you the Region command. If you have 4 lines that make up a shape, you can't extrude the lines, but you can use the Region command to create an extrudable object.**

LOFT (Fig 10)

The loft command is similar to the extrude command, but much more versatile. Instead of extruding a single shape, the loft command allows you to extrude several shapes and make one continuous object.

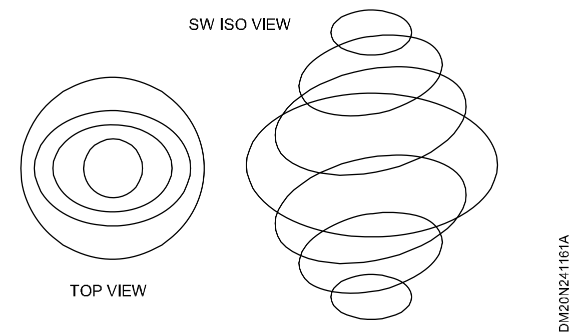


Fig 10

Here is a front view of the objects before and after the loft command: (Fig 11)

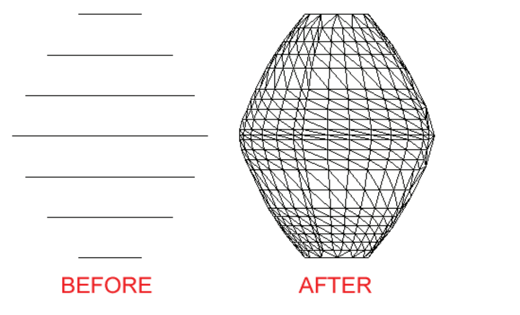


Fig 11

The example above is very simple, but think of how you can create complex shapes using this simple command. (Fig 12)

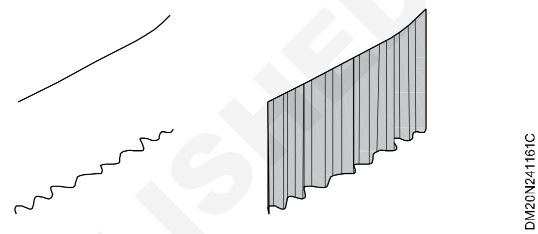


Fig 12

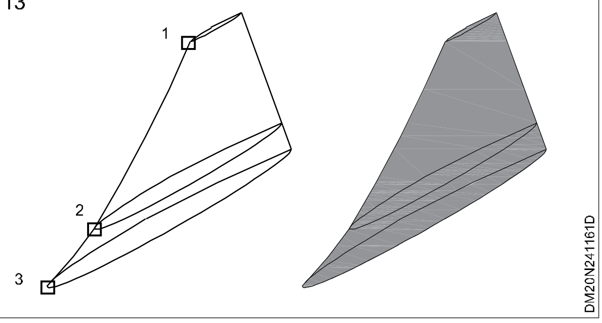
Objects That Can Be Used as Cross Sections	Objects That Can Be Used as a Loft Path	Objects That Can Be Used as Guides
2D polyline	Spline	2D spline
2D solid		
2D spline	Helix	3D spline
Arc	Arc	Arc
Circle	Circle	2D polyline **Note:** 2D polylines can be used as guides if they contain only 1 segment.
Edge sub-objects	Edge subobjects	Edge subobjects
Ellipse	Ellipse	3D polyline
Elliptical arc	Elliptical arc	Elliptical arc
Helix	2D polyline	
Line	Line	Line
Planar or non-planar face of solid		
Planar or non-planar surface		
Points (first and last cross section only)	3D polyline	
Region		
Trace		

Loft command (Fig 13)

Creates a 3D solid or surface by specifying a series of cross sections. The cross sections define the shape of the resulting solid or surface. You must specify at least two cross sections.

Loft cross sections can be open or closed, planar or non-planar, and can also be edge subobjects. Open cross sections create surfaces and closed cross sections create solids or surfaces, depending on the specified mode.

Fig 13



When creating surfaces, use SURFACEMODELINGMODE to control whether the surface is a NURBS surface or a procedural surface. Use SURFACEASSOCIATIVITY to control whether procedural surfaces are associative.

Sweep:

A sweep command is an AutoCAD command that moves a line or arc along a path. A sweep command is the most commonly used AutoCAD command. It is used to create lines, arcs, and circles in straight lines, curves, and ellipses. The sweep command can be used to draw a line from one point to another point on the same plane.

Creates a 3D solid or 3D surface by sweeping a 2D object or subobject along an open or closed path.

Open-ended objects create 3D surfaces, while objects that enclose an area can be set to create either 3D solids or 3D surfaces.

You can use the following objects and paths when creating a swept solid or surface:

Objects that Can Be Swept	**Objects that Can Be Used as a Sweep Path**
2D and 3D splines	2D and 3D splines
2D polylines	2D and 3D polylines
2D solids	Solid, surface and mesh edge subobjects
3D solid face subobjects	Helices
Arcs	Arcs
Circles	Circles
Ellipses	Ellipses
Elliptical arcs	Elliptical arcs
Lines	Lines
Regions	
Solid, surface and mesh edge subobjects	

Trace

> **Note: Select face and edge subobjects by pressing Ctrl while you select them.**

To automatically delete the original geometry used to create the object, use the DELOBJ system variable. For associative surfaces, the DELOBJ system variable is ignored and the originating geometry is not deleted.

The following prompts are displayed.

Objects to Sweep

Specifies an object to use as the sweep profile.

Sweep Path

Specifies the sweep path based on the object you select.

Mode

Controls whether the sweep action creates a solid or a surface. Surfaces are swept as either NURBS surfaces or procedural surfaces, depending on the SURFACEMODELINGMODE system variable.

Alignment

Specifies whether the profile is aligned to be normal to the tangent direction of the sweep path.

If the profile is not perpendicular (normal) to the tangent of the start point of the path, then the profile automatically aligns. Enter No at the alignment prompt to prevent this.

Base Point

Specifies a base point for the objects to be swept.

Scale

Specifies a scale factor for a sweep operation. The scale factor is uniformly applied to the objects that are swept from the start to the end of the sweep path.

- Reference. Scales the selected objects based on the length you reference by picking points or entering values.

Twist

Sets a twist angle for the objects being swept. The twist angle specifies the amount of rotation along the entire length of the sweep path.

- Bank Specifies whether the curve(s) being swept will naturally bank (rotate) along a 3D sweep path (3D polyline, spline, or helix)

Working in 3D usually involves the use of solid objects. At times you may need to combine multiple parts into one, or remove sections from a solid. AutoCAD has some commands that make this easy for you. These are the boolean operations as well as some other helpful commands for solids editing.:

FILLET:

A fillet can be added along the edge of a 3D solid or surface. When prompted to select the first object to define a fillet, select the edge of a 3D solid or surface.

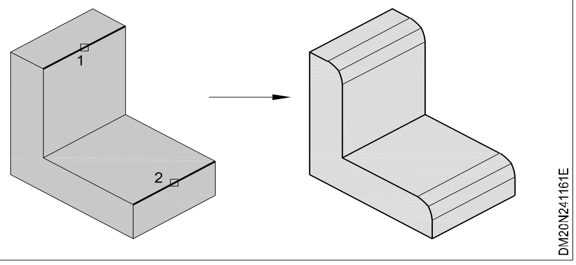
Note: If you select a mesh object, you can choose to convert the mesh to a 3D solid or surface and continue the operation.

The following prompts are displayed after selecting the edge of a 3D solid or surface.

Edge (Fig 14)

When the edge of a 3D solid is selected, you can select multiple edges to fillet. Press Enter to end selection.

Fig 14



If you select three or more edges that converge at a vertex to form the corner of a box, the vertices are blended to form part of a sphere if the three incident fillets have the same radii.

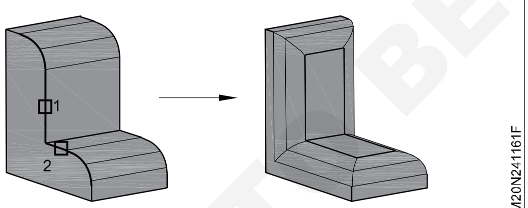
Chain (Fig 15)

Changes selection mode between single-edge and sequential tangent edges, called a chain selection.

For example, if you select an edge along the side of a 3D solid, the tangential edges that touch the selected edge are selected.

- Edge Chain. Enables sequential tangent edge selection mode.
- Edge. Enables single-edge selection mode.

Fig 15



Loop (Fig 16)

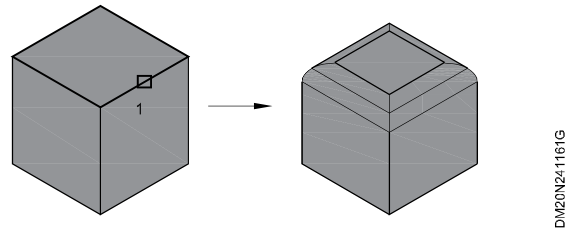
Specifies a loop of edges on the face of a 3D solid or surface.

For example, if you select an edge on the top of a 3D solid box, all other tangential edges along the top of the box are selected.

For any edge, there are two possible loops. After selecting a loop edge, you are prompted to accept the current selection or select the adjacent loop.

- Accept. Selects the edges of the current loop.
- Next. Selects the edges of the adjacent loop.

Fig 16



Radius

Sets the radius of the fillet.

Expression

Controls the fillet radius with a mathematical expression.

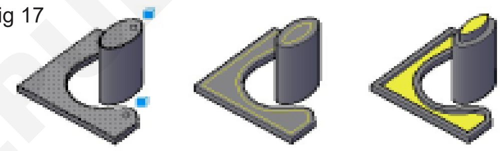
OFFSETEDGE:

Creates a closed polyline or spline object that is offset at a specified distance from the edges of a selected planar face on a 3D solid or surface.

You can offset the edges of a planar face on a 3D solid or surface. The result is a closed polyline or spline that is located on the same plane as the selected face or surface, and can be inside or outside the original edges. (Fig 17)

Tip: You can use the resulting object with PRESSPULL or EXTRUDE to create new solids.

Fig 17



The following prompts are displayed.

Select face

Specifies a planar face on a 3D solid or surface.

Through point

Creates an offset object that passes through the specified point. This point is always projected line-of-sight onto the plane of the selected face.

Distance

Creates an offset object at a specified distance from the edges of the selected face.

Specify distance

Enter the offset distance, or press Enter to accept the current distance.

Specify point on side to offset

Specify a point location to determine whether the offset distance is applied inside or outside the edges of the face.

Corner

Specifies the type of corners on the offset object when it is created outside the edges of the selected face. External and internal corners create rounded corners differently depending whether the corners are concave or convex.

Sharp

Creates sharp corners between offset linear segments.

Rounded

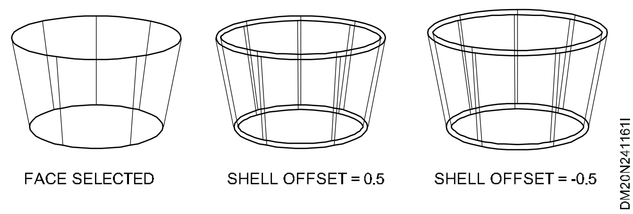
Creates rounded corners between offset linear segments, using a radius that is equal to the offset distance. The radius of the generated arcs is equal to the specified offset distance.

SHELL (Fig 18)

Convert a 3D solid to a hollow wall, or shell.

When you can convert a solid object to a shell, new faces are created by offsetting existing faces inside or outside their original positions. Continuously tangent faces are treated as a single face when they are offset.

Fig 18

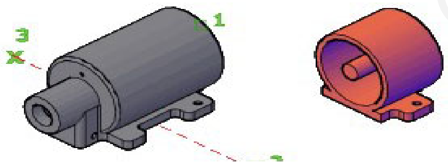


SLICE (Fig 19)

Creates new 3D solids and surfaces by slicing, or dividing, existing objects.

The cutting plane is defined with 2 or 3 points by specifying a major plane of the UCS, or by selecting a planar or a surface object (but not a mesh). One or both sides of the sliced objects can be retained.

Fig 19



- 3D solid objects can be sliced using specified planes and surface objects
- Surface objects can be sliced by specified planes only
- Meshes cannot directly be sliced or used as slicing surfaces

Sliced objects retain the layer and color properties of the original objects, however the resulting solid or surface objects do not retain a history of the original objects.

The following prompts are displayed.

Objects to slice

Specifies the 3D solid or surface object that you want to slice. If you select a mesh object, you can choose to convert it to a 3D solid or surface before completing the slice operation.

- Start point of slicing plane
- Planar object
- Surface
- Z axis
- View
- XY
- YZ
- XZ
- 3points

Start point of slicing plane

Sets the first of two points that define the orientation of the slicing plane. With this option, the slicing plane is always perpendicular to the XY plane of the current UCS. After you specify the second point on the plane, you can choose whether to keep both sides of the sliced object or you can specify another point on the side of the plane that you want to keep.

- Second point on plane. Sets the second of two points on the slicing plane. If the second point is not located on the XY plane of the UCS, it is projected onto the plane.
- Specify a point on the desired side to keep
- Keep both sides

Planar object

Aligns the cutting plane with a plane that contains the selected circle, ellipse, circular or elliptical arc, 2D spline, 2D polyline, or planar 3D polyline.

- Select a circle, ellipse, arc, 2D-spline, or 2D-polyline. Specifies the planar object that defines the cutting plane. A planar 3D polyline object can also be selected.
- Specify a point on desired side to keep
- Keep both sides

Surface

Aligns the cutting plane with a selected surface.

- Select a surface. Specifies a cutting surface.

Note: You cannot specify mesh, 3D face, or thickened objects as the cutting surface.

- Select the sliced object on the desired side to keep
- Keep both sides

Z axis

Defines the cutting plane by specifying a point on the plane and another point on the Z axis (normal) of the plane.

- Specify a point on the section plane. Sets a point on the slicing plane.
- Specify a point on the Z-axis (normal) of the plane. Specifies a point that defines the axis that is perpendicular to the slicing plane.
- Specify a point on the desired side to keep
- Keep both sides

View

Aligns the cutting plane parallel to the current viewport's viewing plane. Specifying a point defines the location of the cutting plane.

- Specify a point on the current view plane. Sets a point on the object to start the slice.
- Specify a point on the desired side to keep
- Keep both sides

XY

Aligns the cutting plane with the XY plane of the current UCS. Specify a point to define the location of the cutting plane.

- Point on the XY-plane. Aligns the cutting plane parallel to the XY plane of the UCS and passing through a specified point.
- Specify a point on the desired side to keep
- Keep both sides

YZ

Aligns the cutting plane with the XY plane of the current UCS. Specify a point to define the location of the cutting plane.

- Point on the YZ-plane. Aligns the cutting plane parallel to the YZ plane of the UCS and passing through a specified point.
- Specify a point on the desired side to keep
- Keep both sides

XZ

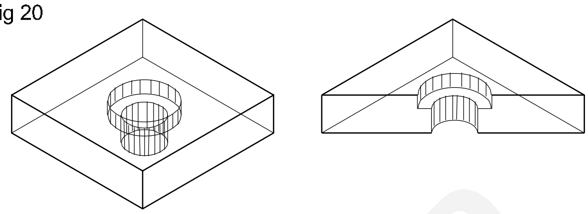
Aligns the cutting plane with the XZ plane of the current UCS. Specify a point to define the location of the cutting plane.

- Point on the XZ-plane. Aligns the cutting plane parallel to the XZ plane of the UCS and passing through a specified point.
- Specify a point on the desired side to keep
- Keep both sides

3 points

- Defines the cutting plane using three points. (Fig 20)

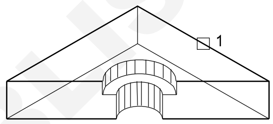
Fig 20



Specify a point on the desired side to keep

Uses a point to determine which side of the sliced object to keep. The point cannot lie on the cutting plane. (Fig21)

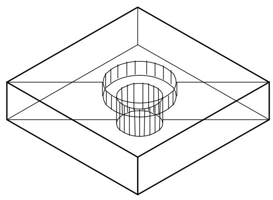
Fig 21



Keep both sides

Retains both sides of the sliced objects. (Fig 22)

Fig 22



Boolean operations

Objectives: At the end of this lesson you shall be able to
- **state the use of union subtract and intersect commands.**

COMMAND	INPUT	ICON	DESCRIPTION
UNION (Boolean)	UNION / UNI		Joins two or more solids into creating one based on the total geometry of all.
SUBTRACT (Boolean)	SUBTRACT / SU		Subtracts one or more solids from another creating a solid based on the remaining geometry.
INTERSECT (Boolean)	INTERSECT / IN		Creates a single solid from one more solids based on the intersected geometry.
EXTRUDE FACE	SOLIDEDIT		Allows you to increase the size of a solid by extruding out one of its faces.
SLICE	SLICE		Slices a solid along a cutting plane.
3D ALIGN	3DALIGN		Aligns 2 3D Objects in 3D space.

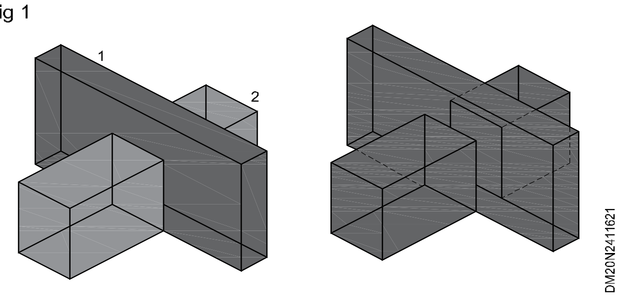
The boolean commands work only on solids or regions. They are easy to work with if you follow the command line prompts. Here is an example of each.

Union (Fig 1)

Combines two or more 3D solids, surfaces, or 2D regions into a single, composite 3D solid, surface, or region

Select two or more objects of the same type to combine.

Fig 1



Using the Union Command with Surfaces

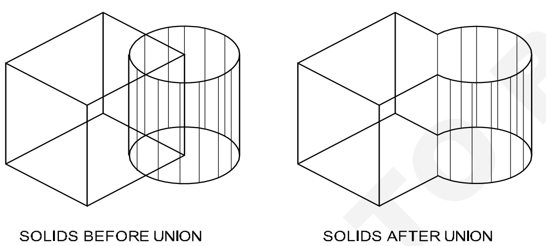
Although you can use the UNION command with surfaces, it will cause the surface to lose associativity. Instead, it is recommended that you use the surface editing commands:

- SURFBLEND
- SURFFILLET
- SURFPATCH

Using the Union Command with Solids and Regions

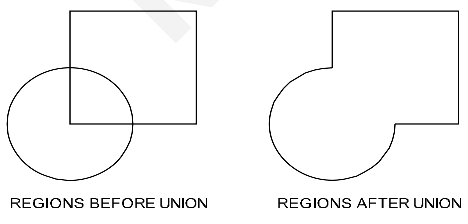
The selection set can contain objects that lie in any number of arbitrary planes. For mixed object types, selection sets are divided into subsets that are joined separately. Solids are grouped in the first subset. The first selected region and all subsequent coplanar regions are grouped in the second set, and so on. (Fig 2)

Fig 2



The resulting composite solid includes the volume enclosed by all of the selected solids. Each of the resulting composite regions encloses the area of all regions in a subset. (Fig 3)

Fig 3



You cannot use UNION with mesh objects. However, if you select a mesh object, you will be prompted to convert it to a 3D solid or surface.

The following prompt is displayed.

Select objects

Select the 3D solids, surfaces, or regions to be combined.

Subtract:

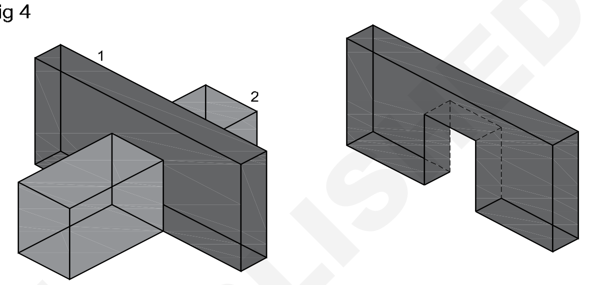
Creates as a new object by subtracting one overlapping region or 3D solid from another.

With SUBTRACT, you can create a 3D solid by subtracting one set of existing 3D solids from another, overlapping set. You can create a 2D region object by subtracting one set of existing region objects from another, overlapping set.

> **Note: Using SUBTRACT with 3D surfaces is not recommended. Use the SURFTRIM command instead.**

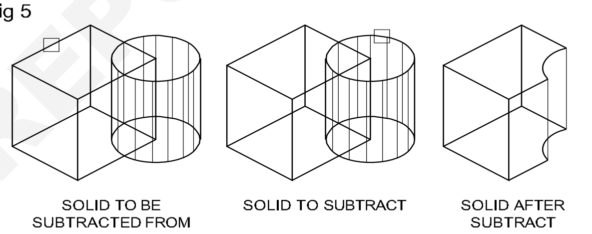
Select the objects that you want to keep, press Enter, then select the objects that you want to subtract. (Fig 4)

Fig 4



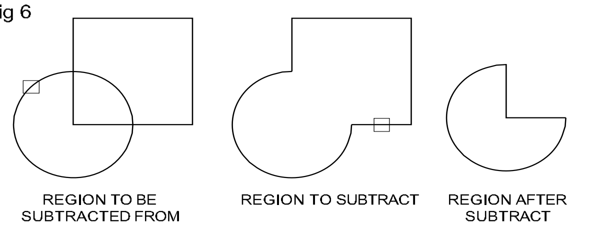
Objects in the second selection set are subtracted from objects in the first selection set. A single new 3D solid or surface is created. (Fig 5)

Fig 5



When subtracting regions, objects in the second selection set are subtracted from objects in the first selection set, and a single new region is created. (Fig 6)

Fig 6



You cannot use SUBTRACT with mesh objects. However, if you select a mesh object, you will be prompted to convert it to a 3D solid or surface.

The following prompts are displayed.

Select objects (to subtract from)

Specifies the 3D solids, surfaces, or regions to be modified by subtraction.

Select objects (to subtract) (Fig 7)

Specifies the 3D solids, surfaces, or regions to subtract.

Fig 7

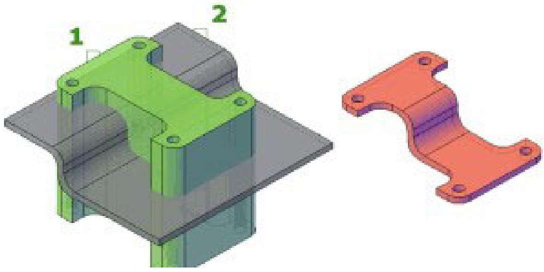
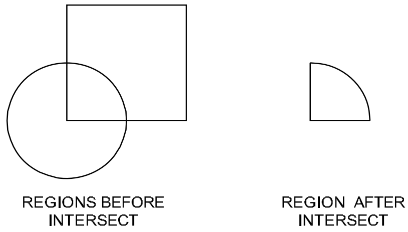


Fig 8



Intersect:

Creates a 3D solid, surface, or 2D region from overlapping solids, surfaces, or regions.

With INTERSECT, you can create a 3D solid from the common volume of two or more existing 3D solids, surfaces, or regions. If you select a mesh, you can convert it to a solid or surface before completing the operation.

You can extrude 2D profiles and then intersect them to create a complex model efficiently. (Fig 8)

The selection set can contain regions, solids, and surfaces that lie in any number of arbitrary planes. INTERSECT divides the selection set into subsets and tests for intersections within each subset. The first subset contains all the solids and surfaces in the selection set. The second subset contains the first selected region and all subsequent coplanar regions. The third subset contains the next region that is not coplanar with the first region and all subsequent coplanar regions, and so on until all regions belong to a subset.

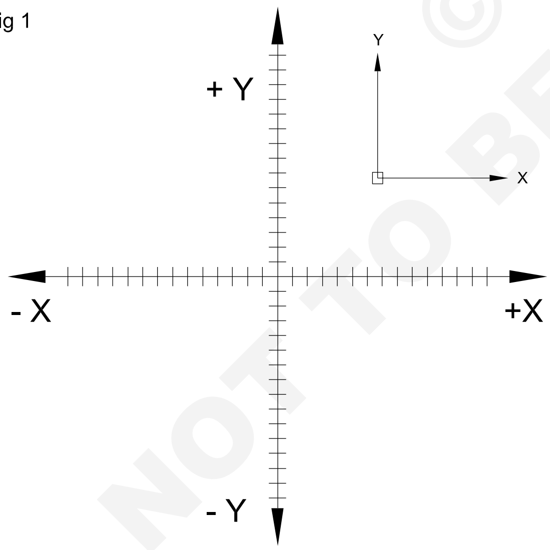
3D Co-ordinate systems

Objectives: At the end of this lesson you shall be able to
- **state the concept of UCS.**
- **describe 3D rotate.**

3-D Co - ordinate system

By now you should be very comfortable working your way around the X-Y coordinate system. Anyway, here is a quick review. Looking from the plan (top view), this is what you see to (Fig 1) out where is positive X and positive Y.

Fig 1

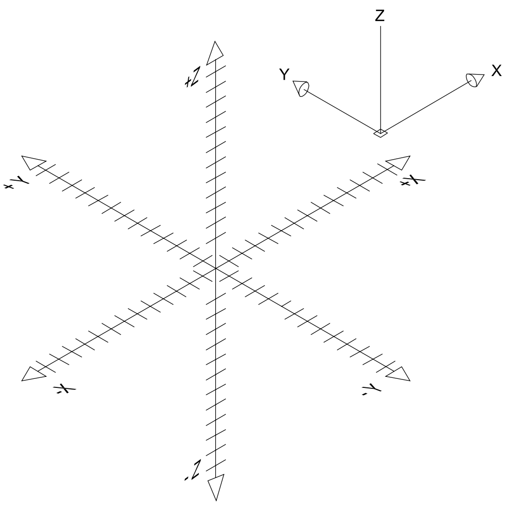


If you were to look at the same picture, but at a slight angle, you would see the third axis (Fig 2). This new axis is called the Z-axis. Imagine that the positive Z-axis is coming towards you out of the monitor.

The Z-axis has always been there, lurking in the background, waiting for you.

When you entered points previously, you would enter them in the format: X,Y. By doing this, you let AutoCAD know that in these cases, Z was equal to zero (Fig 3). Entering 4,3 would be the same as entering 4,3,0. Now if you draw a line from the origin (0,0,0) to a point at 4,3,2, you would get a line that goes 4 inches to the right, 3 inches up and 2 inches towards you. The properties of this line would be this:

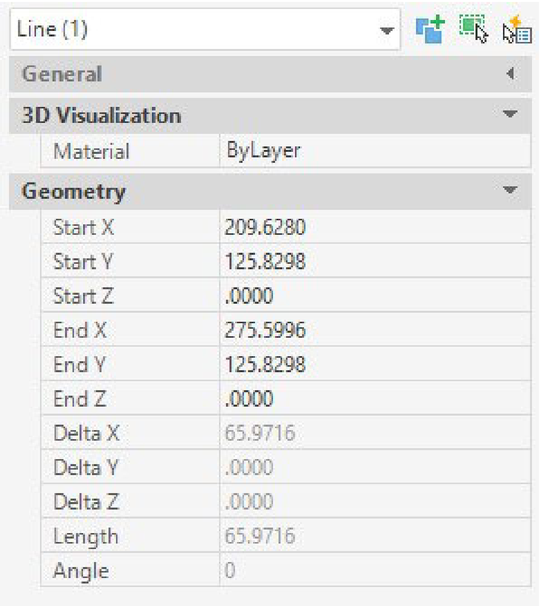
Fig 2



Notice that the line is actually 5.3852" long. If you were to look at it from the plan view, it would look exactly like a line drawn from 0,0 to 4,3 Draw a line from 0,0 to 4,3 and then compare the properties. (Fig 3)

The diagrams below, show (Fig 4) this line from 4 different views to illustrate how things can look different in 3D. Look at each one carefully, and see if it makes sense to you.

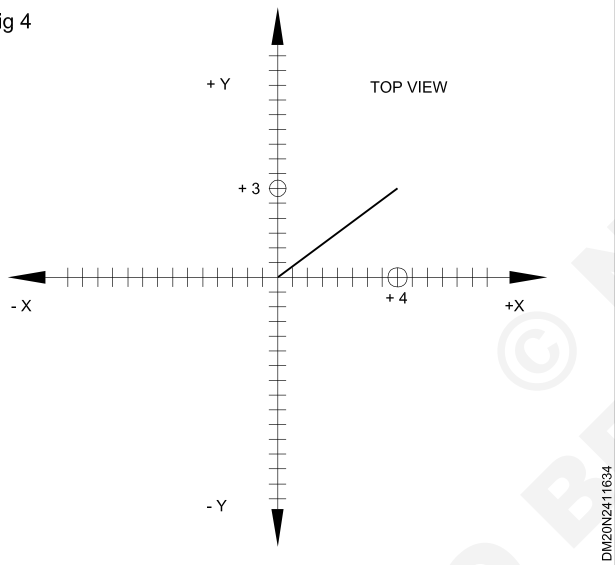
Fig 3



Line (1)

General	
3D Visualization	
Material	ByLayer
Geometry	
Start X	209.6280
Start Y	125.8298
Start Z	.0000
End X	275.5996
End Y	125.8298
End Z	.0000
Delta X	65.9716
Delta Y	.0000
Delta Z	.0000
Length	65.9716
Angle	0

Fig 4



This is the usual view you have seen when using AutoCAD in 2D. You are looking straight down the Z axis (positive Z is pointing at you). It looks like any other line you have drawn, going from 0,0 to 4,3 - but there is a difference...

If you were to look at the line from the front, instead of the top (as shown above) you would be able to notice the elevation of 2 units in the Z axis. This is the same line as above, only viewed from a different angle. In this view, you are looking straight down the -Y axis(Fig 5).

Just for fun, here is the same line but viewed from the left. This would be looking down the -X axis (Fig 6).

Finally, here is the line as viewed in 3D space from the Southeast view (Fig 7). This is where viewing 3D objects on a 2D monitor gets tricky. You need to visualize the Z Axis.

Fig 5

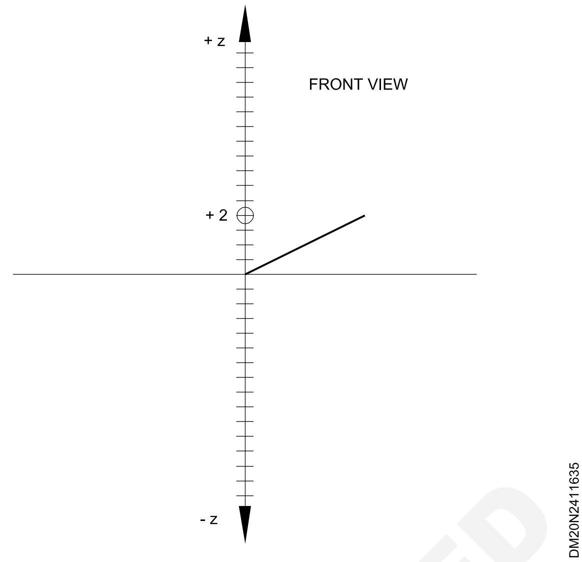


Fig 6

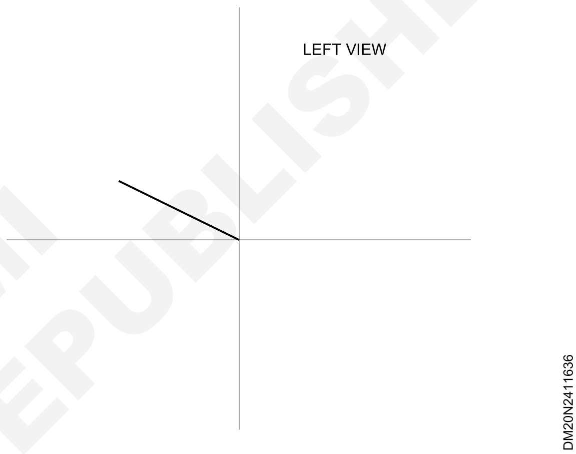
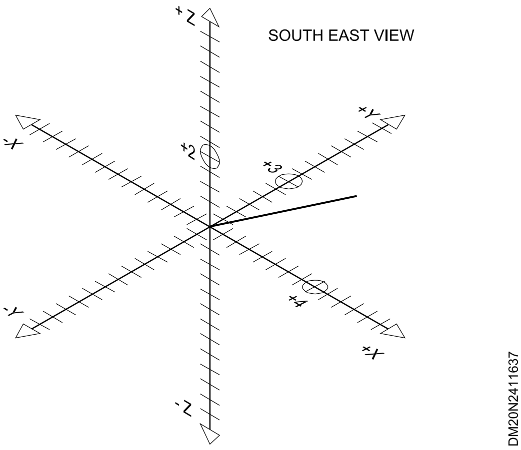


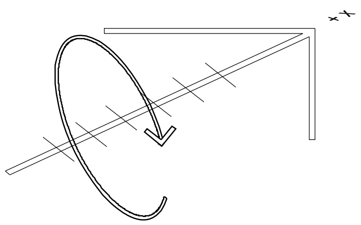
Fig 7



What the above images show you is that you will have to get used to looking at a 3D world on a 2D monitor. In each image, the black line looks flat, but you have to use your reference points to determine where it truly is. If you don't understand this perfectly right now, don't worry. It's just an exercise to expose you to 3D viewing. As the lessons progress, you will get much more familiar to this.

3D Rotation (Fig 8)

Fig 8



DIRECTION OF POSITIVE ROTATION

DM20N2411638

Now for the confusing part. You already know how to rotate 2D objects, but you also have to know how AutoCAD measures angles of rotation in 3-D. There is a somewhat simple rule for this called "The Right Hand Rule" (Fig 8). To figure out which is the positive rotation angle, imagine that you are wrapping your right hand around the axis with your thumb pointing towards the positive end. The direction that your fingers are wrapped is the positive direction. This applies to all three axes.

Direction of positive rotation

The main point of this lesson is to tell you that objects can trick you in 3D space. Shortcuts don't always work, you have to be careful with Osnaps and your drawing can turn into a mess very quickly if you're not paying attention. Trust me, I've seen enough students take the easy route and have to start over. If you want to learn 3D, review each lesson before progressing. Make sure you know the concepts inside and out. This is just an introduction to the concepts, you will learn more in the following lessons. You may still want to refer back to this tutorial, though.

Annotations in 3D modeling

Annotations in 3D will snap right onto the 3D surface and draw exactly where your cursor is pointed allowing you to make the most accurate measurements ever in 3D. This will enable you to precisely measure complex 3D structures:

Print Preview

Displays the drawing as it will be plotted.

The preview is based on the current plot configuration, as defined by the settings in the Page Setup or Plot dialog box. It shows exactly how the drawing will look when plotted, including lineweights, fill patterns, and other plot style options.

The cursor changes to a magnifying glass with plus (+) and minus (-) signs. Dragging the cursor toward the top of the screen while holding down the pick button enlarges the preview image. Dragging toward the bottom of the screen reduces the preview image.

Two settings for your graphics system configuration will affect the preview. To access these settings, enter 3dconfig, and click Manual Tune to display the Manual Performance Tuning dialog box. For more information, see Performance Tuning.

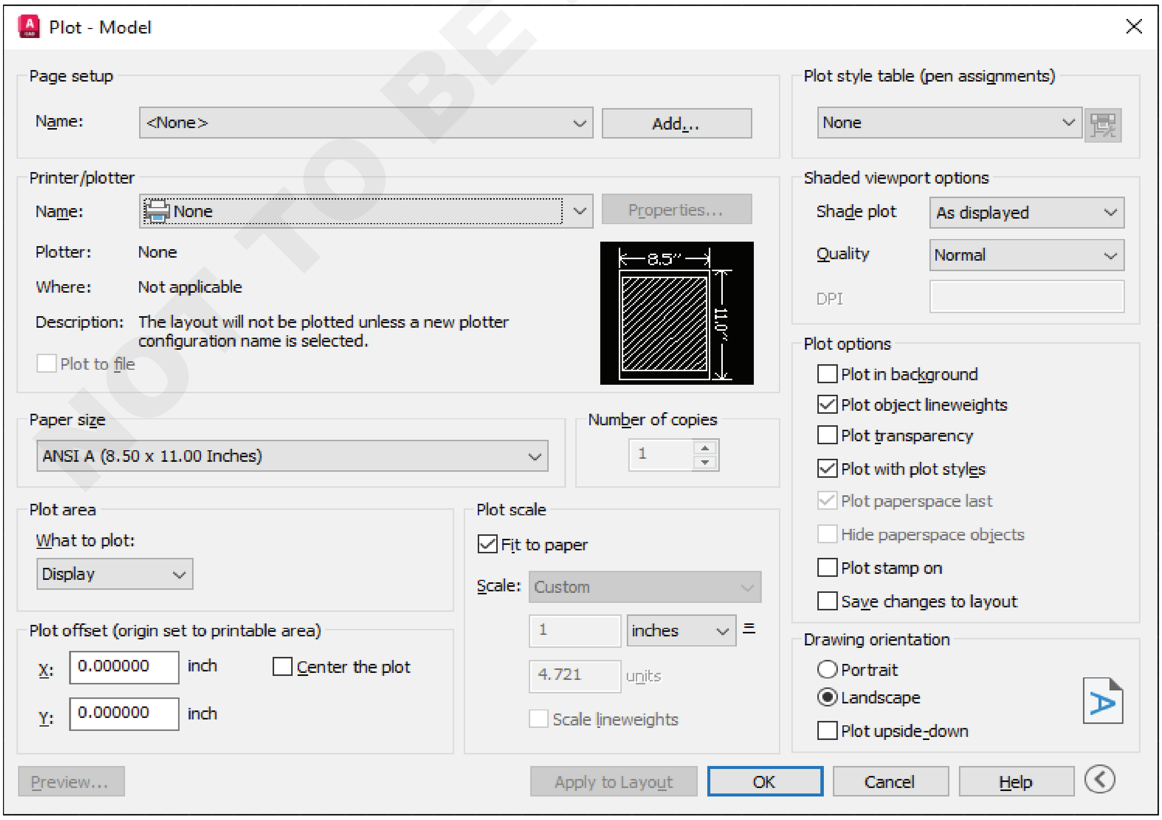
Plot

Plots a drawing to a plotter, printer, or file.

The Plot dialog box is displayed. Click OK to begin plotting with the current settings.

The Plot, and the Page Setup dialog boxes, you can choose from options that affect how objects are plotted.

Fig 9



About Setting Options for Plotted Objects

- Shaded Viewport Plotting. Specifies shaded plotting options: As Displayed, Wireframe, or Hidden. The effect of this setting is reflected in the plot preview, but not in the layout.
- Plot Object Lineweights. Specifies that lineweights assigned to objects and layers are plotted.
- Plot Transparency. Specifies that transparency levels applied to objects and layers are plotted. Plot Transparency applies to wireframe and hidden plots only. Other visual styles, such as Realistic, Conceptual, or Shaded will always plot with transparency.
- Plot with Plot Styles. Specifies that the drawing is plotted using plot styles. Selecting this option automatically plots lineweights. If you do not select this option, objects are plotted with their assigned properties and not with the plot style overrides.
- Plot Paper Space Last. Specifies that objects in model space are plotted before those in paper space.
- Hide Paperspace Objects. Specifies whether the Hide operation applies to objects in the layout viewport. The effect of this setting is reflected in the plot preview, but not in the layout.
- Plot Stamp On. Turns on plot stamps and places a plot stamp on a specified corner of each drawing and can add it to a log file. Plot stamp settings are specified in the Plot Stamp dialog box, where you can specify the information you want applied to the plot stamp, such as drawing name, date and time, plot scale, and so on. In the Advanced settings, you can specify the text properties of the plot stamp, including the font used and its size.
- Save Changes to Layout. Saves the changes that you make in the Plot dialog box to the layout.

Page Setup

Modifies the current page layout settings for the plotting device, paper size, plot scale, and several other settings in the command line.

The following prompts are displayed.

Enter an output device name or [?] <current>:

Displays the name of the output device specified in the currently selected page setup. Enter ? to display a list of output devices.

Enter paper size or [?]:

Sets the current paper size. Enter ? to display a list of the standard paper sizes that are available for the specified output device. If no plotter is selected, the full standard paper size list is displayed.

Enter paper units [Inches/Millimeters]<current>:

Sets the current unit convention to be used in the layout, inches or millimeters.

Enter drawing orientation [Portrait/ Landscape]:<current>

Orients and plots the drawing so that either the short edge or the long edge of the paper represents the top of the page

Plot upside down? [Yes/No] <current>:

Orients and plots the drawing upside down.

Enter plot area [Display/Extents/Limits/View/ Window] <current>:

Specifies how the boundaries of the area to be plotted are determined.

Display

Specifies the view in the current viewport in the Model tab or the current paper space view in the layout.

Extents

Specifies the portion of the current space of the drawing that contains objects. All geometry in the current space is plotted.

Limits

When plotting from the Model tab, specifies the entire drawing area that's defined by the grid limits. If the current viewport does not display a plan view, this option has the same effect as the Extents option.

Layout

When plotting a layout, specifies everything within the printable area of the specified paper size, with the origin calculated from 0,0 in the layout.

View

Specifies a view that was previously saved with the VIEW command.

Window

Prompts for the upper-left and lower-right corners of the rectangular area to be plotted.

Enter plot scale (Plotted <Units>=Drawing Units) or [Fit] <current>:

Determines the scale at which a drawing will be plotted, either from model space or a layout.

Plotted <units>

Specifies the relative size of plotted units to drawing units.

Fit

Specifies the scale of the plot to fit within the specified paper size at a custom scale.

Enter plot offset (x,y) or [Center] <0.00,0.00>:

Specifies a shift to be applied to the 0,0 origin point at the lower-left corner of the area to be plotted.

Plot Offset

Specifies the X and Y distances to shift the area to be plotted. The coordinate values can be positive, negative, or zero.

Center

Automatically calculates the X and Y offset values to center the plot on the paper. This option is not available when Plot Area is set to Layout.

Plot with plot styles? [Yes/No] <current>:

Specifies whether a plot style table should be referenced.

Enter plot style table name or [?] (enter . for none) <current>:

Specifies a plot style table to be assigned that is assigned to the current Model tab or layout tab. Enter ? to display a list of the currently available plot style tables. Enter a period (.) to specify no plot style table.

Plot with lineweights? [Yes/No] <current>:

Specifies that non-zero lineweights should be plotted regardless of the way objects are displayed on the screen.

Enter shade plot setting [As displayed/legacy Wireframe/legacy Hidden/Visual styles/Rendered] <current>:

Specifies whether objects are plotted differently than the way they are displayed on the screen.

As displayed

Specifies using the same style for objects the way they are displayed on the screen.

Legacy Wireframe

Specifies a wireframe style regardless of the way objects are displayed on the screen. Uses the legacy SHADEMODE command.

Legacy Hidden

Specifies a hidden-lines-removed style regardless of the way objects are displayed on the screen. Uses the legacy SHADEMODE command.

Visual styles

Specifies that a visual style

Rendered

Specifies a rendered style regardless of the way they are displayed on the screen.

Working principle of valves and their description

Objectives: At the end of this lesson you shall be able to
- **explain valves and their parts**
- **explain the function of safety valves & gate valves.**

A valve is a device that regulates, directs or controls the flow of a fluid (gases, liquids, fluidized solids, or slurries) by opening, or closing, or partially obstructing various passageways. Valves are technically fittings, but are usually discussed as a separate category. In an open valve, fluid flows in a direction from higher pressure to lower pressure.

Valves have many uses, including controlling water for irrigation, industrial uses for controlling processes, residential uses such as on/ off and pressure control to dish and clothes washers and taps in the home. Valves are also used in the military and transport sectors.

Valves are found in virtually every industrial process, including water and sewage processing, mining, power generation, processing of oil, gas and petroleum, food manufacturing, chemical and plastic manufacturing and many other fields.

People in developed nations use valves in their daily lives, including plumbing valves, such as taps for tap water, gas control valves on cookers, small valves fitted to washing machines and dishwashers, safety devices fitted to hot water systems, and poppet valves in car engines.

Valves may be operated manually, either by a handle, lever, pedal or wheel, valves may also be automatic, driven by changes in pressure, temperature or flow,

More complex control systems using valves requiring automatic control based on an external input (i.e. regulating flow through a pipe to a changing set point) require an actuator. An actuator will stroke the valve depending on its input and set- up, allowing the valve to be positioned accurately, and allowing control over a variety of requirements.

Valves vary widely in form and application, sizes typically range form0.1 mm to 60 cm.

Special valves can have a diameter exceeding 5 meters.

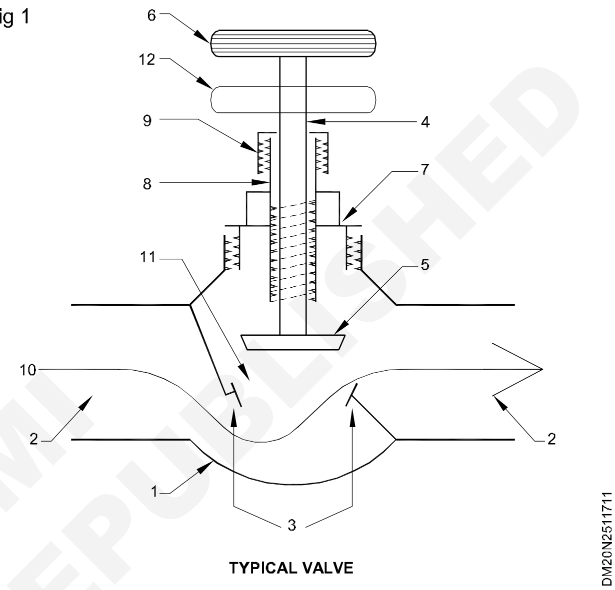
Valves are quite diverse and may be classified into a number of basic types. Valves may also be classified by how they are actuated.

- Hydraulic
- Pneumatic
- Manual
- Solenoid valve
- Motor

Components

Cross-sectional diagram of an open globe valve. (Fig 1)

Fig 1



1 Body

2 Ports

3 Seat

4 Stem

5 Bonnet

6 Packing

7 Gland nut

8 Disc when valve is open

9 Handle or hand wheel when valve is open

10 Fluid flow when valve is open

11 Position of disc if valve were shut

12 Position of handle or hand wheel if valve were shut

The main parts of the most usual type of valve are the body and the bonnet. These two parts form the casing that holds the fluid going through the valve.

Body: The valve's body is the outer casing of most or all of the valve that contains the internal parts or trim. The bonnet is the part of the encasing through which the stem (see Fig 1) passes and that forms a guide and seal for the stem. The bonnet typically screws into or is bolted to the valve body.

Valve bodies are usually metallic or plastic, Brass, bronze, gunmetal, cast iron, steel, alloy steels and stainless steels are very common. Seawater applications, like desalination plants, of use duplex valves, as well as super duplex valves, due to their corrosion resistant properties, particularly against warm sea water. Alloy 20 valves are typically used in sulphuric acid plants, whilst monel valves are used in hydrofluoric acid (HF Acid) plants. Hastelloy valves are often used in high temperature applications, such as nuclear plants, whilst inconel valves are often used in hydrogen applications. Plastic bodies are used for relatively low pressures and temperatures. PVC, PP, PVDF and glass -reinforced nylon are common plastics used for valve bodies.

Ports: Ports are passages that allow fluid to pass through the valve. ports are obstructed by the valve member or disc to control flow. Valves most commonly have 2 ports, but may have as many as 20. The valve is almost always connected at its ports to pipes or other components. Connection methods include threading, compression fittings, glue, cement, flanges, or welding.

Handle or actuator: A handle is used to manually control a valve form outside the valve body. Automatically controlled valve often do not have handles, but some may have a handle (or something similar) anyway to manually override automatic control such as a stop - check valve. An actuator is a mechanism or device to automatically or remotely control a valve from outside the body. Some valves have neither handle nor actuator because they automatically control themselves from inside; for example, check valves and relief valves may have neither.

Valve disc: A disc or valve member is a movable obstruction inside the stationary body that adjustably restricts flow through the valve. Although traditionally disc - shaped, discs come in various shapes. Depending on the type of valve, a disc can move linearly inside a valve, or rotate on the stem (as in a butterfly valve), or rotate on a hinge or trunnion (as in a check valve).A ball is a round valve member with one or more paths between ports passing through it. By rotating the ball, flow can be directed between different ports.

Seat: The seat is the interior surface of the body which contacts the disc to form a leak-tight seal. In discs that move linearly or swing on a hinge or trunnion, the disc comes into contact with the seat only when the valve is shut. In discs that rotate, the seat is always in contact with the disc, but the area of contact changes as the disc is turned. The seat always remains stationary relative to the body. Seats are classified by whether they are cut directly into the body, or if they are made of a different material.

Ball valve: A closed soft seated valve is much less liable to leak when shut while hard seated valves are more durable. Gate, globe, and check valves are usually hard seated while butterfly, ball, plug and diaphragm valves are usually soft seated.

Stem: The stem transmits motion from the handle or controlling device to the disc. The stem typically passes through the bonnet when present. In some cases, the stem and the disc can be combined in one piece, or the stem and the handle are combined in one piece.

The motion transmitted by the stem may be a linear force, a rotational torque, or some combination of these (Angle valve using torque reactor pin and Hub Assembly).

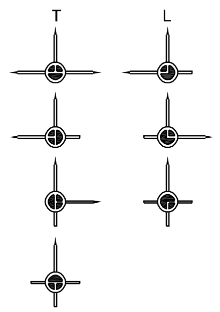
Valves whose disc is between the seat and the stem and where the stem moves in a direction into the valve to shut it are normally-seated or front seated.

Gaskets: Gaskets are the mechanical seals, or packing's used to prevent the leakage of a gas or fluids from valves.

Valve balls: A valve ball is also used for several duties, high-pressure, high-tolerance applications. They are typically made of stainless steel, titanium, Stellite, brass, or nickel. They can also be made of different types of plastic, such as ABS, PVC, PP or PVDF.

Spring: Many valves have a spring for spring-loading, to normally shift the disc into some position by default but allow control to reposition the disc. Relief valves commonly use a spring to keep the valve shut, but allow excessive pressure to force the valve open against the spring-loading. Coil springs are normally used. Typical spring materials include zinc plated steel, stainless steel.

Fig 2



THREE PORT VALVES

DM20N2511712

Valve operating positions:

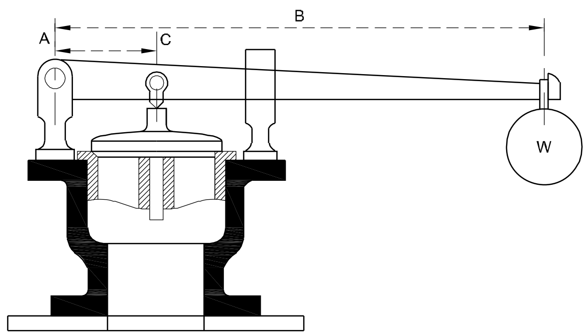
Valve positions are operating conditions determined by the position of the disc or rotor in the valve. Some valves are made to be operated in a gradual change between two or more positions. Return valves and non-return valves allow fluid to move in 2 or 1 directions respectively.

Two-port valves: Operating positions for 2-port valves can be either shut (closed) so that no flow at all goes through, fully open for maximum flow, or sometimes partially open to any degree in between.

Three-port valves (Fig 2)

Schematic 3-way ball valve: L-shaped ball right, T-shaped left. Valves with three ports serve many different functions. A few of the possibilities are listed here.

Fig 3



LEVER SAFETY VALVE

Three-way ball valves come with a T- or L- shaped fluid passageways inside the rotor. The T valve might be used to permit connection of one inlet to either or both outlets or connection of the two outlets. The L valve could be used to permit disconnection of both or connection of either but not both of two inlets to one outlet.

Four-port valves

Main article: four-way valve: A 4-port valve is a valve whose body has four ports equally spaced round the body and the disc has two passages to connect adjacent ports. It is operated with two positions.

Control: Many valves are controlled manually with a handle attached to the stem. If the handle is turned ninety degrees between operating positions, the valve is called a quarter-turn valve. Butterfly, ball valves, and plug valves are often quarter-turn valves. If the handle is circular with the stem as the axis of rotation in the center of the circle, then the handle is called a hand wheel.

Lever safety valve: The main Objectives of safety valve is that to prevent the excessive pressure in the boiler to avoid accident. For this a device is provided through which the steam can escape when it reaches high pressure.

Description of lever safety valve: Fig 3 shows a simple diagram of a lever safety valve and

It consists of a valve which is resting over a gun metal seat, is called valve seat. The valve seat set over on a mounting blocks, fitted out the boiler shell. One end of the lever is hinged to a rod of the mounting blocks. The other carries a weight. A small strut is fixed over the valve working of a lever.

Safety valve

The pressure of the lever is transferred to the valve strut. As and when the steam thrust exceeds the safe limit, the upward pressure of the steam lift the valve and the steam escapes till the thrust pressure falls down to the normal. The valve then gets back to its original position. ie. closed position. The accepted weight at the end of the lever for keeping the pressure 'P' in the boiler is get by taking moments about the hinged point.

The lever safety valve is employed in stationary boilers only.

Description and working principle of dead weight safety valve

Objectives: At the end of this lesson you shall be able to
- **explain the construction features of a dead weight safety valve**
- **explain function of dead weight safety value.**

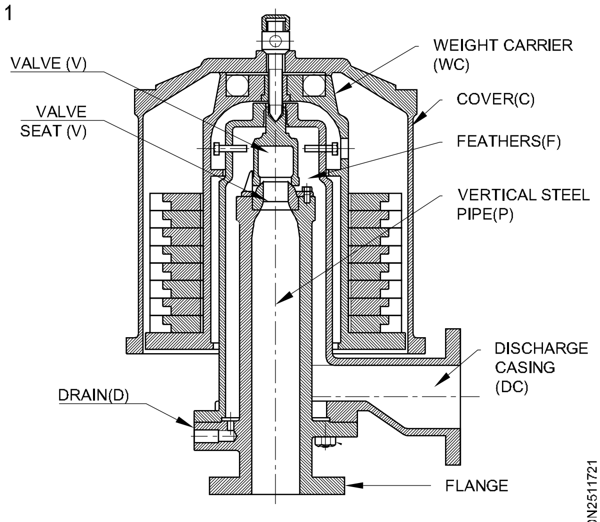
Dead weight safety valve

Function of Dead weight safety valve

A valve is placed over a valve seat, which is fixed upon a long vertical pipe. It has a flange at the bottom to fix at the top of the boiler. A weight carrier which carries cast iron ring suspended at the top of the valve. As and when the steam pressure in the boiler exceeds the normal pressure, it lifts the valve along with its weight. The steam which seems to be excess escapes through the pipe, until the pressure decreases to the normal valve. This type of valve is employed only to the stationary type of boilers, because it cannot withstand any jerk or vibration due to displacement (marine). This is heavy in weight and required to withstand the stem pressure. So it is not acceptable for high pressure boilers. The objection to dead weight safety valve is that it carries heavy weight.

The construction features of a dead weight safety valve. (Fig 1)

Fig 1



DEAD WEIGHT SAFETY VALVE

The dead weight safety valve has a valve V which is made of gun metal to prevent from rusting. The valve is seated on a gun metal seat 'S'. It is fixed to the top of a vertical steam pipe P. The vertical pipe which carries steam has a flange 'F' at its bottom to fix at the top of the boiler shell.

A weight carrier 'C' hanged from the top of the boiler which carries a cast iron rings. The rings are called as weight 'W', and the total weight must be sufficient to keep the valve as the seat against the normal working pressure.

Description and working principle of rams bottom safety valve

Objectives: At the end of this lesson you shall be able to
- **explain the function and construction features of rams bottom safety valve.**

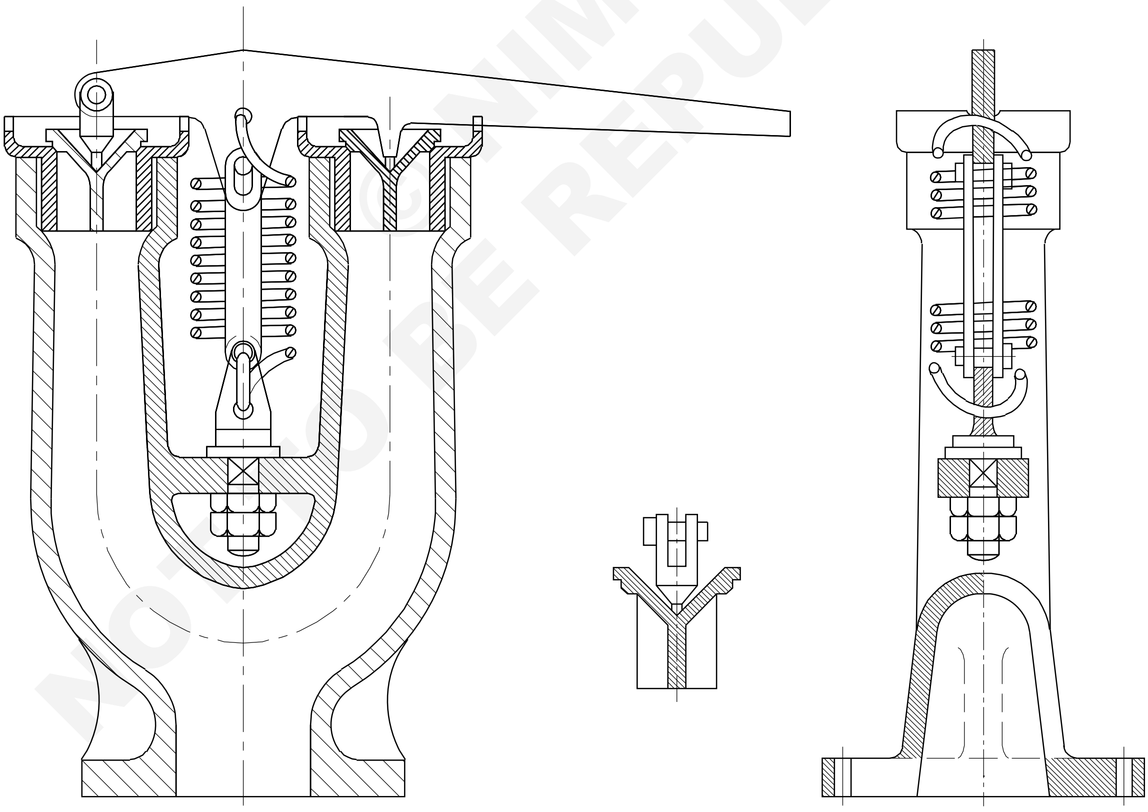
Rams bottom safety valve (Fig 1)

It is a boiler mounting and a safety device which protects the boiler against building-up of excess pressure. The spring used in the safety valve is set to act when the stream pressure exceeds the set value and allows the steam to escape. Thus, only the permissible value of steam pressure is allowed inside the boiler.

Figure 1 shows the details of Rams bottom safety valve. It consists of housing 1 with two valve chests. The valve seats 4 are screwed into the housing and valves 5 are located in the valve seats. The eye bolt 2 is fastened to the bridge of the housing, by means of washer 11 and both the nuts 12 and 13. Pivot 6 is pinned to the lever 9 and it is placed over the valves and held in position by safety links 3 and spring 10. The safety links 3 are fixed at one end to the lever and the other end to the eye bolt 2 by pins 7 and split pins 8. The required rigidity is provided to this assembly by fixing the spring 10 between the eye bolt and the lever (holes are provided in the lever and eye bolt for this purpose)

When the set valve of the pressure exceeds in the boiler, the lever moves and allows the valves to get lifted from the seats concerned. The movement of the lever is permitted due to the slot provided centrally in it and returns to the original position due to spring action. Figure shows the assembled views of the Rams bottom safety valve.

Fig 1



RAMSBOTTOM SAFETY VALVE -ASSEMBLY

DM20N2511731

Description and working principle of Gate valve

Objectives: At the end of this lesson you shall be able to
- **Working principle of Gate valve.**

A gate valve is a control valve that either allows Media to flow through unobstructed or stops the fluid flow.

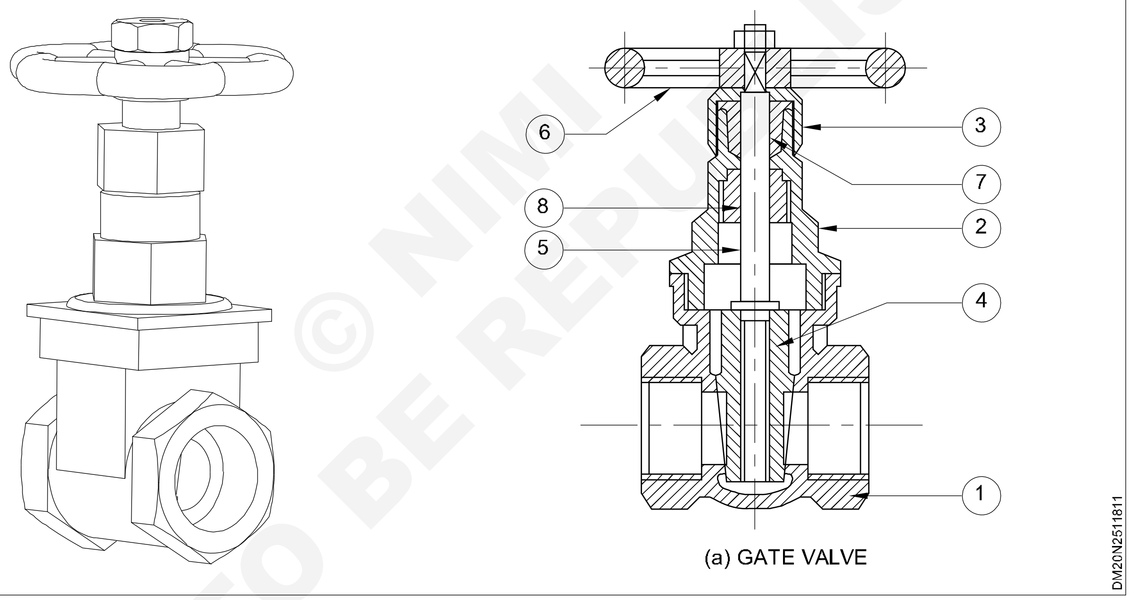
The gate valve as illustrated in on the right, Generally Consists of a gate like disc, actuated by a screwed stem and hand Wheel which moves up and down and right angles to the flow. To retain the fluid in the pipe line, a gland is provided which is supplied with some type of packing to resist leakage.

Gate valve principle:

Gate valve commits of three major comments: Body, bonnet, and stem. The body is Generally connected to the pipes by means of flanged, screwed, or welded connection the bonnet containing the moving parts, is joined to the body. generally with bolts, to permit cleaning and Maintenance... the Valve portion consists of the stem, the gate, the wedge, or disc, and the seat rings.

The main operation Mechanism is very simple. When the hand-wheel is turned, it rotates the stem, which is translated into the Vertical movement of the gate via threads. They are considered multitum valves as it takers more than one 360 turn to fully open/close the valve. When the gate is lifted from the path of the flow, the valve opens and when it is returned to its closed position, it seals the bore resulting the full closer of the valve.

Fig 1



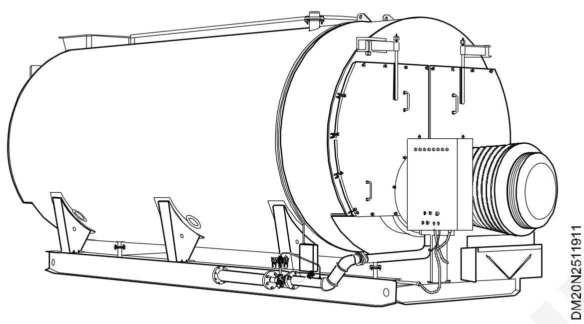
(a) GATE VALVE

Simple stationary fire tube boiler & boiler mountings

Objectives: At the end of this exercise you shall be able to
- **state the use of boiler**
- **explain working principle of a boiler**
- **state the different types of boiler and explain their features**
- **describe the importance of boilers mountings.**

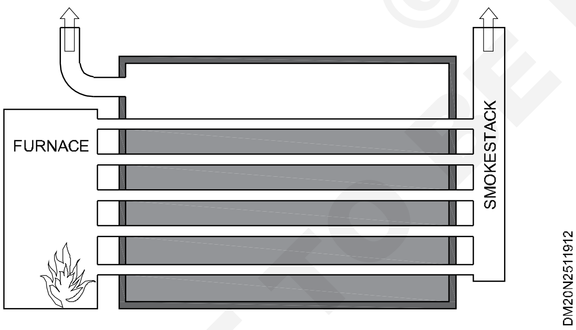
In this lesson we will study about a boiler; The boilers are used in power plant for the generation of steam. They are crucial for the working of a power plant. They are mostly used in the power plants where steam turbines are used for the generation of electricity. The knowledge of boiler is very essential if you are a mechanical engineer.

Fig 1



A boiler is a closed vessel which is used to convert the water into high pressure steam. The high pressure steam so generated is used to generate power.

Fig 2



Working principle of a Boiler

The boiler works on the same principle as the water is heated in a closed vessel and due to heating , the water changes into steam. This steam possesses high pressure kinetic energy. The boiler contains water. The water is heated to its boiling temperature by the use of heat from the furnace. Due to heating of water, it gets converted into high pressure steam. The steam generated is passed through the steam turbines. As the high pressure steam strikes the turbine, it rotates the turbine. A generator is attached to the turbine and the generator also starts to rotate with the turbine and produces electricity.

Different types of Boiler:Boilers can be classified in different basis but here discussing the only important basis of boiler classification.

1 **According to the contents in the tubes:** According to the contents in the tubes, the boilers can be classified as fire tube boiler and water tube boiler.

   i **Fire Tube Boiler:** In fire tube boiler the fire or hot gas are present inside the tubes and water surrounds these fire tubes. Since fire is inside the tubes and hence it is named as fire tube boiler. The heat from the hot gases is conducted through the walls of the tube to the water.

   - The examples of the fire tube boiler are: simple vertical boiler, Cochran boiler, Lancashire boiler, Cornish boiler, Locomotive boiler, Scotch marine boiler and Vulcan boiler.

   ii **Water Tube Boiler:** In water tube boilers, the water is present inside the tubes and the fire or hot gases surrounds these water tubes.

   - The examples of water tube boilers are: La -Mont boiler, Benson boiler, Sterling boiler, Babcock and Wilcox boiler, Yarrow boiler and Loffler boiler.

2 **According to the Number of Tubes:** According to the no of tubes, the boilers are classified as single tube boiler and multitubular boilers.

   i **Single Tube Boilers:** The boilers which contain one fire tube or water tube are called as single tube boiler.

   - The examples of single tube boilers are Cornish boiler and simple vertical boiler.

   ii **Multi tubular Boiler:** The boilers which has two or more water tube or fire tubes are called multi tubular boilers.

   - Lancashire boiler, Locomotive boiler, Cochran boiler, Babcock and Wilcox boilers are multi tubular boilers.

3 **According to the position of the Furnace:** According to the position of the furnace, the steam boilers are classified as internally fired boilers and externally fired boilers.

   i **Internally Fired Boilers:** The boilers in which the furnace is located inside the boiler shell are called internally fired boilers.

   - Among all the fire tube boilers, most of the boilers are internally fired boilers.

   ii **Externally Fired Boilers:** In externally fired boilers, the furnace is located outside the boiler shell. In this the furnace is arranged underneath in brick work setting.

- Water tube boilers are always externally fired boilers.

4 **According to the Axis of the Shell:** According to the axis of the shell, the boilers are classified as vertical boilers and horizontal boilers.

i **Vertical boilers:** The in which the axis of the shell is vertical are called vertical boilers.

- Examples of vertical boilers are: simple vertical boiler and Cochran boiler.

ii **Horizontal Boilers:** When the axis of the shell in a boiler is found horizontal then it is called as horizontal boiler.

- Lancashire boiler, Babcock and Wilcox boiler and locomotive boilers are examples of horizontal boilers.

5 **According to the Methods of Circulation of Water and Steam:** According to the method of circulation of water and steam, the steam boilers are divided into natural circulation boilers and forced circulation boilers.

i **Natural Circulation Boilers:** In natural circulation boilers, the circulation of water takes place naturally by the convection currents that set up during the heating of water.

- In most of the boilers there is a natural circulation of water such as Lancashire boiler, Cochran boiler etc.

ii **Forced Circulation Boilers:** In this type of steam boilers, the water circulation takes place with the help of a centrifugal pump driven by some external power, Here the circulation is forced by some external agency.

- Forced circulation is used in high pressure boilers such as La- Mont boiler, Loffler boiler, Benson boiler etc.

6 **According to the use:** According to the use, the boilers are classified as stationary boilers and mobile boilers

i **Stationary Boilers:** These are the boilers which are stationary and cannot be moved from one place to another. Once they are installed, cannot be transported to other destination.

- These boilers are used in power plants and in industrial process works.

ii **Mobile Boilers:** these are the steam boilers which can be moved from one place to another.

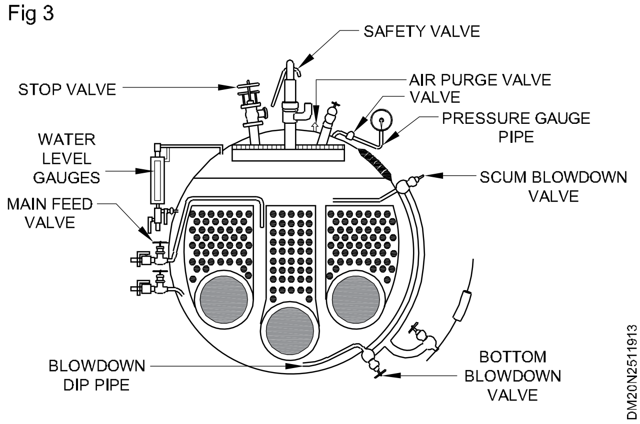
- Locomotive and marine boilers are mobile - boilers

In this article we have studied about what is a boiler? different types of boilers.

Boiler mountings (Fig 3)

The boiler mountings are fittings which are mounted on the boiler for its proper functioning. It may be noted that a boiler cannot function safely without the mountings.

Fig 3



Following are the important boiler mountings:

1 Water level indicator

2 Pressure gauge

3 Safety valve

4 Stop valve

5 Blow off cock

6 Feed check valve

7 Fusible plug

Water level indicator

The boiler's water level indicator, a key component, shows the current water in the boiler. It is a safety device that ensures the boiler operates safely.

Working principle

The water is made up of two gunmetal tubes. A and B, attached to a vertical hard glass tube G. The glass tube is connected to the steam space of the boiler by tube A, and the glass tube is connected to the water space of the boiler by tube B. A valve "S," referred to as a steam valve, is installed in tube A, and a valve "W," referred to as a water valve, is established in tube B. Along with these valves, a third valve D, a drain valve, is attached to the water level indicator so that water and condensed steam from the gunmetal tube A can occasionally be emptied via it.

Pressure gauge

Pressure gauges are used to measure the steam pressure inside a steam boiler. The pressure gauge is fixed in front of a steam boiler.

Working Principle

Bourdon pressure gauge is the pressure gauge. It is made up of spring tube A, which is round. The Bourdon tube has one end that is sealed up and attached to a link Land the other that is connected to a hollow block B. The closed end of the tube is connected to the toothed sector C, which is hinged at O, by the link L. the sector gears with teeth and pinion D carrying pointer P. On a dial with graduated pressure units, the pointer moves.

Safety valves

These devices are mounted to the steam boiler to stop high steam internal pressure explosions. When the boiler pressure exceeds its normal operating pressure, the safety valve automatically opens to prevent the pressure from rising past that level. This enables additional steam to escape into the atmosphere until the pressure levels out, at which point it can no longer rise above. In this way, a safety valve safeguards a boiler against harm brought on by excessive steam pressure. Following is the list of boiler safety devices:

Standard safety valves include:

- Lever safety valve
- Deadweight safety valve
- Safety valve with spring-loaded

Steam stop valve

A stop valve's job is to regulate the boiler's internal steam flow and, if necessary, entirely halt it. A stop valve or junction valve controls steam from the boiler. The valves installed in pipelines that enable steam to flow in one direction are known as stop valves, whereas the valves located on boilers that alter the direction of steam flow by 90° are known as junction valves.

Blow-off cock

A blow-off cock's purpose is to periodically empty the boiler while it is being cleaned or examined and to remove the sediments that have built up at the bottom of the boiler while it is in use. Under the pressure of steam, the water rushes out with incredible velocity when the blow-off valve is opened, carrying the sediments with it. When the blow-off valve has opened the water under the pressure of steam, it rushes out with tremendous velocity, thus carrying out the sediments.

Feed Check Valve

When the water level in the boiler decreases, feed water is supplied to replenish je until, reaches the desired level. Because the pressure inside the boiler will be high, a pump must raise the pressure of the feed water before it is introduced to the boiler. The boiler receives the feed water under high pressure through the feed check valve. A feed check valve's job is to regulate the water flow from the feed pump to the boiler and stop water from returning from the boiler to the pump when it stops working or when the pump pressure is lower than the pressure. The feed check valve appears at the boiler end of the feed pump's delivery pipe.

Fusible Plug

Tin or a lead alloy with a low melting point makes up the plug. The fusible plug's job is to extinguish the fire in the boiler's furnace when the water level drops below a dangerous level, preventing an explosion that would occur from overheating the tubes and shell. It is positioned above the furnace's or combustion chamber's crown.

Description and working principle of steam stop valve & Blow off cock

Objectives: At the end of this lesson you shall be able to
- **Working principle and functions of steam stop valve & blow off cock**

Steam stop valves mount in boilers are important for the Safe operation of the boiler. It is present at the top of the boiler. It is used to transfer the steam from the boiler to the place where it is needed.

It is commonly used to regulate the flow of steam from a boiler to the steam pipe or Steam pipe to another steam pipe

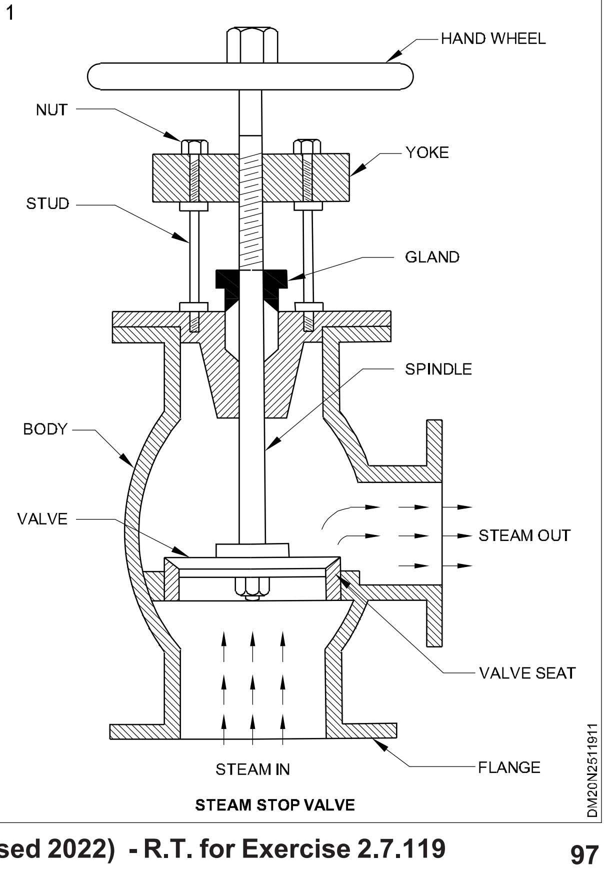
Principle of Steam Stop Valve:

When the spindle is rotated with the help of the hand wheel the valve moves up and down. When the valve sits on the valve seat, the passage of steam stops completely.

The steam passage can be partially or fully opened ,by moving the valve upward, the clearance (passage) between the valve and their valve seat control the flow of steam from the boiler with the help of rotating the hand wheel.

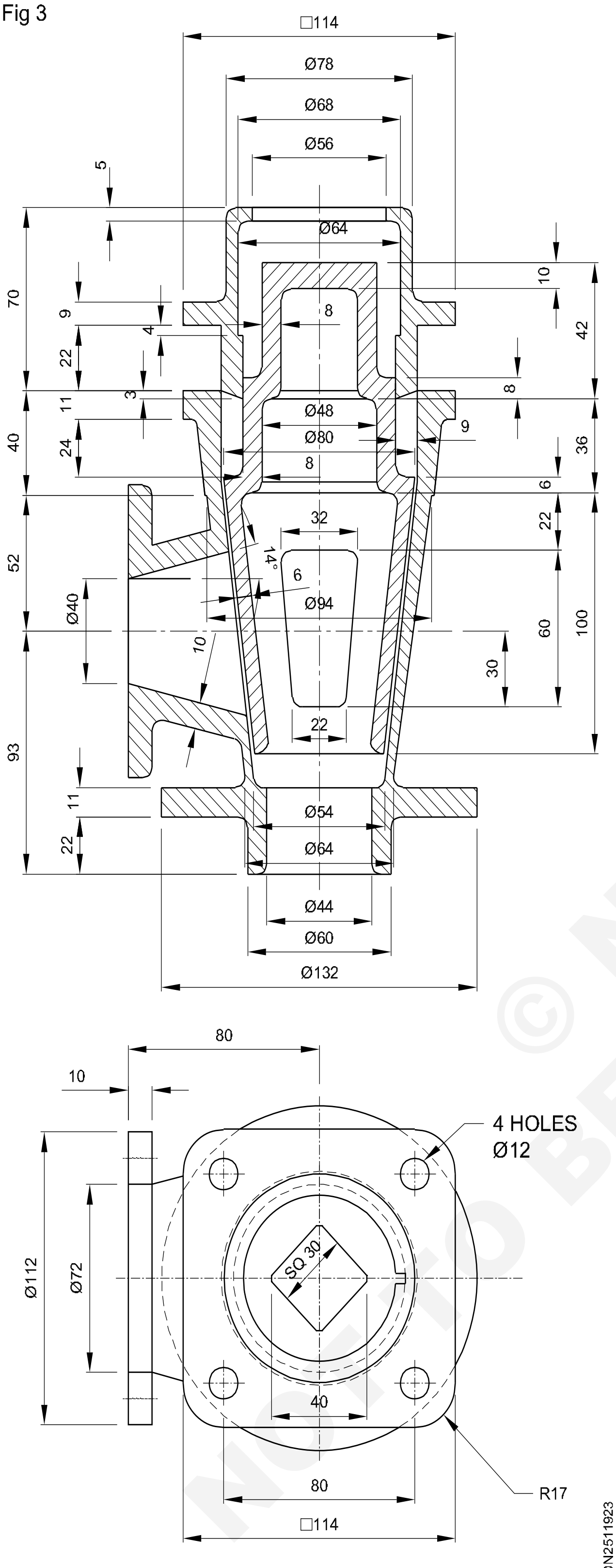
In locomotive boilers the supply of steam is regulated through a regulator that is placed inside the boiler cell and operated from the driver's cabin. (Fig 1)

Fig 1



STEAM STOP VALVE

Fig 3



ASSEMBLY OF BLOW-OFF COCK

Function and purpose of blow off cock: A blow of cock is fitted at the lowest part of the boiler, to remove the sediments collected. At the time of operation, water and sediments forcedly rush through the side flange of cock and out through the bottom flange. Figure shows the parts of blow of cock which consist of hollow conical shaped body in which the cock is located. Both the cock body have vertical slots and when they are aligned, water rushes through the cock. The gland is fastened to the body by means of studs, To prevent leakage, packing material is placed between the cock and gland. (Fig 2)

Blow of cock is used to drain out or blow off the water from the boiler shell, when it is excepted for chocking repairing or cleaning process In this blow of cock used to control the flow is called plug or cock and hence it is called as blow of cock.

The material of blow of cock is either cast iron or gun - metal generally the cock of the block is hollow conical as said above but in some cases it may be hollow cylindrical.

Hydraulic system, components & working principle and function of hydraulic jack

Objectives: At the end of this lesson you shall be able to
- **define Hydraulic System**
- **describe the working principle and function of hydraulic jack.**

Definition

Hydraulic System is Mechanical function that operates through the force of liquid pressure. The system performs and functions multiple tasks by using pressurized fluid. That pressurized fluid is used to make things work and this process us known as hydraulic system. (Fig 1 & 2)

Fig 1

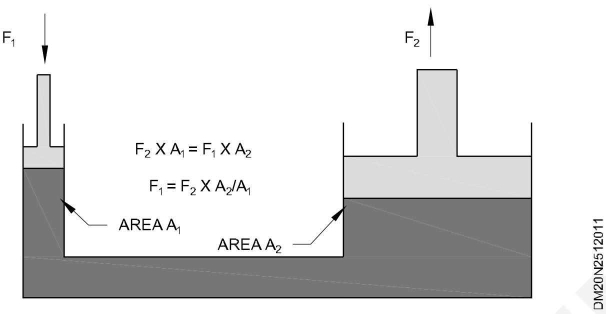
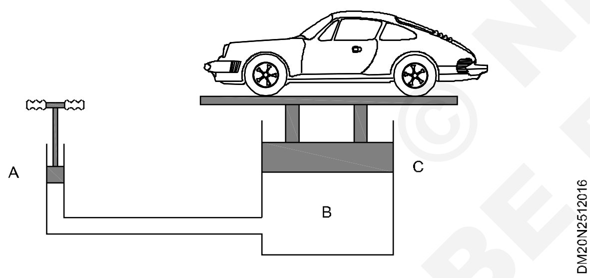


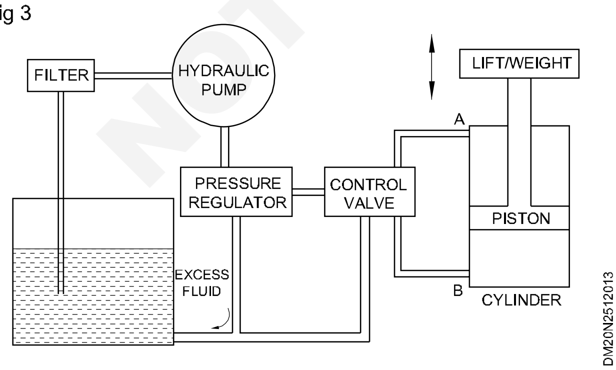
Fig 2



Hydraulic System Components (Fig 3)

The major components that make up a hydraulic system are the reservoir, pump, valve(s) and actuator(s) (motor, cylinder, etc.).

Fig 3



Reservoir

The purpose of the hydraulic reservoir is to hold a volume of fluid, transfer heat from the system, allow solid contaminants to settle and facilitate the release of air and moisture from the fluid.

Filter

Filter removes small foreign particles from hydraulic oil and is most effective as a safeguard against contaminants. Filters are generally located in a reservoir tank, a pressure line, a return line, or in any other location wherever necessary.

Pump

The hydraulic pump transmits mechanical energy into hydraulic energy. This is done by the movement of fluid which is the transmission medium. There are several types of hydraulic pumps including gear, vane and piston. All of these pumps have different subtypes intended for specific applications such as a bent-axis piston pump or a variable displacement vane pump. All hydraulic pumps work on the same principle, which is to displace fluid volume against a resistant load or pressure.

Regulators

Hydraulic pressure regulators maintain the output pressure of a hydraulic system at a set value to minimize fluctuations in a pressurized line.

Valves

Hydraulic valves are used in a system to start, stop and direct fluid flow. Hydraulic valves are made up of poppets or spools and can be actuated by means of pneumatic, hydraulic, electrical, manual or mechanical means.

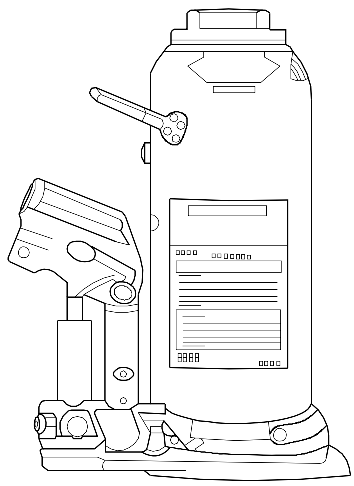
Actuators

Hydraulic actuators are the end result of Pascal's law. This is where the hydraulic energy is converted back to mechanical energy. This can be done through use of a hydraulic cylinder which converts hydraulic energy into linear motion and work, or a hydraulic motor which converts hydraulic energy into rotary motion and work. As with hydraulic pumps, hydraulic cylinders and hydraulic motors have several different subtypes, each intended for specific design applications:

HYDRAULIC JACK

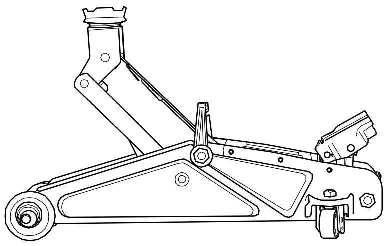
A Jack is a Mechanical Device used as a lifiting device to lift heavy loads or to apply great forces. A hydraulic Jack is a device that uses forces to lift heavy loads by hydraulics system. Hydraulic jacks tend to be stronger ad can lift heavier loads higher, the two types of hydraulic jacks are bottle jacks (Fig 4) and floor jacks. (Fig 5)

Fig 4



DM20N2512014

Fig 5



HYDRAULIC JACK

DM20N2512015

Components of Hydraulic Jack

There are seven primary hydraulic jack parts:

- **Reservoir:** The reservoir stores the hydraulic fluid for a change in pressure.
- **Plunger or piston:** The plunger or piston pushes the hydraulic fluid from the reservoir through a check valve to the ram cylinder.
- **Check valve:** The check valve prevents fluid return from the ram cylinder to the plunger cylinder. Therefore, the ram cylinder maintains the rising pressure.
- **Ram cylinder:** The ram cylinder transfers the pressure of the hydraulic fluid to the ram piston.
- **Ram piston:** The ram piston lifts the load.
- **Release valve:** The hydraulic jack release valve returns pressurized fluid to the reservoir.
- **Handle:** The hydraulic jack handle provides leverage to operate the plunger piston easily.

A simple diagram of the hydraulic components in a hydraulic floor jack: (Fig 5)

A - Saddle/bearing pad

B - Ram piston in ram cylinder

C - Check valve between ram cylinder and plunger cylinder

D - Plunger piston in plunger cylinder

F - Check valve between ram cylinder and reservoir

E - Handle

G - Reservoir

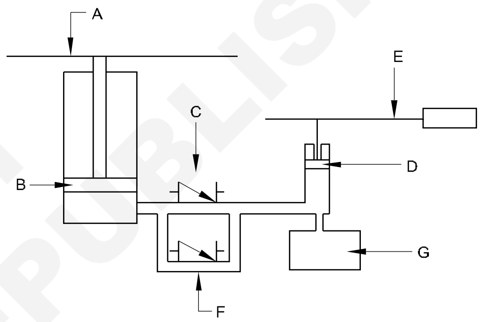
Working principle

Hydraulic system works on principle of Pascal's law, which says that the pressure in an enclosed fluid is uniform in all the directions.

Pascal's Law defines how a hydraulic floor jack uses force multiplication to easily lift heavy loads. According to Pascal's Law, pressure is equal to force divided by area (P = F / A)

Function (Fig 6)

Fig 6



DM20N2512016

In the case of a hydraulic floor jack, area refers to the diameter of the two pistons; the plunger piston is narrower than the ram piston.

Figure 5 is a simple diagram of the hydraulic system in a hydraulic floor jack. When the handle (labelled E) moves the socket up, the plunger or piston (labelled D) moves backward and siphons hydraulic fluid from the reservoir (labelled G) into the plunger cylinder. When the handle moves the socket down, the plunger piston moves forward and pushes the hydraulic fluid into the ram cylinder (labelled B). A check valve (labelled C) stops hydraulic fluid from flowing from the ram cylinder to the plunger cylinder. As a user pumps the handle, more and more fluid builds up in the ram cylinder, building the pressure and raising the bearing pad (labelled A).

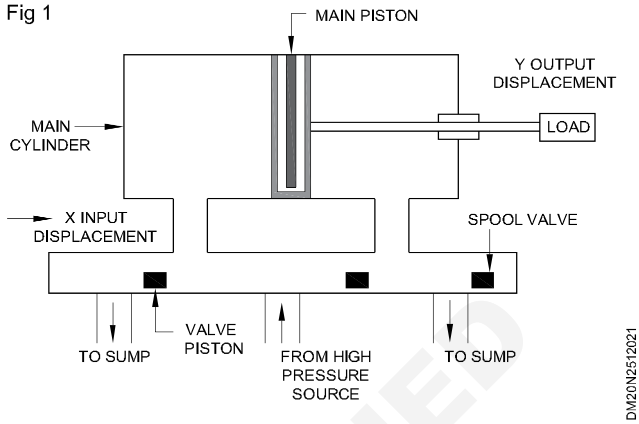
To release pressure in the ram cylinder, a user turns the release valve, which opens the check valve (labelled F) between the ram cylinder and the reservoir. Hydraulic fluid flows back into the reservoir, and the saddle lowers.

Hydraulic actuator

Objectives: At the end of this lesson you shall be able to
- **define Hydraulic Actuator**
- **explain types of Hydraulic Actuator.**

A device that is used to change the fluid's pressure energy into mechanical is known as a hydraulic actuator (Fig 1). The hydraulic actuator includes a cylinder or a fluid motor that works through hydraulic power for mechanical operation. The mechanical motion provides an output in the form of rotary, linear otherwise oscillatory motion.

Fig 1



Types of Hydraulic Actuator

Hydraulic actuators are classified into three types based on actuation like linear actuator, rotary actuator, and semi-rotary actuator.

- **A linear actuator** is used for linear actuation. They provide the force or motion within a straight line, such hydraulic actuators are called a hydraulic cylinders.
- **A rotary actuator** is used for rotary actuation. They provide the torque or rotational motion; such hydraulic actuators are called hydraulic motors. By using these actuators, constant angular movement can be achieved.
- **The semi-rotary actuator** is used for the partial angle of actuation. These are capable of partial angular movements that can be numerous complete revolutions although 360 degrees or below is more usual.

Directional Control Valve

Objectives: At the end of this lesson you shall be able to
- **define Hydraulic Directional Control Valve**
- **describe working of DC valves**
- **identify the symbols of DC valve.**

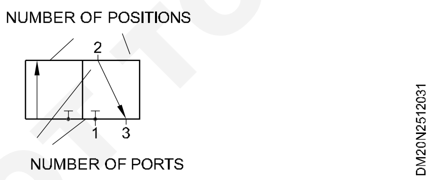
Hydraulic Directional Control Valve:

Directional control valves allow fluids to flow into different paths from valve ports, which provide a passageway for flow to or from other components sources.

Directional Control valves are classified according to their number of ports, the number of directional positions.

for example (Fig 1)

Fig 1



2 squares= 2 positons

3 Ports (1,2 & 3)

On the right hand side you can see the basic position of a normally closed 3/2- way valve. (Fig 2)

- Port * 1 = p pressure supply is closed (blue).
- Port 2 = working, in basic position connected to port t * 3 = ex exhaust (red)
- Basic position or normal position drawn in green.

The second square displays the actuated position of the valve (Fig 3)

- Valve has been actuated (actuation elements not shown here).

Fig 2

Fig 3

- Port 1 is connected to working port 2 (blue).
- Exhaust port 3 is closed (black).
- Actuated positon drawn in green.

Symbols of the most common valves (Fig 4&5)

Working of hydraulic DC valves

2/2-way valves (Fig 6)

2/2-way valves are for opening and closing. They block the medium or let it pass. 2/2-way valves can be either normally closed or normally open.

In the scheme below two 2/2-way solenoid valves (S1 and S2) are used to control a cylinder with spring return (single acting) C1. Without actuation both solenoid valves are closed. In order to move the piston rod to the outer position (right) 52 has to be actuated. Compressed air is flowing from the source through $2 into the cylinder. In order to move the piston rod to the opposite position S2 needs to be de-energized and S1 has to be actuated. In case none of the valves are actuated, the piston rod stays in last position.

The symbol at the bottom displays an FRL unit (iter, regulator lubricator). The functions of Synders as well as of air preparation units will be discussed in a later chapter)

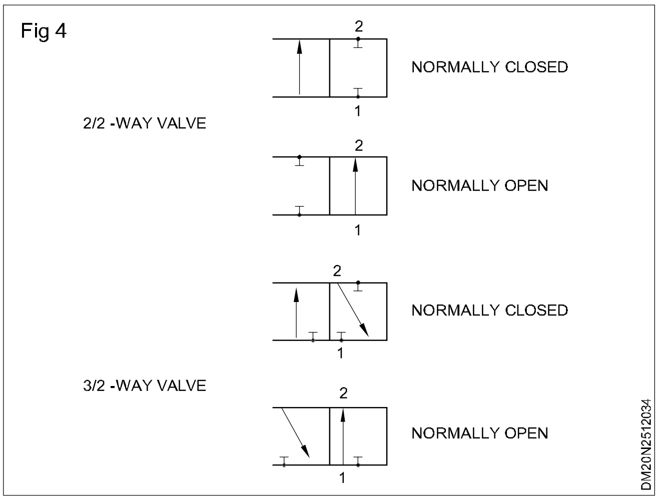


Fig 4

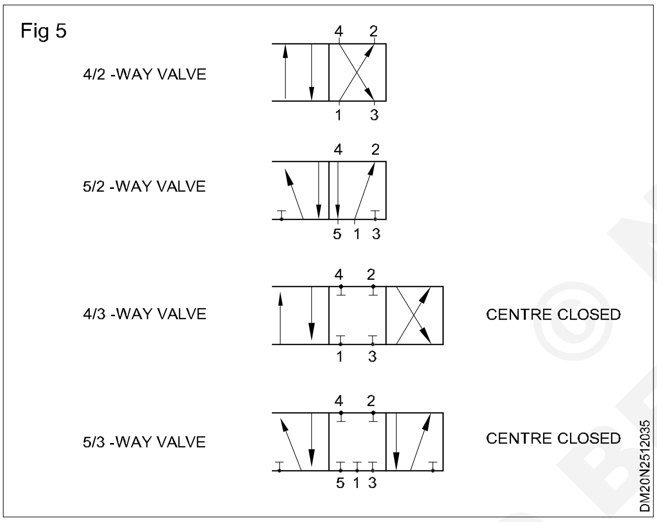


Fig 5

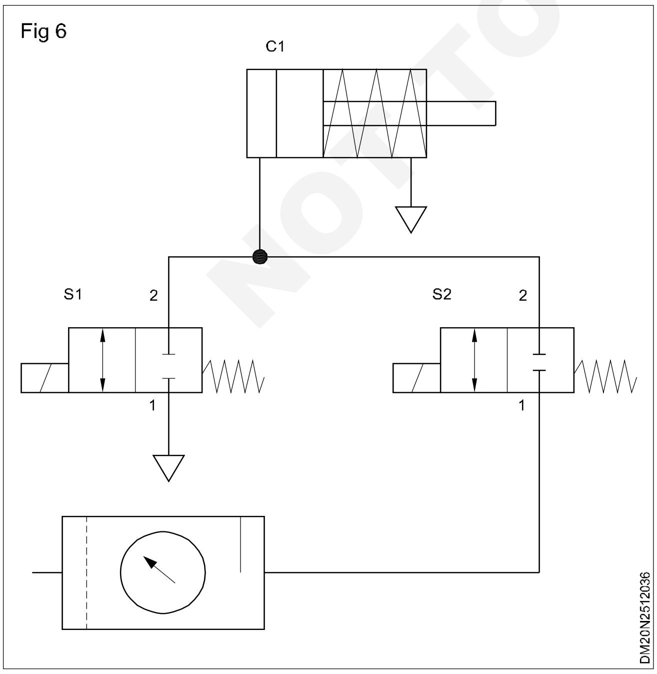


Fig 6

3/2-way valves (Fig 7)

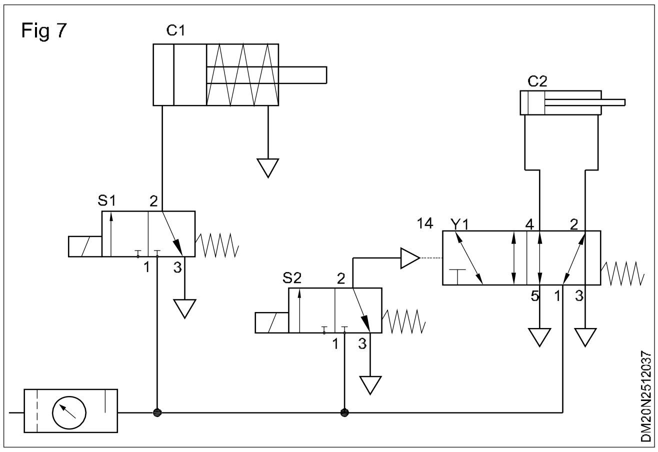


Fig 7

3/2-way valves are mostly used to control single acting actuators. They can be normally closed or normally open. In the scheme below you can see two applications.

1 actuated 3/2-way valve (S1) controls the single acting cylinder (C1).

When the valve is actuated, air flows from 1 to 2; the piston rod of the cylinder is moving to outer position.

When the valve is de-energized, it switches back to normal position and the mechanic spring in the cylinder drives the piston rod back.

2 The double acting cylinder (C2) is controlled by a 5/2-way valve (Y1). Valve Y1 is controlled by an electrically actuated, normally closed 3/2-way valve (S2).

Valve S2 is actuated (air flows from port 1 to port 2). The air actuates valve Y1. It switches and air flows from port 1 to port 4; the piston rod of cylinder C2 moves to the outer position.

As soon as valve S2 is de-energized, air exhausts from port 2 to 3. Valve Y1 switches back o normal position because of the built-in mechanic spring. Compressed air in valve Y1 from 1 to 2 and the cylinder's exhaust from 4 to 5 as the piston rod moves back in.

4/2-way and 5/2-way valves (Fig 8)

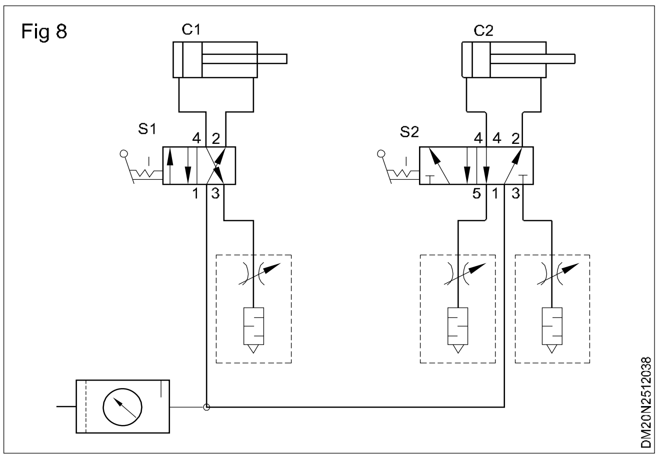


Fig 8

valves 4/2-way and 5/2-way, as well as 4/3-way and 5/3-way valves are usually used to control double acting actuators.

In the example below a manually actuated valve (S1 or S2) controls a double acting cylinder (C1 or C2). Additionally, in order to control the speed of the cylinder, flow control silencers are in use.

The major difference between the 4-way and the 5-way valve is that the 4-way valve offers only one exhaust port. Therefore the speed of the piston rod moving in or out cannot be controlled independently as the two chambers of cylinder C1 are exhausted through the same exhaust port 3 of valve S1.

As for the 5/2-way valve (S2), the two chambers on cylinder (C2) are exhausted through separate exhaust ports (5 and 3). This offers the possibility to regulate the speed of the piston rod independently.

Non-Return Valve

Objectives: At the end of this lesson you shall be able to
- **describe the use of Non-return valve**
- **describe working of Non-return valve**
- **identify the symbol of Non-return valve.**

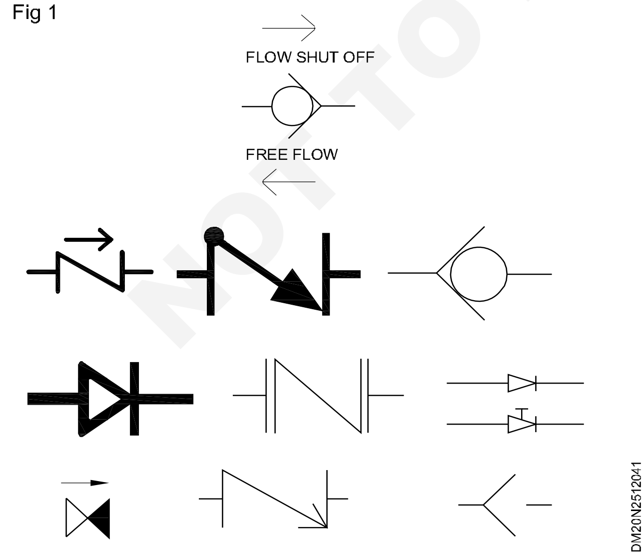
Non return valves (or check valves) are used in hydraulic systems to stop flow in one direction and allow free flow in the opposite direction.

Working of non return valve:

Non-return valves use the mechanism to allow the medium only in the right direction. It has two openings; one inlet and the other outlet. A closing member separates the inlet and outlet staying in between. When the fluid enters the non-return valve through the valve inlet, the fluid pressure keeps the closing member open. On the other hand, when the fluid attempts to flow in the backward direction from the outlet side to the inlet side, the closing member closes the entrance which prevents the flow. Non-return valves work automatically without the need for control of any external element.

When there is flow through the valve in the direction of the arrow, the poppet is lifted from its seat by the fluid pressure and allows free flow. In the opposite direction, the spring and the fluid push the poppet onto the seat and close the connection.

Fig 1



Types of Non-Return Valves

Depending on the working mechanism, various types of non-return valves are available in the market. Some of those are:

Swing check NRV: In this type of non-return valve, the movable part that allows/blocks the fluid flow swings on a hinge or trunnion.

Stop check NRV: Stop check non-return valves possess an override control that stops the flow. It does not depend on the fluid pressure or flow direction.

Ball NRV: The ball type of NRV features a movable spherical ball to block the flow. Sometimes they are spring-loaded.

Diaphragm NRV: This type of non-return valve uses a diaphragm (usually made of flexible rubber) that is controlled by fluid pressure.

Lift check NRV: In a lift check NRV, a disc known as a lift operates to allow/block the flow. When the inlet pressure is high, the disc is lifted and the flow is allowed. When the pressure drops gravity force or outlet pressure lowers the disc and the flow is stopped. Normally used for high-pressure service.

In-line NRV: This type of non-return valve uses a spring and the flow is allowed when the upstream pressure exceeds the spring tension. Again when the pressure goes below the pressure to overcome spring tension the flow is blocked.

Folding Disc NRV: Mainly used for gaseous or low-pressure liquid service, this type of non-return valves are made in a wafer body pattern. They are also known as double-disc or split-disc check valves.

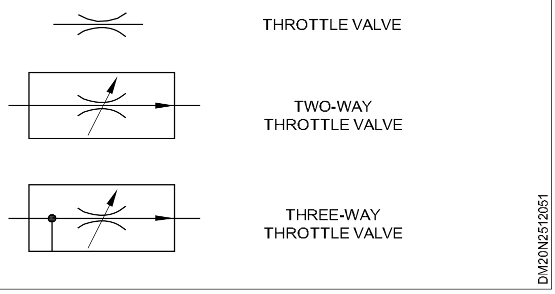
Tilting Disc NRV: Tilting disc types of non-return valves are suitable for turbulent, pulsing, or high- speed flows. The disk of this type of NRV floats within the flow and fluid runs on its top and bottom surfaces

Throttle Valve

Objectives: At the end of this lesson you shall be able to
- **tell the use of throttle Valve**
- **describe the working of throttle valve**
- **identify the symbol of throttle valve.**

A throttle valve is a valve used to open, close or regulate the flow of fluid. They are basically control valves, as the throttle valve discs can regulate the flow, temperature or pressure of the fluid medium passing through them.

Fig 1



Working

The picture above is the axial orifice type throttle valve. The inlet port and outlet port T are drilled on the valve house, there is a axial triangle throttle orifice hole is created on the top of valve poppet (part no 3), the fluid flows into P oil ports and flows out from T oil port through triangle throttle orifice hole to actuators or to oil tank. By regulating he adjustable knob to move the valve poppet position axially, which is be able to achieve fluid flow rate adjustment by adjusting cross-sectional area of throttle port.

Pneumatic System

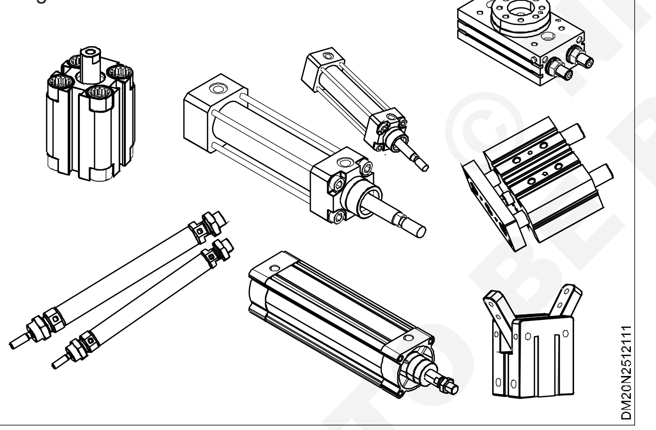
Objectives: At the end of this exercise you shall be able to
- **define pneumatic system**
- **explain basic styles of pneumatic system**
- **describe the use of FRL unit.**

Pneumatic System (Fig 1) The principles of pneumatics are the same as these for hydraulics, but pneumatics transmits power using a gas instead of a liquid compressed air is usually used but nitrogen or other gases can be used for special application.

There are thousands of industrial applications that require a linear motion during their operation sequence. One of the simplest and most cost effective ways to accomplish this s with a pneumatic actuator. Pneumatic actuators are also very clean operating because the operating fluid is a gas, which prevents leakage from dripping and contaminating the surroundings.

This section will discuss the basic construction and function of a pneumatic actuator, the relationship with a fluid power system and the selection guidelines for pneumatic actuators or air cylinders. (Fig 1)

Fig 1



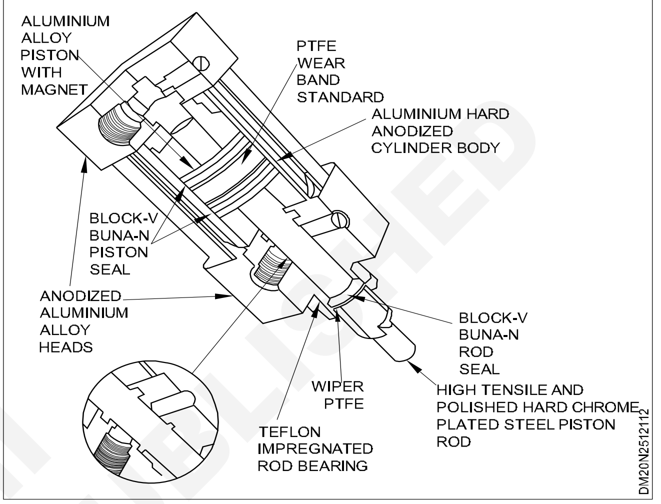
Basic styles

Pneumatic actuators convert compressed air into rotary or linear motion. There are many styles of pneumatic actuators: diaphragm cylinders, rod less cylinders, telescoping cylinders and through - rod cylinders.

This actuator style can be sub-divided into two types based on the operating principle: single acting and double acting.

Single - acting cylinders have a single port to allow compressed air to enter the cylinder to move the piston to the desired position. They use an internal spring or sometimes simply gravity to return the piston to the "home" position when the air pressure is removed. Single - acting cylinders are a good choice when work is done only in one direction such as lifting an object or pressing an object into another object.

Fig 2



Double - acting cylinders (Fig 2) have a port at each end and move the piston forward and back by alternating the port that receives the high pressure air. This uses about twice as much energy as a single-acting cylinder, but is necessary when a load must be moved in both directions such as opening and closing a gate.

In a typical application, the actuator body is connected to a support frame and the end of the rod is connected to a machine element that is to be moved. A control valve is used to direct compressed air into the extend port while opening the retract port to atmosphere. The difference in pressure on the two sides of the piston results in a force equal to the pressure differential multiplied by the area of the piston. If the load connected to the rod is less than the resultant force, the piston and rod will extend and move the machine element. Changing the valve to direct compressed air to the retract port while opening the extend port to atmosphere will cause the cylinder assembly to retract back to the "home" position.

Pneumatic actuator

Pneumatic actuators are at the working end of a fluid power system. Upstream of these units, which produce the visible work of moving a load, there are compressors, filters, pressure regulators, lubricators, control valves and flow controls. Connecting all of these together is a network of piping or tubing (either rigid or flexible) and fittings.

Pressure and flow requirements of the actuators in a system must be taken into account when selecting these upstream system components to ensure the desired performance. Undersized.

Schematic diagram of pneumatic actuator (Fig 3)

FRL Unit

FRL stands for filter regulator lubricator. This unit deliver clean air at a fixed pressure and are lubricated (if needed) to ensure the proper pneumatic component operation, which increases their operational lifetime.

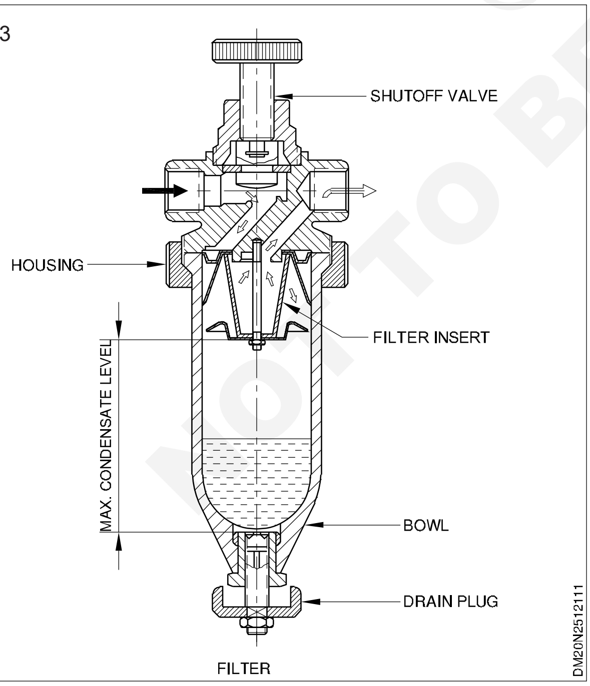
The air supplied by compressors is often contaminated, over-pressurized, and non-lubricated. In that places FRL unit is required to prevent damage to equipment. Filters, regulators and lubricators can be brought individually or as a package.

Fitter,regulator,lubricator (FRL) assemblies are pre-packaged or modular assemblies of air filters,pressure regulators,and gauges. Air leaving a compressor is hot,dirty,and wet and can cause damage to equipment and tools if it is not filtered.

The filter cleans compressed air by trapping solid particles and separating liquids,such as oil and water,that are trapped in the compressed air. Filters are installed in the air line upstream of regulators,lubricators,and all pneumatically-powered tools and equipment. They remove contaminants from pneumatic systems,preventing damage to equipment and reducing production losses due to contaminant-related downtime.

Pressure regulators control fluid pressure in compressed air systems. Regulators are also known as pressure reducing valves(PRVS). Pressure regulators maintain a constant output pressure regardless of input perssure variations and demands made on the system by downstream components.

Fig 3



FILTER

Lubricators add controlled quantities of oil into the compressed air system to reduce the friction between moving components within air tools and other equipment that are powered by the system. Adding lubrication oil to the system also clears compressor oils that travel through the system in vapor form. To prevent build-up of oil within system components, mineral oils are added to the system to flush away the deposits.

Downstream equipment flow and pressure requirements determine the correct regulator and lubricator for the application. Manufactures offer flow characteristics charts on their products to help chose the correct combination of regulators and lubricators.

Types

There are several choices for regulator type.

- **General-purpose regulators** are designed for typical industrial use they generally operate only above atmospheric pressure.
- **High- pressure regulators** are rated for inlet pressures higher than general purpose,typically over 1,000 psi.
- **Low- pressure regulators** have special design characteristics for precise control of pressures typically below 15-20 psi.
- **Differential** or **bias regulators** maintain a pressure differential between two locations in the system.
- **Pressure- reducing valves** provide a sub-circuit with a supply of fluid at a pressure that is less than the pressure in the main circuit.

Specifications

Performance specifications

- **Regulating (adjustment) range** - Dictates the limits of adjustment control
- **Maximum flow (gas or air)** - Unnecessary to specify if primary application is liquid
- **Maximum pressure rating**- Refers to the pressure rating for the valve or inlet pressure for the regulator
- **Filter minimum particle size rating** - Applies to filter,regulator,and lubricator (FRL) assemblies. It is the smallest size particle that will be entrapped by the filter. This rating is an indication of the largest opening in the filter element.

Other important specifications include:

- Regulator type
- Medium
- Adjustment control
- Connectors or pipe size
- Body material
- Environmental parameters

Pump systems

Objectives: At the end of this exercise you shall be able to
- **name different types of pumps**
- **describe different types of pumps**
- **define energy and head in pump systems.**

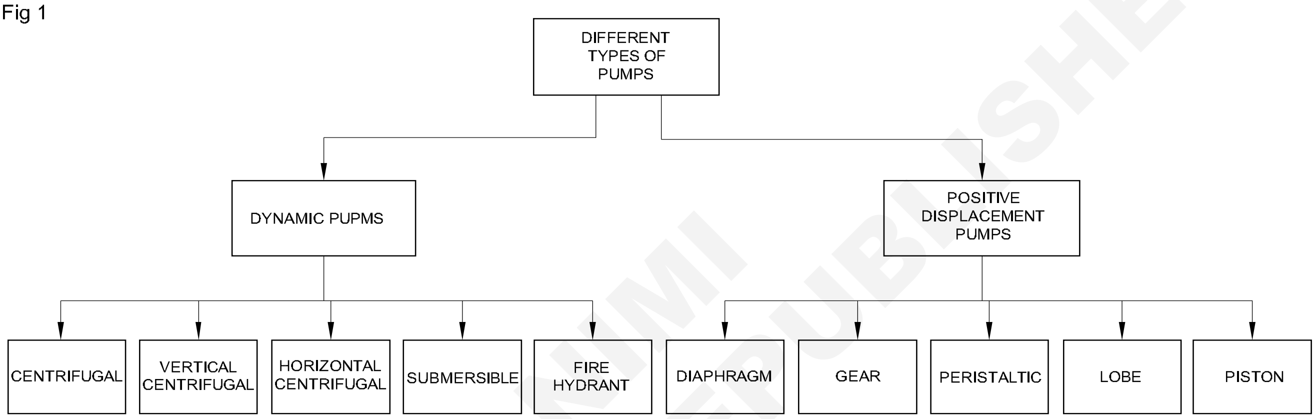
Different Types of Pumps system:

There are different types of pumps available in the market. The type of pump, as well as selection, mainly depend on our requirement. The application mainly includes the type of fluid you desire to pump, the distance you desire to move the fluid, and the quantity you require to get over a particular time frame. The identifying of the pump can be done with the design as well as positions.

Types of Pumps

Pumps are classified into two types namely Dynamic pumps as well as Positive Displacement Pumps.(Fig 1)

Fig 1



TYPES OF PUMPS

DM20N2512211

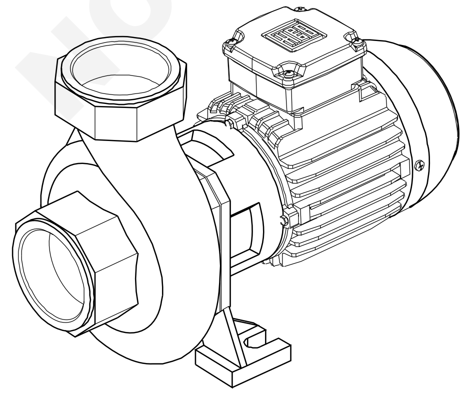
Dynamic Pumps

Dynamic pumps are classified into different types but some of them are discussed below like Centrifugal, Vertical centrifugal, Horizontal centrifugal, Submersible pumps.

Centrifugal Pumps (Fig 2)

These types of pumps are most commonly used worldwide. This pump is strong, efficient and fairly cheap to make. Whenever the pump is in action, then the fluid pressure will increase from the inlet of the pump to its outlet. The change of pressure will drive the liquid throughout the system.

Fig 2

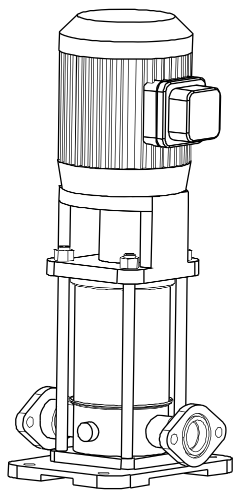

CENTRIFUGAL PUMP

DM20N2512212

This kind of pump produces an enhancement within force by transmitting mechanical power from the electrical motor to the liquid throughout the revolving impeller. The flow of liquid will enter the center of impeller and exits along with its blades. The centrifugal power hereby enhances the velocity of fluid & also the energy like kinetic can be altered to force.

Vertical Centrifugal Pumps (Fig 3)

Fig 3


VERTICAL CENTRIFUGAL PUMP

DM20N2512213

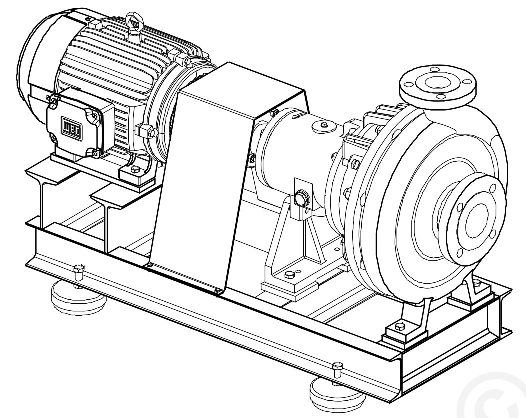
Vertical centrifugal pumps are also called as cantilever pumps. These pumps use an exclusive shaft & maintain design that permits the volume to fall within the pit as the bearings are external to the pit. This mode of pump utilizes no filling container to cover the shaft however in its place uses a throttle bushing.

Horizontal Centrifugal Pumps (Fig 4)

These types of pumps include a minimum of two otherwise more impellers. These pumps are utilized in pumping services. Every stage is fundamentally a divide pump.

All the phases are in a similar shelter & mounted on a similar shaft. On a solo horizontal shaft, a minimum of eight otherwise additional stages can be mounted. Every stage enhances the head by around an equal amount. These types of pumps are normally utilized in companies that transfer large amounts of industrial fluids. All kinds of pumps have been providing as well as servicing this type of centrifugal pump.

Fig 4



HORIZONTAL CENTRIFUGAL PUMP

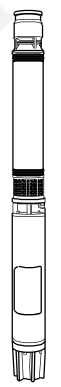
DM20N2512214

Submersible Pumps (Fig 5)

These pumps are also named as stormwater, sewage, and septic pumps. The applications of these pumps mainly include building services, domestic, industrial, commercial, rural, municipal, & rainwater recycle applications.

These pumps are apt for shifting stormwater, subsoil water, sewage, black water, grey water, rainwater, trade waste, chemicals, bore water, and foodstuffs. The applications of these pipes mainly include in different impellers like closed, contra-block, vortex, multi-stage, single channel, cutter, otherwise grinder pumps.

Fig 5



DM20N2512215

Positive Displacement Pumps

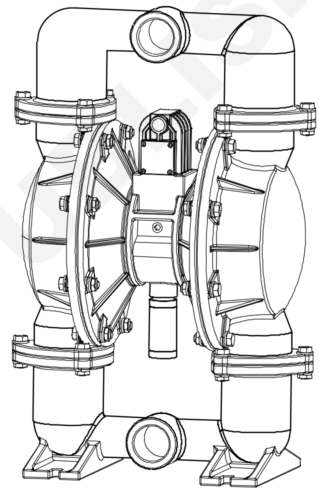
Positive displacement pumps are classified into different types but some of them are discussed below like diaphragm, gear, peristaltic, lobe, and piston pumps.

Diaphragm Pumps (Fig 6)

Diaphragm pumps also known as AOD pumps (Air operated diaphragms), pneumatic, and AODD pumps. The applications of these pumps mainly include in continuous applications like in general plants, industrial and mining. AOD pumps are particularly employed where power is not obtainable, otherwise in unstable and combustible regions. These pumps are also utilized for transferring chemical, food manufacturing, underground coal mines, etc.

These pumps are responding pumps and include two diaphragms which are driven with condensed air. The section of air by transfer valve applies air alternately toward the two diaphragms; where every diaphragm contains a set of ball or check valves.

Fig 6



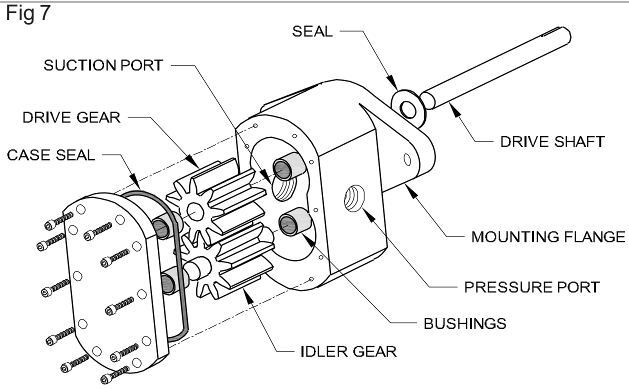
DIAPHRAGM PUMP

DM20N2512221

Gear Pumps (Fig 7)

These pumps are a kind of rotating positive dislocation pump, which means they force a stable amount of liquid for every revolution. These pumps move liquid with machinery coming inside and outside of mesh for making a non-exciting pumping act. These pumps are capable of pumping on high forces & surpass at pumping high thickness fluids efficiently.

Fig 7



HYDRAULIC GEAR PUMP

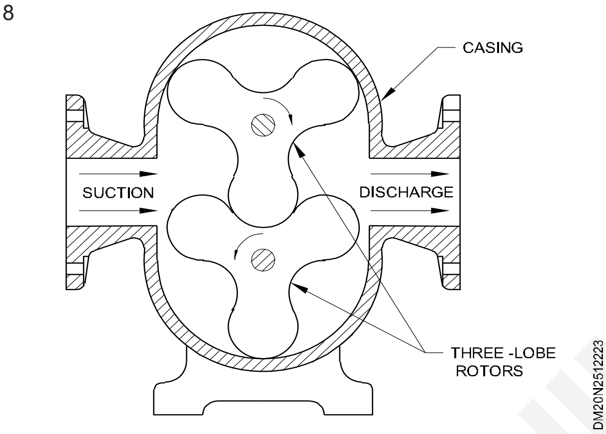
DM20N2512222

A gear pump doesn't contain any valves to cause losses like friction & also high impeller velocities. So this pump is compatible for handling thick liquids like fuel as well as grease oils. These pumps are not suitable for driving solids as well as harsh liquids.

Lobe Pumps (Fig 8)

These pumps offer different characteristics like an excellent high efficiency, rust resistance, hygienic qualities, reliability, etc. These pumps can handle high thickness fluids & solids without hurting them. The working of these pumps can be related to gear pumps, apart from the lobes which do not approach into contact by each other. Additionally, these pumps have superior pumping rooms compare with gear pumps that allow them to move slurries. These are made with stainless steel as well as extremely polished.

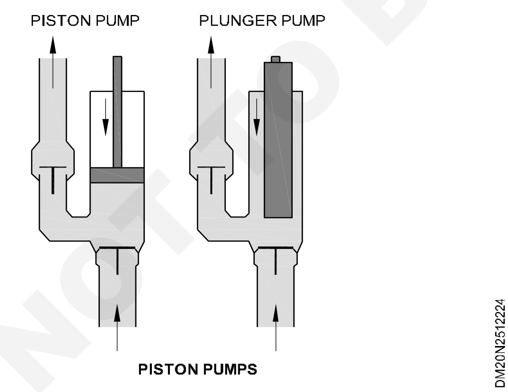
Fig 8



Piston Pumps (Fig 9)

Piston pumps are one kind type of positive dislocation pumps wherever the high force seal responds through the piston. These pumps are frequently used in water irrigation, scenarios requiring high, reliable pressure and delivery systems for transferring chocolate, pastry, paint, etc.

Fig 9



Characteristics of a pump system

The pumps' role is to provide sufficient pressure to move the fluid through the system at the desired flow rate. Pressure, friction, and flow are three important characteristics of a pump system.

The pressure is the driving force responsible for the movement of the fluid. Friction is the force that slows down fluid particles. Flow rate is the amount of volume that is displaced per unit of time. The unit of flow in SI unit is meters cube per hour (m3/h).

Pump pressure is often expressed in kiloPascals (kPa) in the metric system.

The term pressure loss or pressure drop is often used, this refers to the decrease in pressure in the system due to friction, for example, the pressure is high at the tap and zero at the hose outlet, this decrease in pressure is due to friction and is the pressure loss.

Friction is always present, even in fluids, it is the force that resists the movement of objects. When you move a solid on a hard surface, there is friction between the object and the surface. If you put wheels on it, there will be less friction. In the case of moving fluids such as water, there is even less friction but it can become significant for long pipes. Friction can also be high for short pipes that have a high flow rate and small diameter as in the syringe example.

In fluids, friction occurs between fluid layers that are traveling at different velocities within the pipe. There is a natural tendency for the fluid velocity to be higher in the center of the pipe than near the wall of the pipe. Friction will also be high for viscous fluids and fluids with suspended particles.

Friction depends on:

- average velocity of the fluid within the pipe
- viscosity
- pipe surface roughness

An increase in any one of these parameters will increase friction.

The amount of energy required to overcome the total friction energy within the system has to be supplied by the pump if you want to achieve the required flow rate. In household systems, friction can be a greater proportion of the pump energy output, maybe up to 50% of the total because small pipes produce higher friction than larger pipes for the same average fluid velocity in the pipe.

Another cause of friction is all the fittings (elbows, tees, y's, etc) required to get the fluid from point A to B. Each one has a particular effect on the fluid streamlines. For example in the case of the elbow, the fluid particles that are closest to the tight inner radius of the elbow lift off from the pipe surface forming small vortices that consume energy. This energy loss is small for one elbow but if you have several elbows and other fittings the total can become significant.

Energy and head in pump systems

Energy and head are two terms that are often used in pump systems.

We use energy to describe the movement of liquids in pump systems because it is easier than any other method. There are four forms of energy in pump systems: pressure, elevation, friction, and velocity.

The pressure is produced at the bottom of the reservoir because the liquid fills up the container completely and its weight produces a force that is distributed over a surface which is pressure. This type of pressure is called static pressure. Pressure energy is the energy that builds up when liquid or gas particles are moved slightly closer to each other and as a result, they push outwards in their environment

Elevation energy is the energy that is available to a liquid when it is at a certain height. If you let it discharge it can drive something useful like a turbine producing electricity.

Friction energy is the energy that is lost to the environment due to the movement of the liquid through pipes and fittings in the system.

Velocity energy is the energy that moving objects have, When water comes out of a garden hose, it has velocity energy.

The energy that the pump must supply is the friction energy plus the elevation energy.

PUMP ENERGY = FRICTION ENERGY + ELEVATION ENERGY

Head is actually a way to simplify the use of energy. To use the energy we need to know the weight of the object displaced.

Elevation energy E.E. is the weight of the object W times the distance d:

EE = W x d

Friction energy FE is the force of friction F times the distance the liquid is displaced or the pipe length l:

FE = F x l

Head is defined as energy divided by weight or the amount of energy used to displace an object divided by its weight. For elevation energy, the elevation head EH is:

EH = W x d / W = d

For friction energy, the friction head FH is the friction energy divided by the weight of the liquid displaced:

FH = FE/W = F x l / W

Total head and flow are the main criteria that are used to compare one pump with another or to select a centrifugal pump for an application. Total head is related to the discharge pressure of the pump.

For these reasons, the pump manufacturers have chosen total head as the main parameter that describes the pump's available energy.

Total head is the height that the liquid is raised to at the discharge side of the pump less the height that it is raised to at the suction side.

Clamping devices on lathe

Objectives: At the end of this lesson you shall be able to
- **define clamping devices**
- **state the types of clamping devices.**
- **describe clamping system**
- **explain work holding devices of lathe.**

Clamping devices: The clamping device should clamp the work-piece rigidly in place, i.e as vibration free as possible without deforming it.

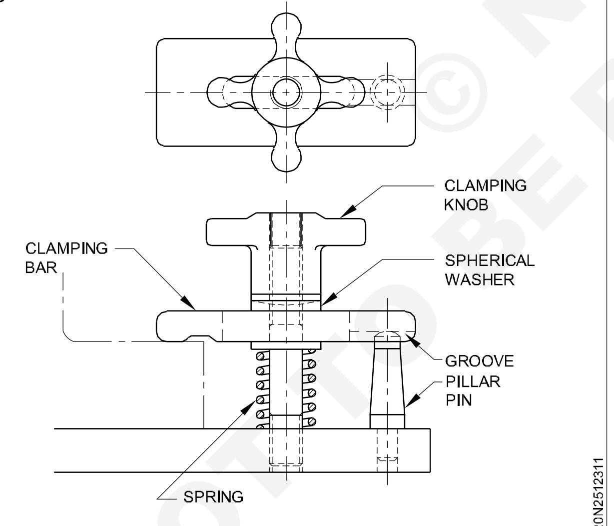
In other words clamps in jigs are meant for holding the component in position against the cutting force. They also help in rapid loading and unloading of the components. Clamps are fitted in such a way they do not interfere with the cutting operation.

The commonly used types of clamps are:

Strap clamp (Fig 1)

1 Strap clamps, also known as band clamps, resemble the ratchet straps used to tie loads down - such as on a vehicle's roof rack or a truck bed. The webbing strap is placed around as assembly and tightened, applying pressure to joints.

Fig 1



STRAP CLAMP

Principle of strap clamp

Strap clamps are often fitted with four corner guides, for use in a rectangular arrangement. The guides prevent the corners of the parts from being crushed when the load is applied, enabling the straps to slide freely so that an even pressure is applied to the assembly.

Function of straps clamp

Straps are most commonly made of a textile webbing material, with the guides and clamp body made of plastic. Some heavy-duty strap clamps use metal banding instead of webbing and may be referred to as band clamps.

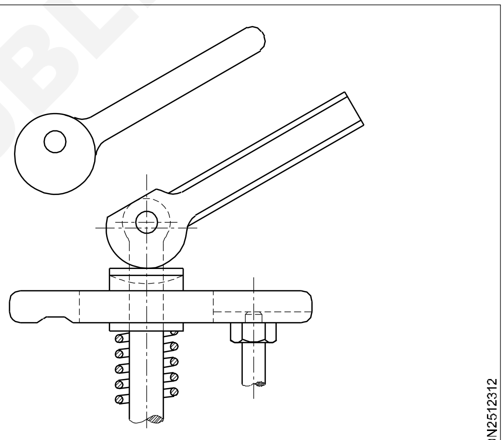
Cam clamp (Fig 2)

Cam action toggle clamps are a range of medium to heavy duty clamps. Unlike toggle clamps cam clamps do not Lock but do have the advantage of being able to clamp materials that vary in thickness.

Principle and function of cam clamp:

The cam lock is simple locking mechanism used to achieve the securing of access to panels and entry points. They are comprised of a body and Latch which rotates. They are used for securing equipment cabinets, enclosures, machine access panels and tool lockers.

Fig 2

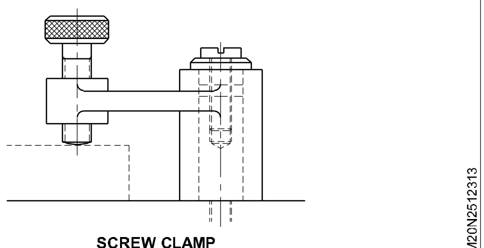


CAM CLAMP

Screw clamp (Fig 3)

screw clamps also known as worm gear clamps. screw clamps are those that feature a built-in screw. They consist of a strip of metal typically made of galvanized steel or stainless steel-with a thread pattern, screw clamps have a screw connected to the thread pattern that is used to tighten or Loosen them.

Fig 3



SCREW CLAMP

Function of screw clamp

clamping screws are mechanical elements which use screw thrust for workpiece fixing and positioning. full ball point contact securely fixes to the workpiece. Clamping screws include several varieties of ball tips shapes and materials, which can be selected according to the application.

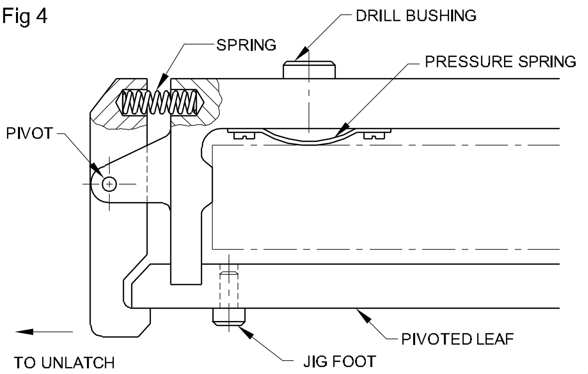
Latch clamp (Fig 4)

Latch type toggle clamp is commonly used for wood working and carpentry projects, generally, this type of toggle clamps is designed to secure and fasten objects in place. This toggle clamp is made up of a handle, a lever system, and a Securing bar. It applies the pressure and holds the object in Place.

There are three basic types of latch clamp. Fixed latch type toggle clamps, U-hook type toggle clamps, J-hook type toggle clamps.

These latch type toggle clamps are also available in various material: Steel plated zinc or stainless steel.

Fig 4



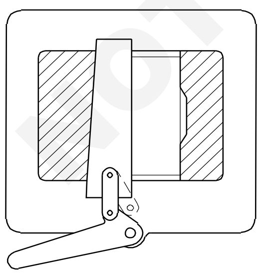
LATCH CLAMP

Wedge clamp (Fig 5)

Wedge a clamp with one end contacting the work below It's surface and the other and butting against a cross piece so that the tightening of a bolt passing through its center causes the clamp to wedge the work in position

Application of wedge clamp: wedge clamps for flat clamping edges are used in injection mould machine applications for die clamping on stamping presess. The wedge clamping elements consist of a guide housing with a one-piece clamping bolt.

Fig 5



WEDGE CLAMP

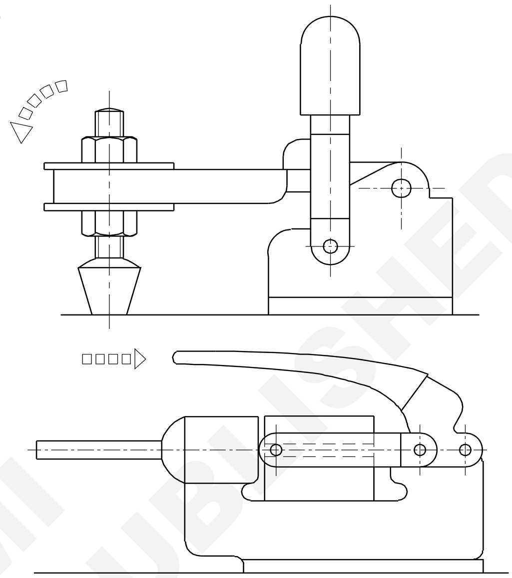
Toggle clamp (Fig 6)

A toggle clamp is a fool that you use to securely locate components or parts in position, typically, but not exclusively, as part of a production process. The primary features of a toggle clamp are that toggle clamps lock in position securely and are quick acting, they can be quickly turned on and off by an operator.

Working principle of toggle clamps

Toggle clamps are quick-action clamping tools that operate using an over- center locking principle known as a toggle action utilizing a system of levers and pivots, the clamping handle moves a linkage to its center position and the clamping arm meets the center to hold the fixture or work piece in a locked position.

Fig 6



TOGGLE CLAMP

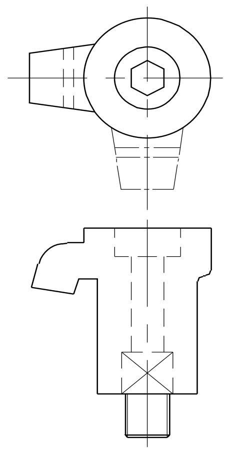
Hook clamp (Fig 7)

Hook clamps are designed to manually swing into clamping position, then clamp straight down by screw action. these clamps allow clear loading while swung away in unchanged position. Ideal in tight spaces where high clamping force is required. Long-arm Hook clamps are available with either a plain arm or a tapped arm.

The Function of hook clamp

clamps are versatile tools that serve to temporarily hold work securely in place. They are used for many applications including carpentry, woodworking, furniture making, welding, construction and metal working.

Fig 7



HOOK CLAMP

Job holding devices in lathe operations

Objectives: At the end of this lesson you shall be able to
- **explain the common types of job-holding devices in lathe operations.**

Introduction:

Job holding Devices used during operations on lathe Machine

When cutting operations are performed on the machine, lots of forces are generated. To counter these forces the work and the tool have to be held rigidly so that during cutting operation there should not be any vibration or jerk. The tool is held rigidly in the tool post with the help of bolts. The work is held in the various types of work holding devices.

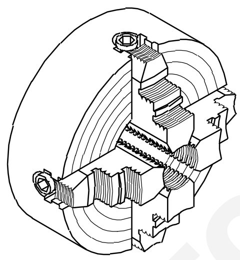
Types of work holding Devices

The following are the various work holding devices used on lathe machine.

- Chuck
- Centres
- Face plate
- Driving plate
- Catch plate
- Angle plate
- Lathe carrier or lathe dog
- Mandrel
- Rests

Chucks (Fig 1)

Fig 1



CHUCK

DM20N2512411

Chucks are efficient and true devices for holding the work on the lathe during the operation. The most common types of chucks are:

a Three jaw chuck

b Four jaw chuck

c Magnetic chuck

d Combination chuck

e Collect chuck

a Three jaw chuck: It is also known as three jaw self centering chuck. It consists of a cylindrical body having three jaws fixed radically at its front. Further, it carries a through hole at its centre to enable the long job to project backward in the spindle. It consists of a circular disc having spiral scroll at its front and a rack at its back. The rear face of jaws is provided with slots corresponding to the scroll serrations. The bevel pinions are fitted radically at the back of the disc and they mesh with the rack at its back. Top of these pinions are matching with the outer surface of the chuck and have square slots to accommodate the chuck key. For operating the chuck anyone of these pinion can be rotated by means of the chuck key which, intern, revolves the scroll disc. This causes all the jaws to move in the radial direction simultaneously. Normally two sets of jaws are provided with each chuck, one for gripping on the outside surface & other for inside.

b Four jaw chuck: In outside appearance, it is very much similar to the three jaw chuck except that it has four jaws, but its internal mechanism differs totally. The rear portion of its jaws is threaded & is engaged with separate adjusting screws. With the result all the jaws can be moved separately and adjusted at desired distance from the centre of the chuck. Due to this it is also known as independent jaw chuck. This enables the chuck to successfully hold irregular or eccentric jobs in addition to the regular cylindrical shaped jobs. It is possible to reverse the same jaws so that the work can be gripped from inside surfaces also.

c Magnetic chuck: It holds the job by magnetic force.

Magnetic chuck is suitable for mass production of thin sectioned jobs and components.

The following are the two types of magnetic chucks these are explained in the subsequent paragraphs:

i **Permanent Magnetic chuck:** it is generally used on lathes and surface grinders. For this no electric current is needed.

ii **Electromagnetic chucks:** These are also called temporary captivating chucks. It implies the use of electric current for developing a strong electromagnet, which holds the job centrally in chuck.

d Combination chuck: As the name implies a combination chuck may be used as a self cantering or as an independent chuck to take the advantages of both types. The jaws may be operated individually by separate screws or simultaneously by the scroll disc. The screws mounted on the frame have teeth cut on its underside which meshes with the scroll and all the jaws together with the screws move radically when the scroll is made to rotate by a pinion.

e Collect chuck: It fits in to the spindle nose of the headstock. It can be used on a centre lathe. Capstan lathe or turret lathe for producing items form bar stock. It is constructed with a hollow body having internal threads for screwing on the spindle nose. The slits in collets provides it with springing action to allow the bar for easy passing collect chucks are mostly used to hold the jobs less than 25mm in diameter. These are of two types:

- Draw in type
- Push out

Centres

The centre is a work holding device in a lathe, that is used to support long jobs in between head stock and tails tock to carry out a lathe operation.

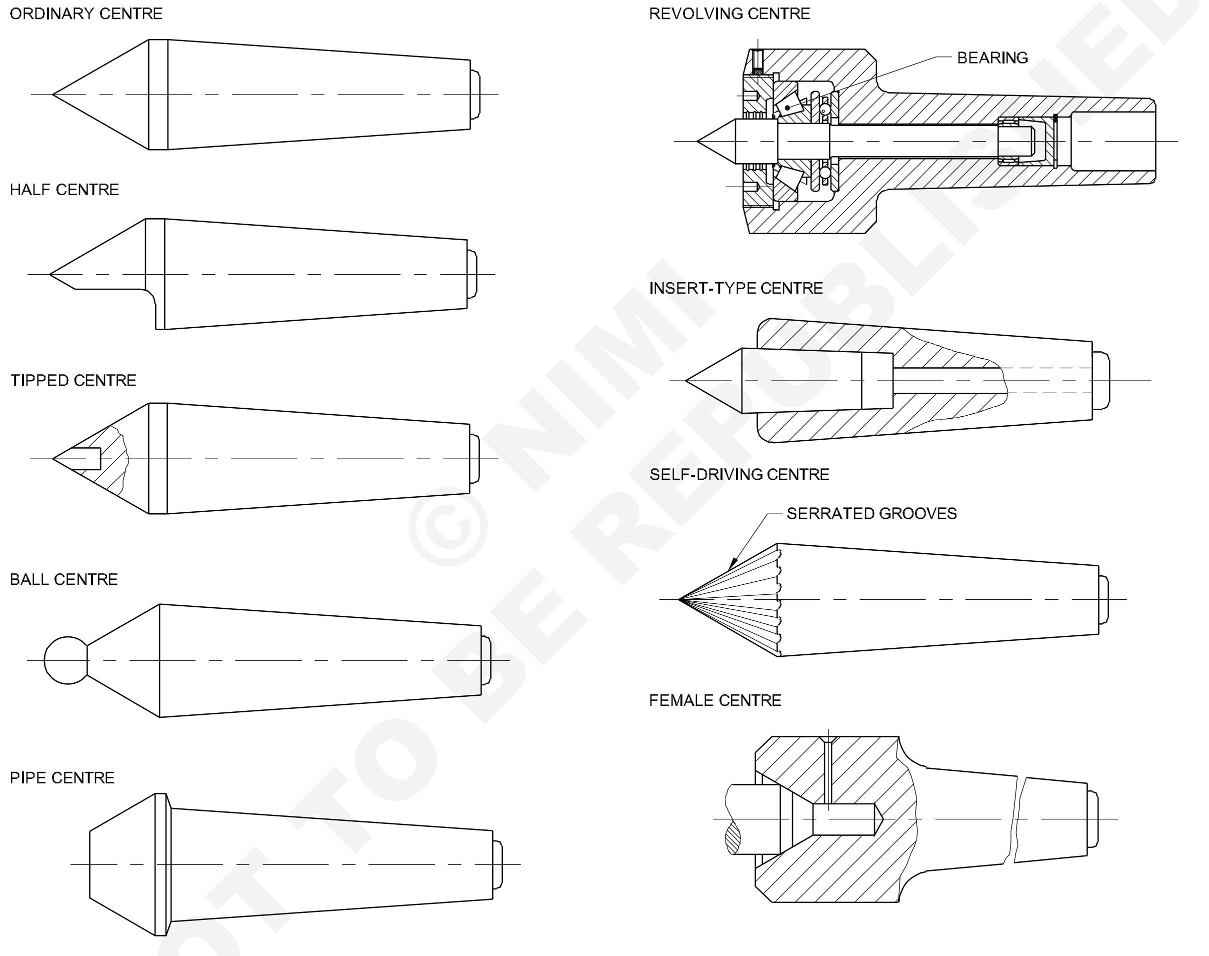
Lathe centres are often made of high carbon steel and then it is hardened tempered and grinded.

The top angle of the corner point of the lathe centre is 60°.

Different types of lathe centres (Fig 2)

Ordinary centre	Revolving centre
Half centre	Inserted type centre
Tipped centre	Self driving live centre
Ball centre	Female centre
Pipe centre	

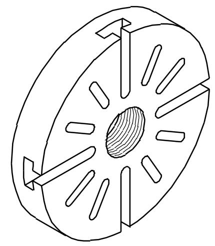
Fig 2



DM20N2512412

Face plate (Fig 3)

Fig 3



FACE PLATE

DM20N2512413

It is usually a circular cast iron disc having threaded hole at its centre so that it can be screw to the threaded nose of the spindle. It consists of number of holes and slots by means of which the work can be secured.

Driving plate (Fig 4)

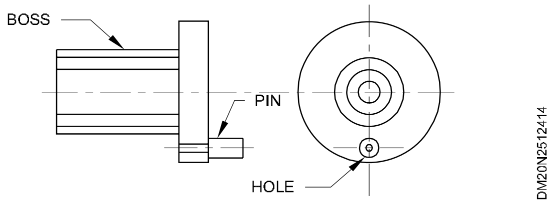
It is a cast circular disk having a projected boss at its rear. The boss carries internal threads so that it can be screwed on spindle nose. It also carries a hole to accommodate a pin which engages with the tail of a lathe dog or carriers.

Types of driving plate

- Catch plate

- Driving plate with pin
- Safety driving plate

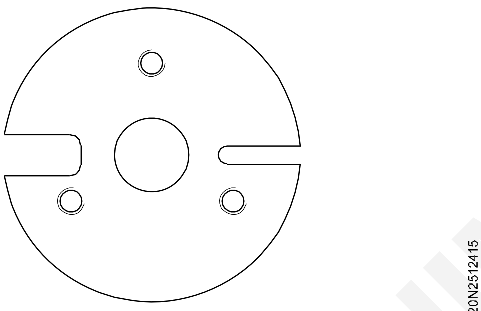
Fig 4



Catch plate

When a work piece is held between centres, the catch plate is used to drive it. It is a circular disc bored and threaded at the centre catch plates are designed with ‘U’-Slots or elliptical slots to receive the bent tail of the corner positive drive between the lathe spindle and the workpiece is effected when the workpiece fitted with the carrier fits into the slot of the catch plate. (Fig 5)

Fig 5

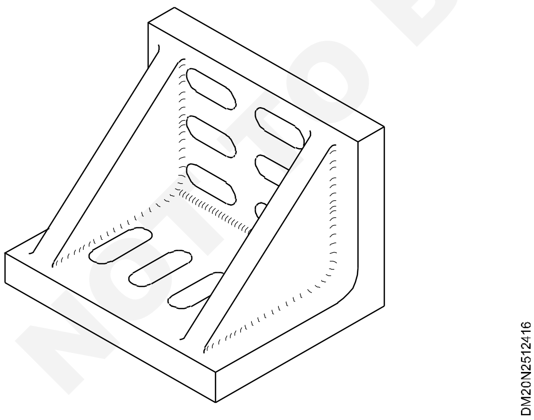


CATCH PLATE

Angle plate (Fig 6)

It is employed for holding odd shape work in conjunction with a faceplate. When the shape of the work is such that it is not possible to mount it directly on the face plate it can be mounted on angle plate.

Fig 6



Lathe Carriers or Lathe Dogs (Fig 7)

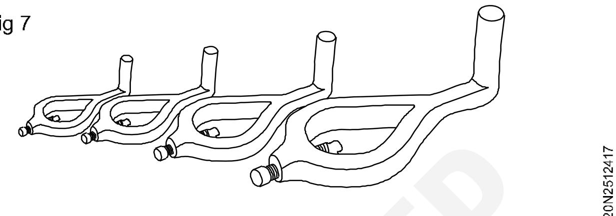
These are used in conjunction with the driving plate. The work to be inserted in the ‘V’ shaped hole of the carrier and then firmly secured in position by means of a screw lathe dogs have two types of tails

a Straight tail

b Bent tail

c Adjustable carrier

Fig 7



LATHE CARRIERS OR LATHE DOG

Mandrels (Fig 8)

The lathe mandrel is used to hold the workpieces or a job that is already bored or drilled.

The mandrel is often hardened with tool steel and grinded to a specified size.

It is grinded on a 1: 2000 taper.

Types of lathe mandrel

Plain mandrel

Stepped mandrel

Collar mandrel

Screwed mandrel

Cone mandrel

Gang mandrel

Expansion mandrel

Taper shank mandrel

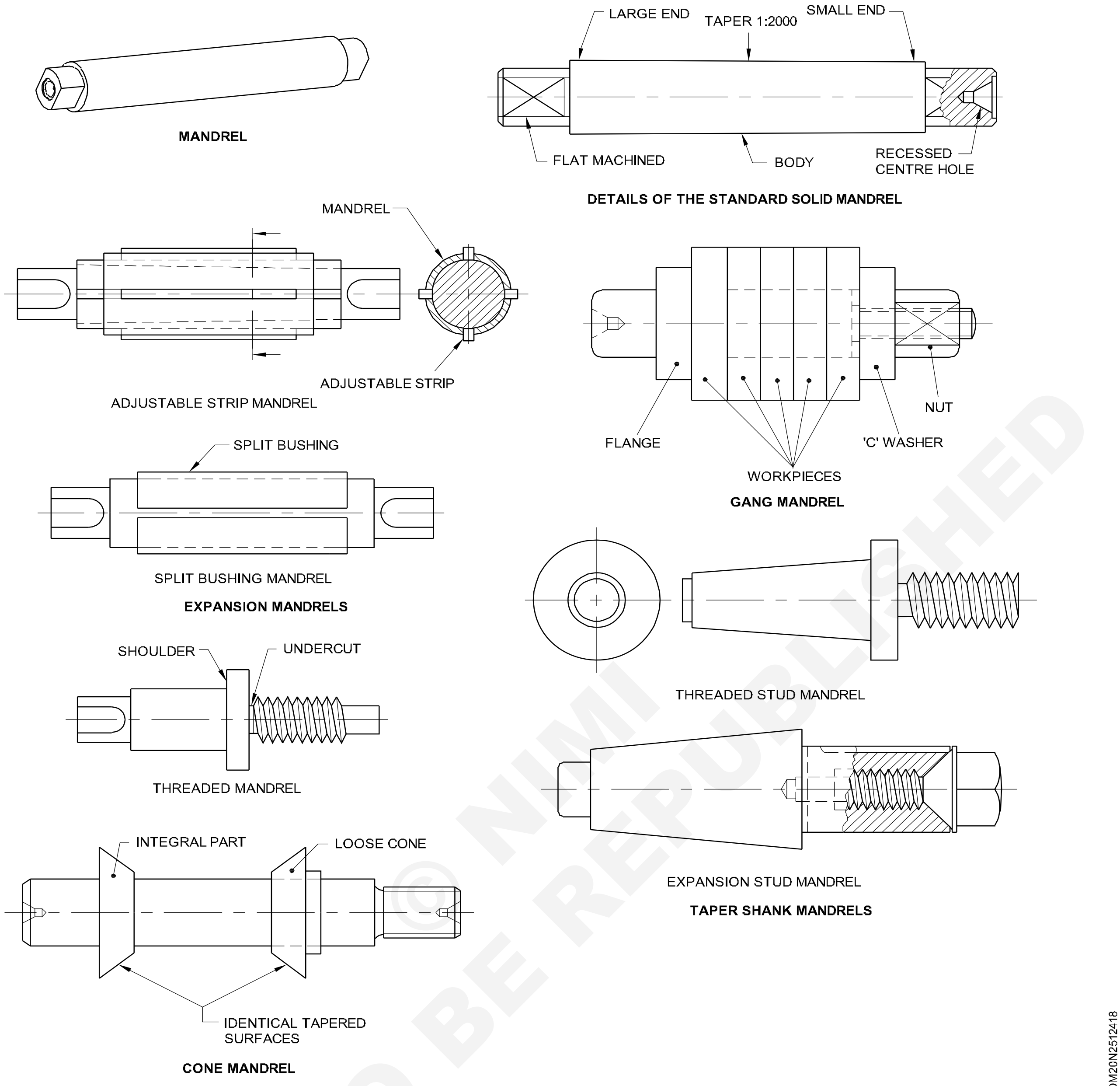
Rests

A rest is a mechanical device to support a long slender workpiece when it is turned between centres or by a chuck. It is placed at some intermediate point to prevert the workpiece from bending due to its own weight and vibrations set up due to the cutting force. These are two different types of rests

1 Steady rest

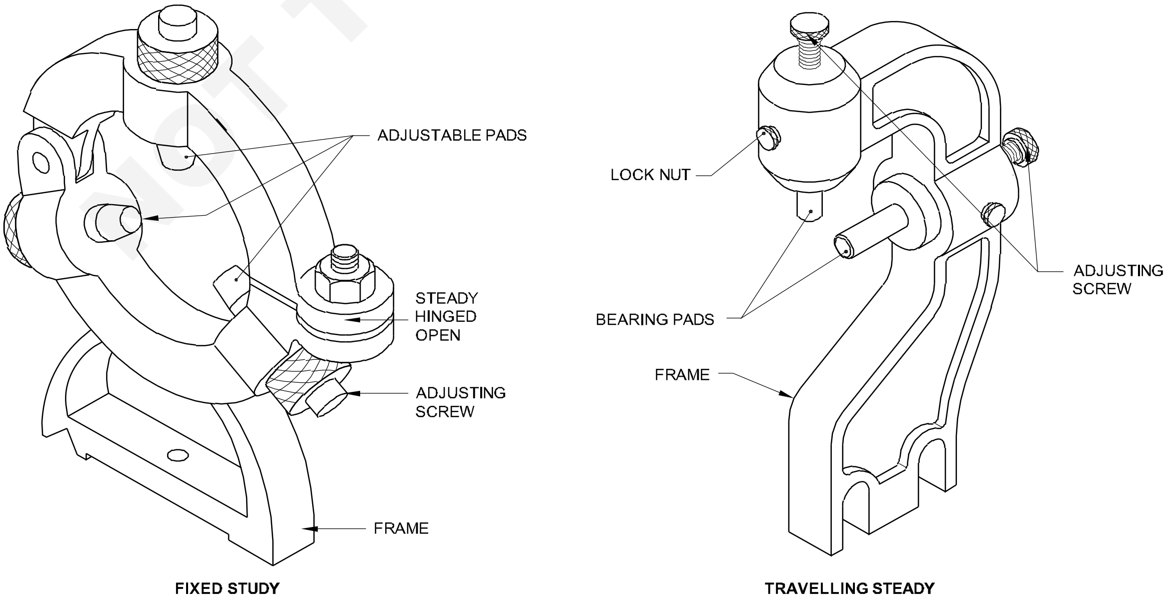
2 Follower rest

Fig 8



MANDREL
LARGE END
TAPER 1:2000
SMALL END
FLAT MACHINED
BODY
RECESSED
CENTRE HOLE
DETAILS OF THE STANDARD SOLID MANDREL
MANDREL
ADJUSTABLE STRIP
ADJUSTABLE STRIP MANDREL
FLANGE
WORKPIECES
'C' WASHER
NUT
GANG MANDREL
SPLIT BUSHING
SPLIT BUSHING MANDREL
EXPANSION MANDRELS
THREADED STUD MANDREL
SHOULDER
UNDERCUT
THREADED MANDREL
EXPANSION STUD MANDREL
TAPER SHANK MANDRELS
INTEGRAL PART
LOOSE CONE
IDENTICAL TAPERED
SURFACES
CONE MANDREL
DM20N2512418

Fig 9



ADJUSTABLE PADS
STEADY
HINGED
OPEN
ADJUSTING
SCREW
FRAME
FIXED STUDY
LOCK NUT
BEARING PADS
FRAME
ADJUSTING
SCREW
TRAVELLING STEADY
DM20N2512419

Different clamping devices on milling and shaping operation

Objectives: At the end of this lesson you shall be able to
- **state about the work holding devices used on milling machine**
- **state the work holding devices used on a shaping machine.**

Work holding devices used on milling machine (Fig 1)

It is necessary that the work should be properly and securely held on the milling machine table for effective machining operations. The cutting pressure exerted by milling cutter is quite high comparing the single point tool of lathe machine. Therefore the work piece has to be secured rigidly to avoid any vibration. The following are the usual methods of holding work on the milling machine.

Types of work holding devices

Various types of work holding devices are explained in the following paragraphs.

T- Bolts and clamps - Bulky work pieces of irregular shapes are clamped directly on the milling machine table using T - bolts and clamps. Different types of clamps are used for different patterns of work. All clamps carry a long hole, through which clamping bolt passes. This hole permits the bolts for adjustment according to the size and shape of the job.

Angle plates - When work surfaces are to be milled at right angles to another face. Angle plates are used for supporting the work.

V block - The V blocks are used for holding shafts on milling machine table in which keyways and slots are to be milled.

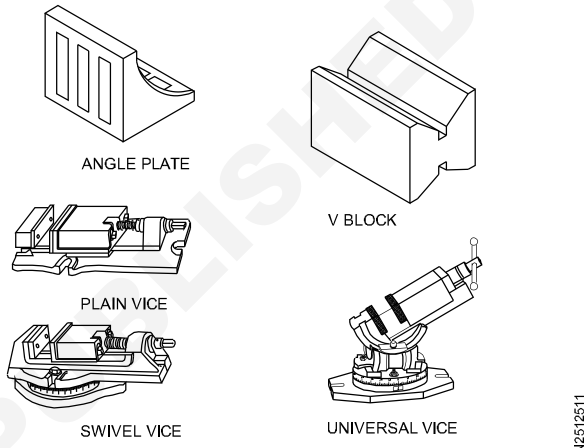
Vices - Vices are most common appliance for holding work on milling machine table. According to its quick loading and unloading arrangement. Vices are of three types.

a **Plain vice** - The plain vice is directly bolted on the milling machine table is the most common type of vice used on plain milling operations, which involves heavy cuts, such as in slab milling. Its especially low construction enables the work to remain quite close to the table. This reduces the chance of vibration to minimum. The base carries slots to accommodate 'T' bolts to fix the vice on the table. Work is clamped between the fixed and movable jaw and for holding work pieces of irregular shape special jaws are sometimes used.

b **Swivel vices** - The swivel vice is used to mill an angular surface in relation to a straight surface without removing the work from the vice. It has got circular base graduated in degrees. The base is clamped on the table by means of T - bolts.

c **Universal vices** - It can be swivelled in a horizontal plane similar to a swivel vice and can also be tilted in any vertical position for angular cut. The vice is not rigid in construction and is used mainly in tool room work. It enables the milling of various surfaces, at an inclination to one another, without removing the work piece.

Fig 1



WORK HOLDING DEVICES USED ON MILLING MACHINE

Dividing Head: Dividing head or indexing head used to hold the work piece and divide the periphery into the number of divisions required. These are of three types.

1 Plain dividing head

2 Universal dividing head

3 Optical dividing head

Work holding devices of shaping machine

Workpieces can be held and supported on the shaper table directly or by having some special devices. Depending on the size and shape of the work, it may be supported on the table by any one of the following methods.

1 Shaper vices

2 Clamps and stop pins

3 T - bolts and step blocks

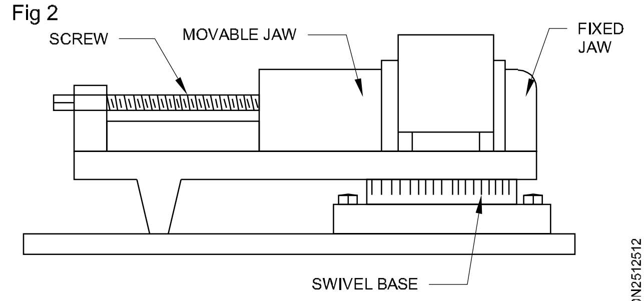
4 Angle plate

5 V - block

6 Special fixtures

1 **Shaper vices:** vices is the most common and simple work holding device used in a shaper. Different types of vices are used in a shaping machine according to the need and they are plain vices, swivel vices and universal vices (Fig 2)

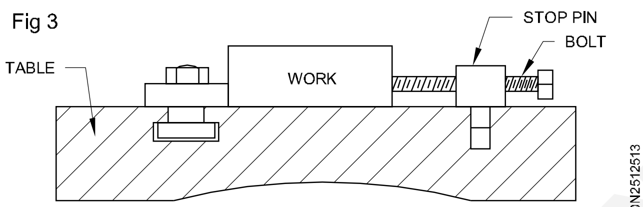
Fig 2



SHAPER VICE

2 **Clamps and stop pins:** T - blots are fitted into the T - slots of the table. The work is placed on the table the work is supported by a rectangular strip at one end and by a stop pin at the other side. The screw is tightened to secure the work properly on the machine table. (Fig 3)

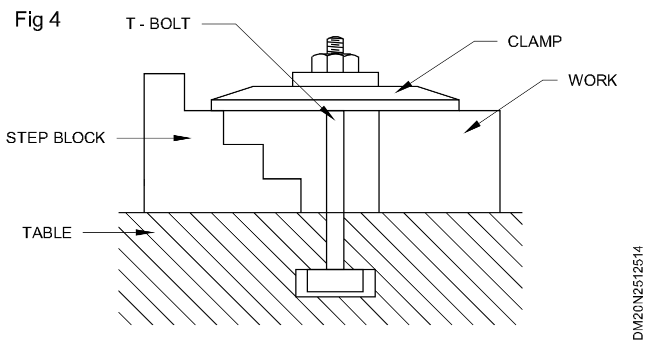
Fig 3



USE OF STOP PIN

3 **T - bolts, clamp and step blocks:** The step blocks are used in combination with T - bolts and clamps to hold the work directly on the machine table. T -bolts are fitted in the T - slots of the machine table. One side of the clamp holds the work and the other side rests on a step of the step block. The different steps of the block are useful in levelling the clamp when holding works of different heights. A nut on the top of the clamp holds the work rigidly. (Fig 4)

Fig 4



4 **Angle plate:** Angle plate resembles the English alphabet 'L'. It is accurately machined to have two sides at right angles. Slots are provided on both the sides. One of the sides is bolted to the machine table and the workpieces are held on the other side.(see Table 1)

5 **V- block:** V- block is a metal block having a 'V' shaped groove on it. It is used for cylindrical workpieces. operations like keyway cutting, slot cutting and machining flat surfaces can be performed on the cylindrical workpieces held on a 'V' block.(see Table 1)

Special fixtures

Work directly wanted on the table for heavy nature of jobs or odd-shaped jobs which is ot possible to hold by other holding devices with the help of slots, T-bolts and nuts. The fixtures are special devices designed to hold work for specific operations more efficiently than standard work holding devices. The fixtures are especially useful when large numbers of identical parts are to be manufactured.

Interchangeability & selective assembly

Objectives: At the end of this lesson you shall be able to
- **define interchangeability**
- **define selective assembly**
- **list types of geometric tolerances.**

Mass production

When identical components are manufactured in large quantities it is stated that they are mass produced. These identical components should fulfil:

- dimensional accuracy
- degree of surface finish
- interchangeability.
- Standardization

Mass production has the advantage of interchangeable manufacture of components machined by different operators on different machine tools under different environments that can be assembled without any rectification with their mating parts. This avoids selective assembly which is time consuming.

Necessity of limit system

It is practically impossible to machine components to an exact size, due to the varying skills of the operators, the condition of the machine tools, the quality of the cutting tools and the accuracy of the precision instrument used. Hence some permissible deviations to the exact size are accepted and given, and the operator is expected to produce the components within the limits, which, even though not necessarily equal to the exact size, will not affect the functioning of the components. This necessitates the introduction of the limit system.

Internationally accepted systems of limits and fits

- British Standard System of Limits and Fits (B.S.).
- International Standard Organization System of Limits and Fits. (I.S.O.)
- Bureau of Indian Standard System of Limits and Fits (B.I.S.)

Apart from the above most commonly used limit systems, various countries follow their own standards to manufacture components for some of their industries.

Advantages of the limit system

- Interchangeability is assured.
- Not necessary to employ highly skilled operators.
- Not necessary to use conventional measuring instruments.
- Time for the manufacture of components will be comparatively less.

Limits, Fits and Tolerance

The B.I.S. standard system of limits and fits is followed by the industries in our country as the standard. It is adopted from the I.S.O. and B.S. standards with modifications to suit our conditions and requirements. For the purpose of B.I.S. standard, the following definitions and symbols are followed.

Interchangeability

The term interchangeability is normally employed for the mass production of identical items within the prescribed limits of sizes. A little consideration will show that in order to maintain the sizes of the part with in a close degree of accuracy, a lot of time is required. But even then there will be small variations. If the variations are within certain limits, all parts of equivalent size will be equally fit for operating in machines and mechanism.

Therefore certain variations are recognised and allowed in the sizes of the mating parts to give the required fitting. This facilitates to select at random from a large number of parts. for an assembly and results in a considerable saving in the cost of production.

In order to control the size of finished part with due allowance for error or interchangeable parts is called limit system.

- **Example:** We have 100 parts each with a hole and 100 shafts which have to fit into these holes.
- If we have interchangeability then we can make any one of the 100 shaft & fit it into any hole & be sure that the required fit can be obtained.
- Any M6 bolt will fit to any M6 nut randomly selected.

Selective Assembly

When the interchangeability is an important factor in the mating parts, the allowance and tolerances are properly given. But for close fits, Very small allowances and tolerances are specified by which the cost may be very high. In order to avoid this expense, selective assembly is often used.

In selective assembly, all parts are inspected and classified in to several grades, according to the actual size, so that small shafts can be matched with small holes, medium shafts with medium holes and large shafts with large holes etc. thus producing approximately the same fit and allowance. Antifrictional bearings are usually assembled selectively.

Advantages

- There is a as large number of acceptable parts.as original tolerances are greater
- This in turn allows the manufacture of cheaper parts.
- Selective assembly assures better and more accurate assembly of parts by insuring closer tolerances between the mating parts.
- Rise the quality and lower manufacturing costs by avoiding tight tolerances.
- Reduces the rejection rate (scrap rate)

Fig 1

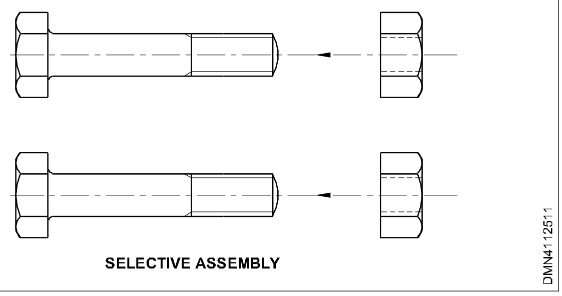
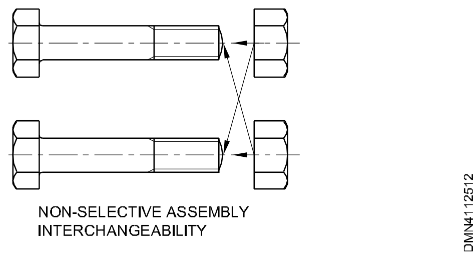


Fig 2



Press and press work

Objectives: At the end of this lesson you shall be able to
- **define press**
- **classify presses**
- **name the power press driving mechanisms**
- **describe different types of dies and operations.**

Introduction

The press is a metal forming machine tool designed to shape or cut metal by applying mechanical force or pressure. The metal is formed to the desired shape without removal of chips. The presses are exclusively intended for mass production work and they represent the fasted and most efficient way to form a sheet metal into finished products.

TYPES OF PRESSES

The classification of different types of presses are given below:

1 Classification based on source of power:

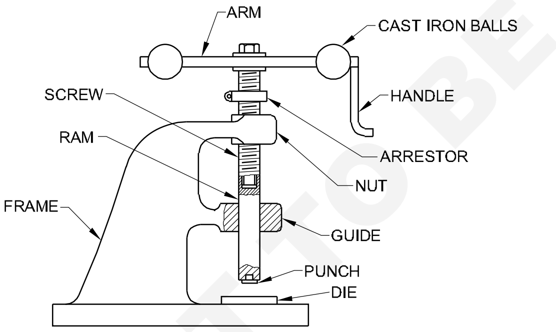
a Hand press or ball press of fly press (Fig 1)

b Power press (Fig 2)

2 Classification based on design of frame :

a Gap	d Horn
b Inclinable	e Stright side
C Adjustable	f Pillar

Fig 1



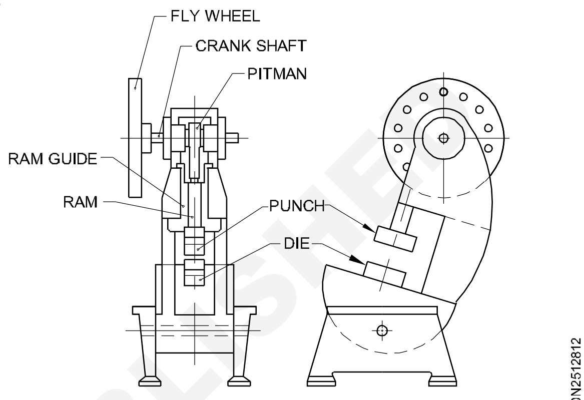
FLY PRESS

Power press parts

The different parts of a power press illustrated in fig 2are described below:

1 Base 2 Frame	6 Crank shaft or eccentric or other driving mechanism
3 Bolster plate	7 Flywheel
4 Ram or slide	8 Clutch
5 Pitman	9 Brake

Fig 2



POWER PRESS

Power press driving mechanism

The following are the different driving mechanisms for imparting reciprocating movement to the ram.

1 Crank and connecting rod drive

2 Eccentric drive

3 Knuckle joint drive

4 Cam drive

5 Toggled lever drive

6 Screw drive

7 Rack and pinion drive

8 Hydraulic drive

Press tools

The general nomenclature of tools used in presses are called dies and punches. The term die is also sometimes used to denote the entire press tool including a punch.

A punch is that part of the press tool which enters into the cavity formed in the die section. The punch is usually the upper member of the press tool which is mounted on the lower end of the ram and slides with it.

A die is that part of the press tool which has an opening or cavity to receive the punch. The die is usually the lower member of the press tool which is clamped on the bolster plate fitted on the table and remains stationary.

The punches and dies are generally made of high speed steel. Die with the working surface made of satellite or cemented carbide are mostly used in production presses.

Types of dies and operations

The dies are classified according to the types of operations performed by them and according to their specific construction. The classification of dies and their functions are given below:

1 Classification based on operations performed:

(i) Shearing
- a Piercing
- b Punching
- c Perforating
- d Blanking
- e Cutting off
- f Parting
- g Notching
- h Slitting
- (i) Lancing

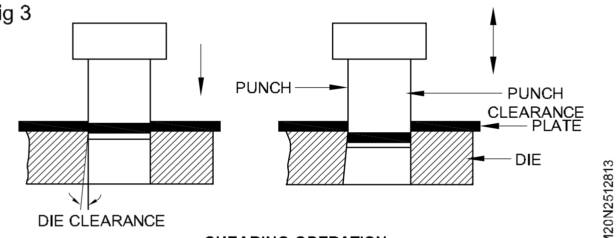
(ii) Drawing :
- a Angle bending
- b Curling
- c Forming
- d Plunging
- a Cupping

(iii) Squeezing:
- a Coining
- b Embossing
- c Flattening or planishing

2 Classification based on construction:
- i Simple
- ii Follow or progressive
- iii Compound
- iv Combination
- v Rubber

Shearing operation: The shearing operation between a punch and a die is illustrated in fig 3 as the punch descends upon the work piece, the pressure exerted by the punch causes the metal to be deformed plastically. As the clearance between the punch and the die is very small, the plastic deformation takes place in a localized area and the metal adjacent to the cutting edges of the punch and the die becomes highly stressed. When the stress reaches beyond the ultimate strength of the material, the fracture starts from both the sides of the plate along the cutting edges of both die and the punch and as the punch continues to descend, the fractures meet at the centre of the plate. The metal is now completely severed from the sheet metal and drops out through the die opening. The fig 3 illustrates a complete shearing operation.

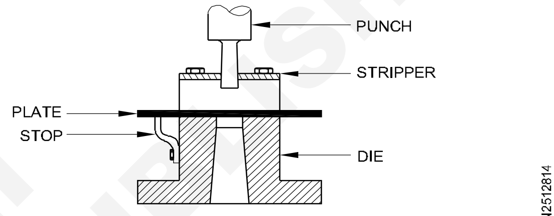
Fig 3



SHEARING OPERATION

Piercing : The piercing is the operation of production of hole in a sheet metal by the punch and the die. The material punched out to form the hole constitute the waste. The punch point diameter in the case of piercing is less than or equal to the work material thickness. The punch governs the size of the hole and the clearance is provided on the die, fig 4 illustrates the punch and the die set up for piercing. The spacing of hole on the plate is actuated by the stop. The stripper plate attached to the die body prevents the sheet metal from being lifted along with the punch after shearing operation.

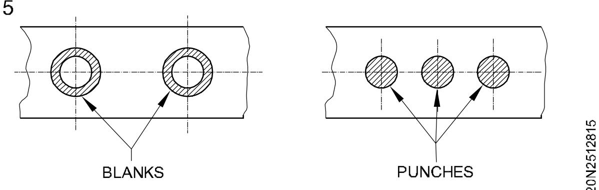
Fig 4



PUNCH AND DIE SET UP FOR PIERCING,PUNCHING AND BLANKING

Punching: The punching operation is similar to the piercing operation while punching the formation of the hole is the desired result. The difference between the punching and the piercing is that in the case of punching a cylindrical hole is produced, whereas in the case of piercing the hole produced may be of any other shape. The size of the hole is determined by the size of the punch and the clearance is allowed on the die. The punch and the die setup is illustrated in fig 4.

Fig 5

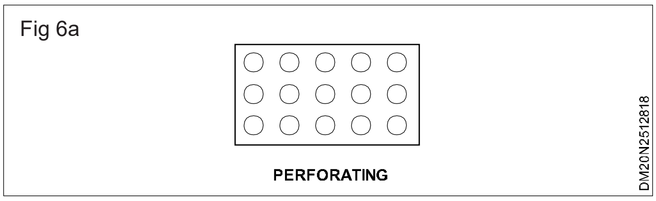


PUNCHING AND BLANKING

Blanking : The blanking is the operation of cutting of flat sheet to the desired shapes. The metal punched out is the required product and the plate with the hole left on the die goes as waste. While blanking the size of the blank is governed by the size. of the die and the clearance is left on the punch. Fig 5 illustrates the difference between punching and blanking. The punch and die set up for blanking is identical to that illustrated in Fig 4.

Perforating : The perforating is the operation of production of a number of holes evenly spaced in a regular pattern on a sheet metal. The perforating operation is illustrated in fig 6a. the punch and the die set up is similar to the piercing and punching operation.

Fig 6a



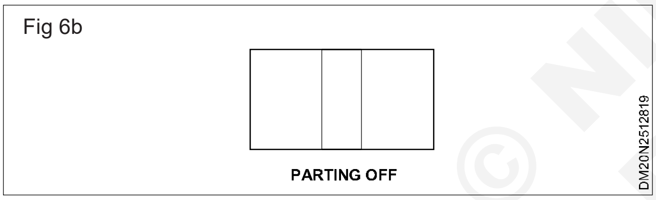
PERFORATING

Cutting off : The cutting off is the operation of severing a piece from a sheet of metal or a bar with a cut along a single line. The cutting off operation illustrated in fig 8 can be performed along a straight line or a curve. The set up required for the cutting off operation is illustrated in fig 7 the work piece is sheared between the two blade. The lower blade is fixed to the machine frame and the upper blade moves up and down with the ram. As the upper blade descends, the hold down springs keeps the plate in position, while the metal is stressed between the fixed and movable blade.

When the ultimate strength of the material is exceeded, the plate is sheared off. The cutting edges of the upper and the lower blades are not aligned in the same plane. They are slightly off centered relative to each other to provide clearance.

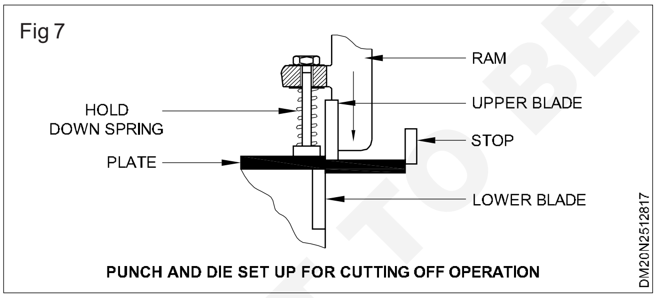
Parting : The parting is the operation of cutting a sheet metal in two parts. Unlike cutting off operation, some quality of scrap is removed to severe the work piece in two parts. The parting off operation is illustrated in fig 6b.

Fig 6b



PARTING OFF

Fig 7

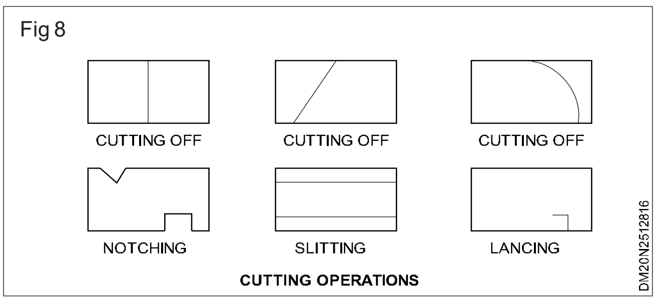


PUNCH AND DIE SET UP FOR CUTTING OFF OPERATION

Notching : The notching is the operation of removal of the desired shape from the edge of a plate. The punch and the die set up is similar to the piercing or punching operation.

Slitting: The slitting is the operation of cutting a sheet metal in a straight line along the length.

Fig 8



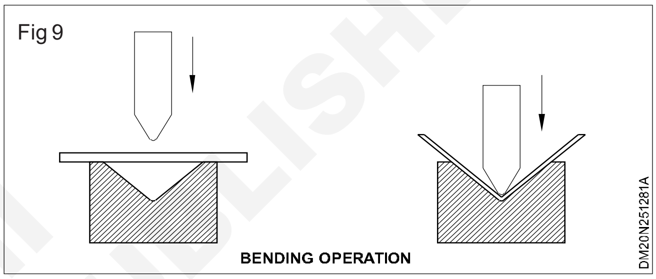
CUTTING OPERATIONS

Lancing: The lancing is the operation of cutting a sheet metal through part of its length and then bending the cut portion.

Bending operation : The bending operation is illustrated in fig 9. while bending, the metal is stressed in both tension and compression at the two sides of the neutral axis beyond the elastic limit but below the ultimate.

Strength of the material. As the metal is loaded beyond the elastic limit, some amount of plastic deformation takes place and when load is removed, the metal retains the bent shape given by the die. There is, of course, some amount of elastic recovery of the metal when the load is removed, resulting in a slight decrease in the bent angle. The effect is known as spring back . the correct the effect of spring back , the metal is bent through a greater angle so that when the load is removed, the component will spring back to the desired angle. The different bending operations are described below:

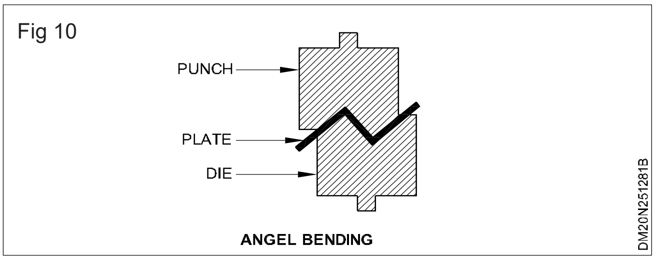
Fig 9



BENDING OPERATION

Angle bending: The angle bending is the operation of bending a sheet metal to the sharp angle. The punch and the die is shaped to the desired angle. The punch and the die is shaped to the desired angle, taking into consideration the effect of spring back. The angle bending operation is illustrated in fig 10.

Fig 10

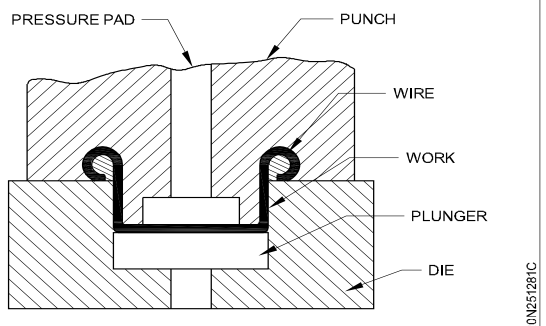


ANGEL BENDING

Curling : The curling is the operation of forming the edges of a component into a roll or a curl by bending the sheet metal in order to strengthen the edges and to provide smoothness to its surface. The curling operation is illustrated in fig 11 as the punch descends into the die, the metal roll into a curl in the radiused cavity of the punch. The curling of the edges are made over on wire to add strength to the edges. The plunger in the die block acts as a pressure pad and lifts the work when the punch starts moving in the upward stroke.the pressure pad fitted in the punch ejects the component out of the punch cavity at the end of the stroke.

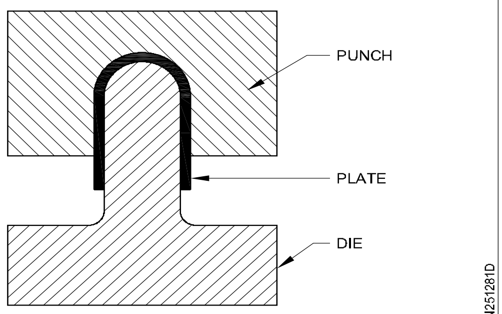
Forming : The forming is the operation of bending a sheet of metal along a curved axis. The metel is confined between the die and is stressed in compression and tension beyond the elastic limit. The shape of the component is governed by the shape of the punch and the die. Fig 12 illustrates the forming operation as the components are pressed on the die walls while forming.

Fig 11



CURLING

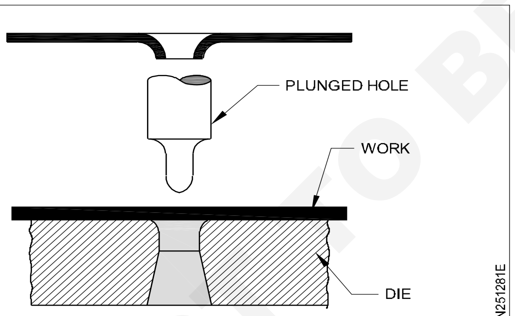
Fig 12



FORMING

Plunging: The plunging is the operation of bending a sheet metal to the desired shape for accommodating a screw or a rod through the plunged hole. The plate is first pierced at the required position and then the plunging pinch is pressed in the hole. This causes the displacement of the metal in the die cavity and the shape of the plunged hole depends on the shape of the punch. The plunging operation is illustrated in Fig 13.

Fig 13



PLUNGING

Drawing operation: the drawing is the operation of production of cup shaped parts from flat sheet metal blacks by bending and plastic flow of the metal. The drawing operation is illustrated in Fig 14. the blank is placed on the die and while the punch descends, the pressure pad holds the blank firmly on the die. As the punch descends further, the blank is pushed in the cavity of the die and the metal is made to flow plastically while it is drawn over the edges of the hole to form the sides of the cup. The pressure irons out the wrinkles developed while drawing . the clearance between the punch and the die is greater than while shearing . the size of a blank required to flow out a cup can be calculated from the formula given below:

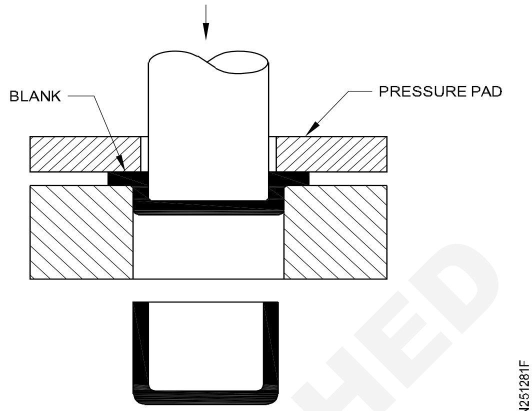
$$D = \sqrt{d^2 + 4dh}$$

Where, D = the diameter of the blank

D= the diameter of the cup

H= the height of the cup

Fig 14



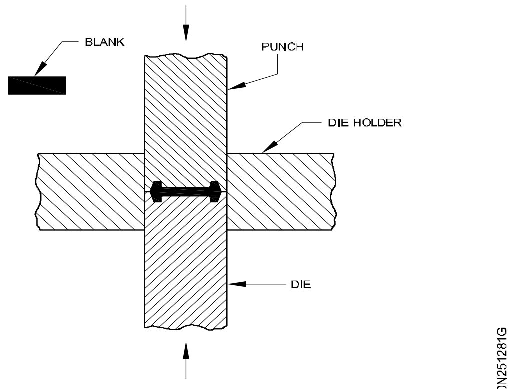
DRAWING OPERATION

Cupping: the cupping of the operation of production of a cup shaped component by drawing operation.

Squeezing operation: the squeezing operation is the most severe of all cold press operation. Tremendous amount of pressure is required to squeeze a metal which is made to flow in a cold state within the cavity of the die and the punch to attain the desired shape. For this reason the squeezing operation is performed in a hydraulic press. The different squeezing operation are described below:

Coining: The coining is the operation of production of coins, medals or other ornamental parts by squeezing operation. Fig 15 illustrates the coining operation. The metal having good plasticity and of proper size is placed within the punch and the die and a tremendous pressure is applied on the blank from both ends. Under severe compressive loads, the metal flows in the cold state and fills up the cavity of the punch and the die. The component thus produced gets a sharp impression on its two sides, corresponding to the engravings on the punch and the die.

Fig 15

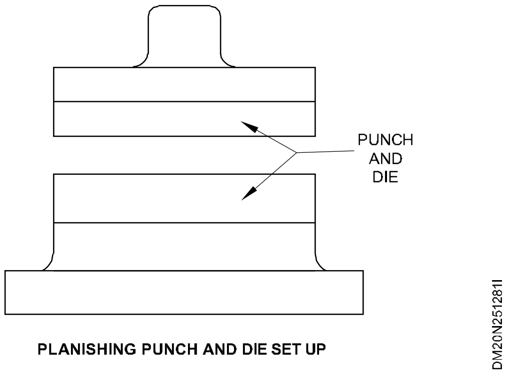


COINING

Embossing : the embossing is the operation of giving impressions of figures, letters or designs on sheet metal parts. The punch, or the die, or both of them may have the engravings which are marked on the sheet metal by squeezing and plastic flow of the metal .

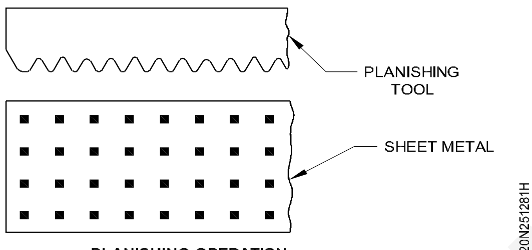
Flattening or planishing: The flattening or planishing is the operation of straightening a sheet metal which is a curved one. The operation is illustrated in Fig 17.

Fig 16



PLANISHING PUNCH AND DIE SET UP

Fig 17



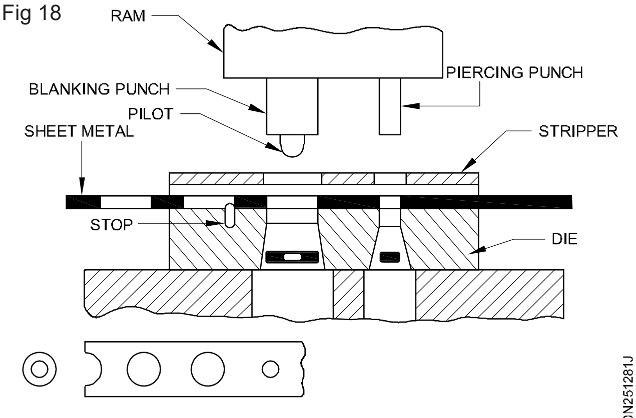
PLANISHING OPERATION

The pin pointed planishing tool is made to descend on the sheet metal to be straightened , and the projections on the tool exert to remove all the residual bending stress present in the plate. The distortion and thus removed, while the pin points on the tool make a series of indentations on the plate surface due to squeezing of metal. The punch and the die set up for flattening in illustrated in Fig 16.

Simple die: in a simple die, only one operation is performed at each stroke of the ram. All the dies which are described before are simple dies.

Follow or progressive die: in a progressive die, two or more operations are performed simultaneously at a single stroke at two or more different stations. The metal is progressed from one station to the other till the complete part is obtained. The progressive punching and the blanking die is illustrated in Fig 18. the sheet metal is fed into the first die where a hole is pierced by the piercing die set in the first cutting stroke of the ram. The plate is then advanced in the next station and the correct spacing is obtained by the stop. In the second cutting stroke of the ram, the pilot enters into the pierced hole and correctly locates it. While the blanking punch descends and shears the plate to form a washer. By the time the blanking operation is performed, the hole for the next washer is also pierced at the first station . Thus although two strokes are required to complete a washer, each piece of waster is discharged on every strokes of the ram due to the continuity on operation.

Fig 18

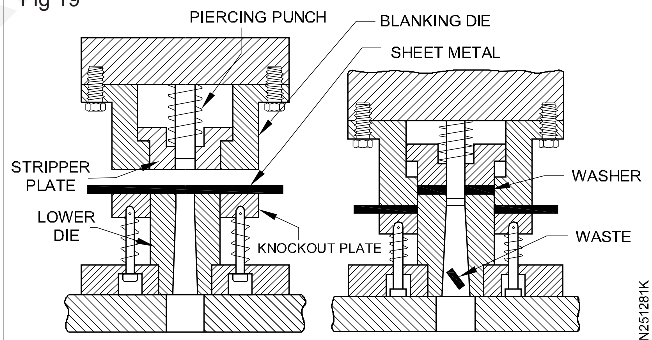


PROGRESSIVE PUNCHING AND BLANKING DIE

Compound die: In a compound die two or more cutting operations are accomplished at one station of the press in every stroke of the ram, Fig 19 illustrates a compound blanking and piercing die. The blanking die and the piercing punch are bolted to the ram. The spring loaded stripper plate is housed within the blanking die. The lower die body has cutting edges both on its outward and inward surfaces. The outside cutting edges serve as a punch for the blanking operation, and the in side cutting edges operate as a die for the piercing punch.

The sheet metal is placed on the lower the block, and as the ram descends, the plate is first blanked, and then pierced by the successive die sets. At end of the operation, the stripper plate fitted on the upper die block discharges the waster, and the knockout plate fitted on the lower die block ejects the blank.

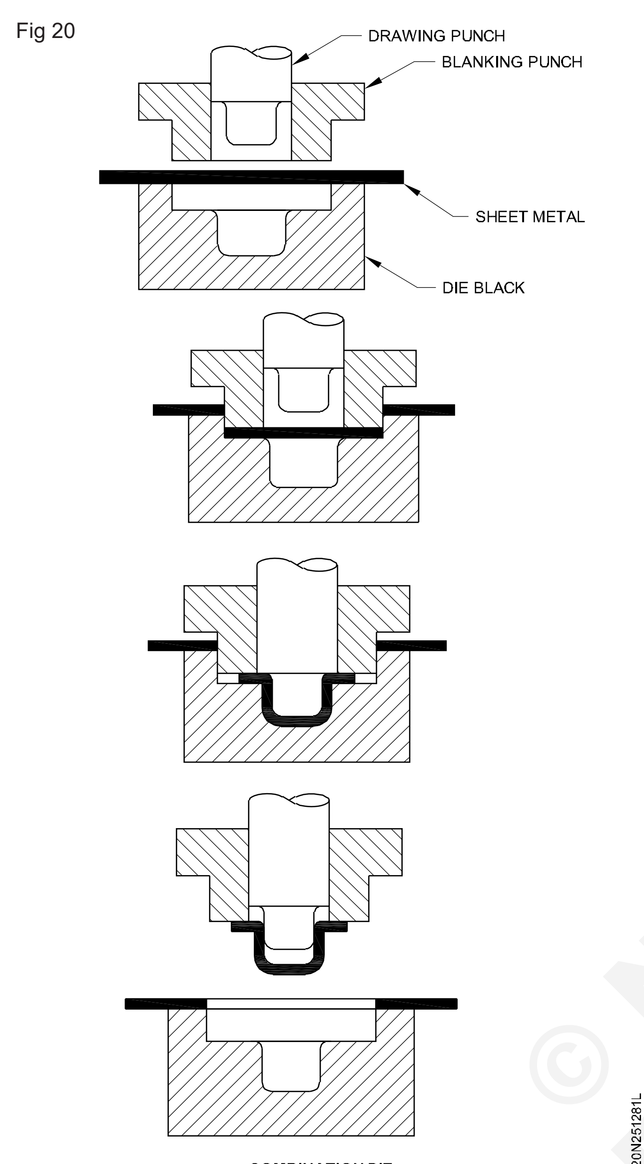
Fig 19



COMPOUND DIE

Combination die: In a combination die, both cutting and noncutting operations are accomplished at one station of the press in every stroke of the ram. Fig 20 illustrates a combination blanking and drawing die showing different stages of the operation. The upper die block serves as a blanking punch and houses a drawing punch at its centre. As the punch descend, the metal is first sheared and the required size of the blank is obtained. The inner punch now descends and draws out the metal, while the blanking punch serves as a pressure pad. The drawn out cup is ejected at the end of the stroke.

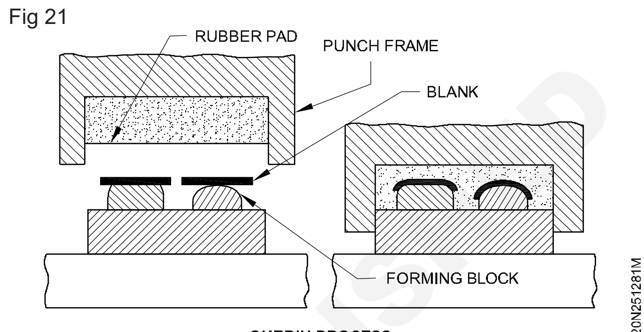
Rubber die: In a rubber die, the rubber is used as a medium of applying pressure on the sheet metal blanks. There are mainly two different processes of operating the rubber die. They are described below:



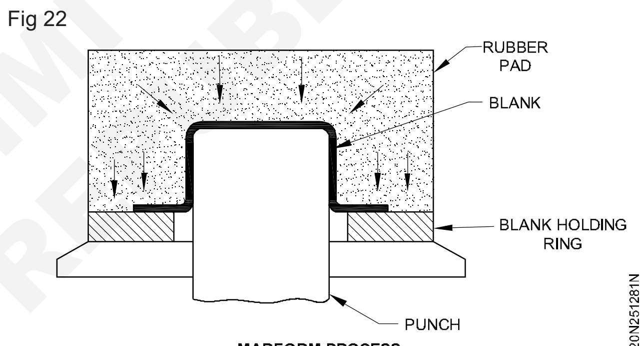
COMBINATION DIE

Guerin process: The Guerin process is employed for performing light drawing , forming or blanking operations by utilizing only one half of the die. Whereas the other half is supplied by the rubber, which acts as a universal die. The fundamental principle of this process is that when the rubber is totally confined and is compressed it acts like a fluid and transmits equal pressure in all directions. The forming operation by Guerin process is illustrated in Fig 21.

Marform process: The marform process is practiced in deep drawing operations Fig 22. illustrates the marform process.



GUERIN PROCESS



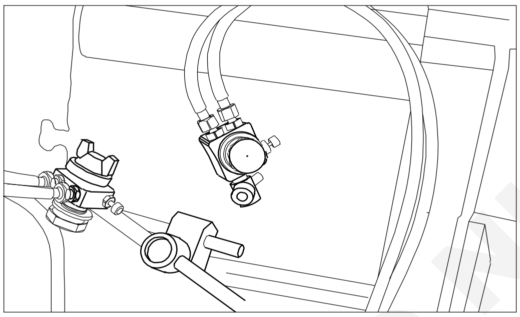
MARFORM PROCESS

Different moulding process, & Die Casting

Objectives: At the end of this lesson you shall be able to
- **state the types of moulding processes**
- **know the special casting techniques.**
- **define die casting**

Types of Moulding processes (Fig 1): Different types of moulding processes form plastic into the desired shape based on the plastic's intended use. Plastic manufacturing relies on different types of moulding in a variety of shapes. Plastic is a synthetic material that is soft or semi - liquid when hot. The soft plastic is placed in moulds, and then the plastic cools, or sets. After setting, the plastic is in the desired shape and is removed from whatever types of moulding were used to create it. Thermoplastics can be melted down and reformed if necessary, however thermo set plastics cannot be reheated.

Fig 1



Plastic manufacturing relies on different types of moulding processes to form liquid, melted plastic into solid shapes. Casting, injection moulding, blow moulding, compression moulding and rotational moulding have different uses and advantages in plastic manufacturing.

Plastic moulding using casting: Plastic moulding using casting is the simplest method as plastic manufacturing as it requires the least amount of complex technology. plastic is simply heated so it turns into a fluid, and then transferred into a mould. The plastic is left to cool and the mould is removed. This process can be used for intricate shapes and is performed under low pressure.

Injection moulding of plastic: Injection moulding of plastic creates high - quality three - dimensional objects that can be commercially reproduced. The injection moulding process begins by melting plastic in a hopper. The melted, liquid plastic is injected into a tightly closed, chilled mould. The plastic quickly takes the shape of the surrounding mould. Once it has completely set, the mould is opened to release the plastic object. The mould can generally be used many times before needing to be replaced. Plastic items such as yogurt cups, butter tubs, plastic toys and bottle caps use the injection moulding process.

Blow moulding plastic manufacturing: Blow moulding is a process used for making hollow objects such as piping or milk bottles. In the blow moulding plastic manufacturing process, plastic is heated until molten. The liquid, molten plastic is injected into a cold mould. The mould has a tube set within it, which has a particular shape when inflated. While the plastic is molten, air is blown into the tube and the plastic is formed around the tubing. The plastic is left to cool and removed from the mould.

Compression moulding of plastic: Compression moulding of plastic is the most labour - intensive type of moulding process. Since compression moulding is more complicated, it is typically only used for large scale production purposes rather than mass production. For example, boat hulls and car tires are made using the compression moulding method. Molten plastic is poured it no a mould. Then a second mould is pressed into it. This squeezes the plastic into the desired shape before the plastic is left to cool and removed from the mould.

Rotational moulding of plastic: Toys, shipping drums, storage tanks and consumer furniture made of plastic are all made using rotational moulding. In this method, liquid plastic forms each object as it is added to the mould from the inside. Two mechanical arms hold the mould in place. The inside. As the mould turns, the plastic coats the inside of he mould to create a new hollow, plastic object.

The arms constantly rotate the mould at the same level while molten.

Special casting Techniques

Classification

a Metal mould casting

- i Gravity or permanent mould casting
- ii Die casting
- iii Slush casting
  - Hot chamber process
  - Cold chamber process
- iv Pressed or corthias casting

b Non-metallic mould casting

- i Centrifugal casting
  - True-Centrifugal casting
  - Semi-centrifugal casting
  - Centrifuge casting
- ii Carbon - dioxide moulding
- iii Investment mould casting or lost - wax process
- iv Shell moulding

v Plaster moulding

vi Mercast process

- Reciprocating moulds
- Draw casting
- Stationary moulds
- Direct sheet casting

c Continuous casting

Die Casting (Fig 2)

The castings produced by forcing molten metal under pressure into a permanent metal mould (known as die) is called die casting.

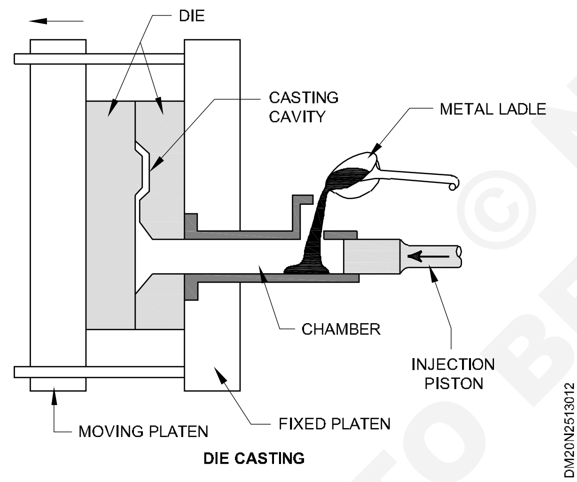
A die is usually made in two halves and when closed it forms a cavity similar to the casting desired. One half of the die that remains stationary is knowns as cover die and the other movable half is called ejector die. The dies are made up of tool steel.

The die casting method is mostly used for castings of non-ferrous metals specifically Aluminium, copper, zinc, lead and tin based alloy of comparatively low fusion temperature. This process is cheaper and quicker than permanent or sand mould casting.

Most of the automobile parts like fuel pump, carburettor bodies, Heaters, wipers,Brackets, steering wheels, Hubs and crank cases are made with this process.

Die cycle:

Fig 2



DIE CASTING

A cycle is a complete set of events in which one casting is produced.

It consists of following steps.

- Closing the die
- Shot: Injection if molten metal in die
- solidification of metal under pressure.
- opening the die
- Ejection of casting from the die

Methods of Die casting:

Die casting is done by two methods

1 Gravity die casting/Permanent die casting
  - Slush casting
  - Low pressure die casting

2 Pressure Die casting
  - Hot chamber die casting
  - Cold chamber die casting
  - Centrifugal casting

Gravity die casting:

- Molten metal is poured under gravity (i.e without pressure)
- Both ferrous and non-ferrous metals can be casted.
- Production rate is slow.
- The casting is not so smooth or dimensionally accurate.

Pressure Die casting

- Molten metal is poured under pressure.

Hot chamber Die casting:

- In this pressure die casting process, the basin of molten metal is a part of the machine.
- Low melting (less thabn 700^0 C) alloys of zinc, tin, and lead are casted in hot chamber machine.
- It is mainly used for small castings (0.3kg to 40kg)
- The injection pressure is 7 to 35 MPa.

Cold chamber die casting:

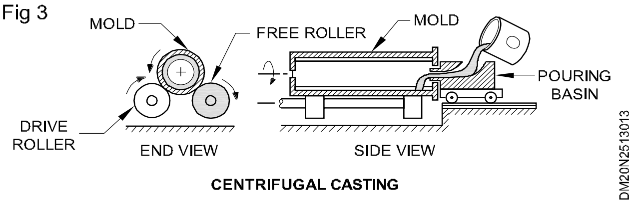
- In this pressure die casting molten metal is poured from an external melting container and a piston is used to inject the metal under high pressure into the die cavity
- High melting alloys of brass, aluminium and magnesium are casted in cold chamber machine.
- Injection pressure is 14 to 140 MPa.

Centrifugal casting (Fig 3)

- Centrifugal casting is also known as Roto casting.
- It is a casting process in which centrifugal force is used and to cast thin-walled cylindrical parts.,
- It is mainly used to produce rotationally symmetric products.
- After obtaining the product it requires some machining for good finishing.

Gating system:

Fig 3



CENTRIFUGAL CASTING

- The gating system completely controls the flow of molten metal into the die cavity.
- Gating systems can be classified as pressurised system and Unpressurised system.

- Pressurised system is used for reactive metals like magnesium alloy etc.
- Unpressurised system is used for normal metals such as brass, steel, aluminium alloy etc.

Elements of Gating system (Fig 4a to 4d)

- Pouring cup.
- Sprue
- Sprue well
- Cross - gate or Runner
- Ingate or gate.

Pouring Cup: It is the funnel - shaped opening made at the top of the mold. The main purpose of pouring basin is to direct the flow of molten metal from laddle to the sprue.
Sprue: It is a vertical passage connects the pouring basin to the runner. It is generally made tapered downward to avoid aspiration of air. The cross section of the sprue may be square, rectangular or circular.

Sprue well: It is located at the base of the sprue or choke. It arrests the free fall of molten metal through the sprue and turns it by a right angle towards the runner.

Runner : It is a long horizontal channel which carries molten metal and distribute it to the ingates.

Gate: These are small channels connecting the mould cavity and the runner. The gates used may vary in number depends on size of the casting.

Riser: Riser system is used to compensate shrinkage caused by casting solidifcation.

Vents: The vent helps to assist in the escape of gases that are expelled from the molten metal during solidification

Types of Gates (Fig 4)

- Depending upon the orientation of the parting plane.

  -Horizontal gating system

  -Vertical gating system

- Depending upon the position of ingate, horizontal gating system may be (Fig 5)

  -Top gating

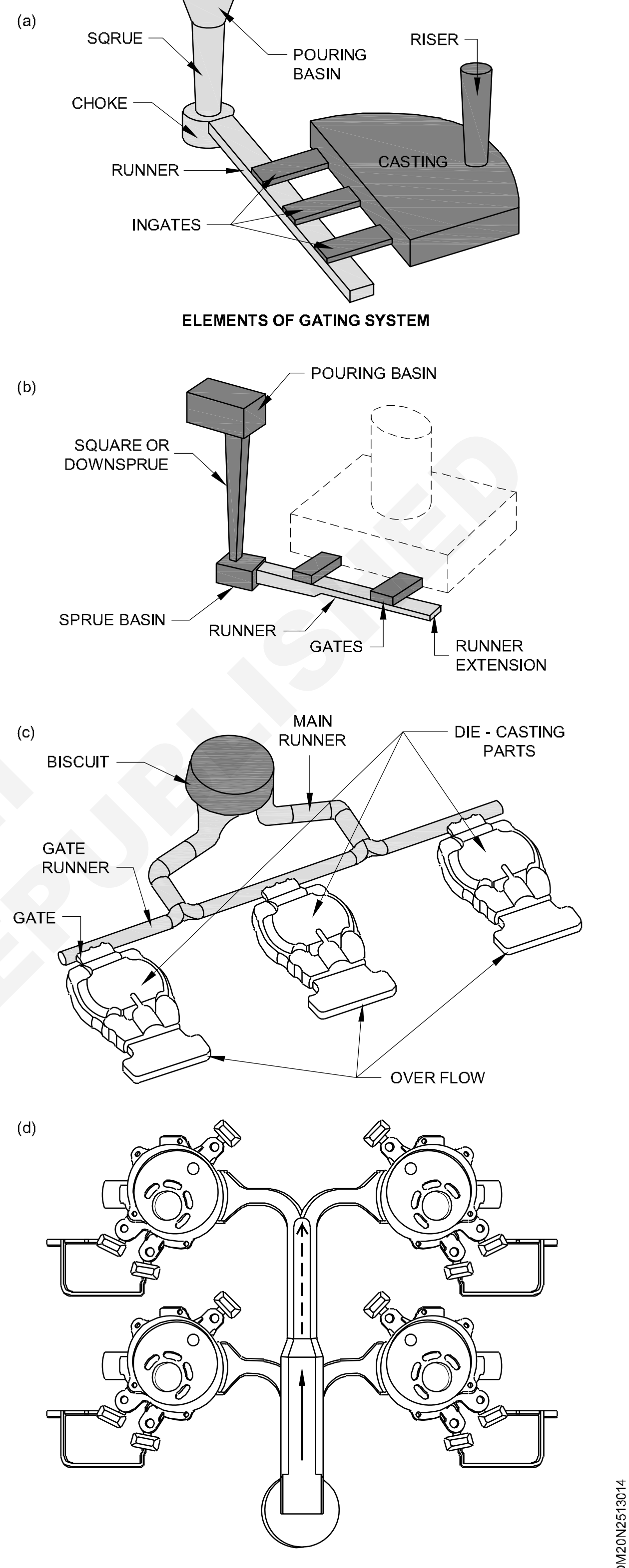
  -Bottom gating

  -Pating line gating

Gating ratio:

- Gating ratio refers to the relation between area of choke to the total area of runner and to the total area of ingates. Mathematically it can be written as AC:AR:AG. Gating ratio depends on the nature of molten metal.
- A gating ratio such as 1:2:1 or 1:0.75:0.5 refers to pressurised system
- Where as the gating ratio such as 1:2:2 or 1:3:3 or 1:1:3 refers to unpressurised gating system.

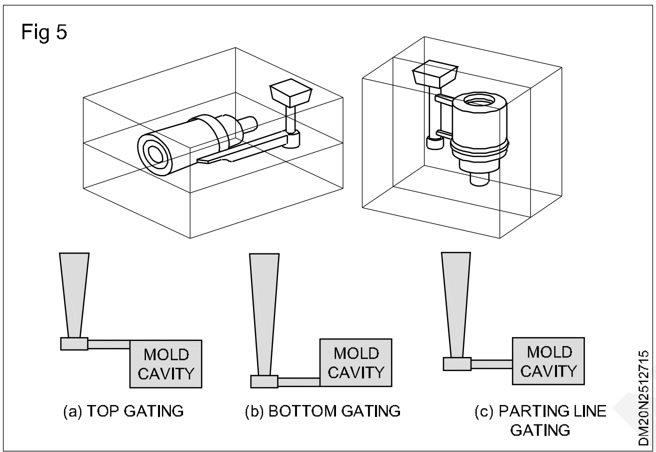
Fig 4



Guidelines for Designing gating system:

- The size of the sprue fixes the flow rate. The amount of molten metal that can be fed into the mold cavity in a given time period is limited by the size of the sprue.
- The sprue should be located at certain distance from the gates so as to minimize the velocity of molten metal at ingates.

- Sprue should be tapered approximately (min) 5% to avoid aspiration of the air and free fall of the metal
- Ingates should be located in thick regions
- Multiple gating is frequently desirable, it helps to reduce the temperature gradients in the casting.
- Sharp corners in any section or portion in gating system should be avoided.
- The most important characteristic of gating system are location and dimension of runners and type of flow.
- Bending of runners if any should be kept away from the mould cavity.
- Gating ratio should reveal that the total cross section of sprue, runner and gate decreases towards the mould cavity which provided a choke effect.



Coatings

- After the mould surfaces have been heated to the required temperature, a refractory coating in the form of slurry is sprayed or brushed on to the mould cavity, riser, gate and runner surfaces.
- French chalk or calcium carbonate suspended in sodium silicate binder is commonly used as a coating for aluminium and magnesium permanent mould castings.
- Coating is dried and then smoothed with steel wool.
- Refractory coating:
  - i Protects mould surfaces from erosion and checking
  - ii exercises insulating effect and thus helps obtaining progressive directional solidification.
  - iii is kept then when chilling is needed and vice versa.
  - iv may be repaired and normally replaced after every eight hours
- Lubricating coatings if sprayed, help removal of castings and cores from the mould. A coating of graphite water paint permits easy removal of a 60-40 brass casting.
- Permanent moulds, besides refractory coating are given a carbon acetous soot coating once every casting cycle.

Chills

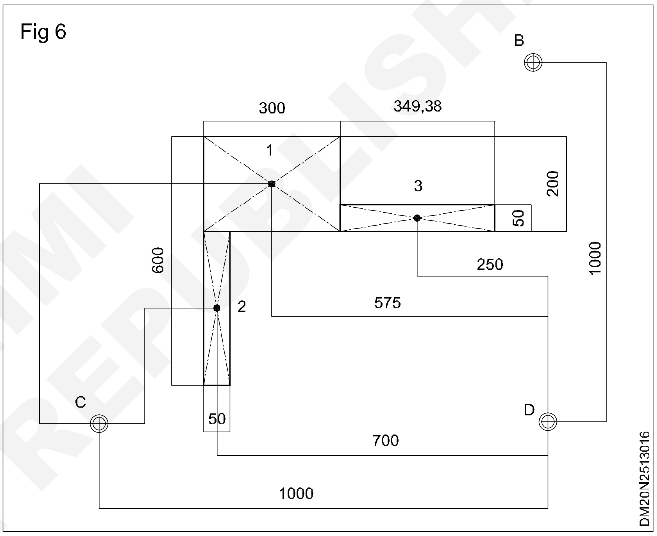
- Chills are pieces of copper, brass or aluminium and are inserted into the mould's inner surface.
- Water passages in the mould or cooling fins made on outside the mould surface are blown by air otherwise water mist will create chilling effect.

A chill is used to promote directional solidification.

Die casting (Fig 6)

1. **Force calculation**
2. **Causes and Remedies**
3. **Die casting estimation**

1 Force calculation



Die locking: Early in the analysis of a die casting, die locking requirements should be calculated. These calculations will establish the machine size to be used.

$$F = P_m A I \left[\text{Where } (P_m) = P_h \left(\frac{D}{d}\right)^2 \right]$$

F = Force required to hold the die closed (tons)

P_h = Hydraulic pressure in injection cylinder

P_m = pressure acting on the molten metal

A = Projected area of all cavities, runners, overflows and sprue and biscuit.

D = Diameter of injection cylinder.

d = Diameter of plunger.

I = Dimensionless impact/freeze factor

The impact/freeze factor 'I' depends on the injection velocities required. Generally the value may range from approximately 3 for shorter fill time to 1.5 for longer fill times. For very thick casting the value may range from 0.6 to 0.8.

Molten metal pressure will usually be about 13.8MPa for Zinc and 34MPa for Aluminum and Magnesium castings.

If the projected area is not centered between the tie bars the load required for each tie bar must be calculated by the sum of the moments. The required machine size is determined by multiplying the load of the tie bar with the greatest load by the number of tie bars.

The first step is to divide the total projected area in to simple geometrical forms such as rectangles to find the centre of gravity of each. Then both the horizontal and vertical distance from the centre of gravity of each geometric shape from the tie bar are computed. Next the area of each geometric form is calculated and multiplied by the injection pressure.

The next step is to use the sum of the moment's method to calculate how the force of each section of projected area is applied to each of the four tie bars. The calculation is simplified by dividing in to several parts. The first part is to calculate the load on the left side of the machine. (I.e. tie bars A and C as shown in figure

Using the formula: (Fig 6)

Load 1 on A + C = $F1\,x\,\frac{X1}{D}$

Where: F1= Force generate by projected area of section 1 (F1=180 Tones ,i.e. 0.3T/cm^2)

X1= Distance from centre of gravity of section1 to the centre line of B and D tie bars. (d1=575mm)

D1= Distance between tie bars, D =1000mm

Therefore load 1 on A + C = $180 \; x \frac{575}{1000}$ = 103.5T

Then by using the same general formula, the load acting on the right side of the machine (i.e. tie bars B and D) due to the same section (section 1) is calculated.

The load 1 acting on B + D = $180 \times \frac{1000 - 575}{1000}$ = 76.5T

A check can be made for the calculations by adding the two results (i.e. 103.5+76.5 =180T). The total should be equal to the force generated by section 1 of the projected area. Next it is necessary to determine how the 103.5 is divided between tie bars A and C and tie bars B and D.

The load 1 acting on A = Load on (A + C)

Where Y1 = Vertical distance between centre of gravity of section1 to the tie bar C

Therefore load 1 on A $= 103.5x\frac{700}{1000}$ =72.45T

Similarly load 1 on c $= 103.5x\frac{1000 - 700}{1000}$ = 31.05T

Similarly the load 76.5 T on B+D is divided:

Load 1 on B $= 76.5x\frac{700}{1000}$ =53.55T

Load 1 on D $= 76.5x\frac{1000 - 700}{1000}$ =22.95T

The procedure is repeated for all section of the projected area.

Therefore load 2 on A + C $= 60x\frac{700}{1000}$ = 42T

Therefore load 2 on B + D $= 60x\frac{1000 - 700}{1000}$ = 18T

Therefore load 2 on A $= 42x\frac{400}{1000} =$ 16.8T

Therefore load 2 on C $= 42x\frac{600}{1000} =$ 25.2T

Therefore load 2 on B $= 18x\frac{400}{1000} =$ 7.2T

Therefore load 2 on D $= 18x\frac{600}{1000} =$ 10.80T

Therefore load 3 on A + C $= 52.5\; x\frac{250}{1000} =$ 13.125T

Therefore load 3 on B + D

$$= 52.5\; x\frac{1000 - 250}{1000} = 39.375T$$

Therefore load 3 on A $= 13.125\; x\frac{625}{1000} =$ 8.2T

Therefore load 3 on C $= 13.125\; x\frac{1000 - 625}{1000} =$ 4.92T

Therefore load 3 on B $= 39.375\; x\frac{625}{1000} =$ 24.6T

Therefore load 3 on D $= 39.375\; x\frac{1000 - 625}{1000} =$ 14.76T

Lastly, the loads are added for each tie bar. Then find out which tie bar has the maximum load acting on it. This load is multiplied by four to get the tonnage to be set on the machine. So in this case the maximum load is acting on tie bar A which is equal to 97.45 (72.45+16.8+8.2). All tie bars must be locked to 103.3875 tones before the shot is made. There for the minimum machine tonnage required is equal to 389.8tones. The die may be loaded on a 400T machine.

Tie bar loading for off-centre conditions (The injection pressure is assumed to be 0.3T/cm^2						
Geometric Form			Tie bar load in Tones			
Section	Area mm^2	Force Tones	A	B	C	D
1	60000	180	72.45	53.55	31.05	22.95
2	30000	60	16.8	7.2	25.2	10.8
3	18000	52.5	8.2	24.6	4.92	14.76
Total		292.5	97.45	85.35	61.17	48.51

3 Die casting defects and remedies:

Casting defect	Cause/sate	Countermeasure
Cast hole	A blow hole generated by entry of air or gas in molten metal or a shrinkage generated due to a short supply of molten metal	Adjust the casting pressure, change the vent hole, and adjust the amount of mold release agent to be applied, or change the position and size of the gate.
Shrinkage	Depression following slow cooling due to a partially overheated mold	Adjust the mold temperature or redesign the mold.
Insufficient filling (poor run of molten metal)	The area near the gate cools down too quickly to fill the entire cavity with molten metal.	Change the mold temperature, adjust the molten metal temperature, or change the position and size of the gate.
Cold shut (weld mark)	A low mold temperature and a low pouring pressure cause molten metal to solidify before preading entirely in a pair of molds, generating a mark at the joining pointof.	Raise the mold temperature, the molten metal temperature, and the plunger speed or change the position and size the gate.
Crack/distortion	An insufficient draft angle, an uneven shrink, or an improper extrusion (hot cracking during solidification and cold cracking in cooling processes and over time)	Redesign the shape or change the extrusion position.
Broken chill layer	A solidification layer generated in the sleeve enters the cavity and is then contained in the die-casting.	Adjust the molten metal temperature and the plunger speed.
Flow mark	A low mold temperature or too much mold release agent.	Raise the mold temperature and reduce the amount of mold release agent.
Scuffing	Die-casting adhered to a mold when being ejected or an improper draft angle	Sufficiently polish the mold surface and provide an appropriate draft angle.
Seizure	A partially overheated mold causes adhesion with the molten metal.	Change the type or application method of mold release agent or redesign the mold.
Blister	Compressed gas near the surface expands and causes swelling on the surface.	Take the same countermeasures as for cast holes and extend the mold cooling time.
Discoloration	The die-cast surface is discolored by one or more mold release agent components.	Change the agent.
Rough surface	A rough mold surface is transferred directly to the die-cast surface.	Clean and polish the mold.
Hard spot	A hard foreign particle enters into the molten metal causing, for example, grinding tool breakage in later processes.	Filter the molten metal.

3 Die casting estimation;

Various Technical terms used in Dies & Moulds Economics

1 **Direct labour:** The workers who are actually processing the materials form the direct or productive labour.

2 **Indirect labour:** The workers who are not actually processing the materials form the indirect or non-productive labour.

3 **Direct labour cost:** It is the wages paid to the direct labour.

4 **Indirect labour cost:** it is the wages paid to the indirect labour.

5 **Direct material cost:** It is the cost of those materials which form the final shape of the product.

6 **Indirect material cost:** It is the cost of those materials which are consumed in order to convert the direct material to their final shape.

7 **Overhead charges:** These are business expenses not chargeable to particular part of the work. These are also known as indirect cost, on cost or burden. The term includes all expenses except direct labour, direct material and direct expenses incurred in production and distribution of the product to the consumers.

8 **Factory over heads:** These are known as expenses chargeable as indirect labour, indirect material etc.

9 **Administrative over heads:** These include salaries of office staff, high rank officials, telephone charges etc.

10 **Prime cost:** It is the sum of the direct labour, direct material and other direct expenses if any. It is also known as direct cost.

11 **Factory cost:** It is the sum of prime cost and factory over heads.

12 **Manufacturing cost:** It is the sum of the factory cost and administrative expenses.

13 **Total cost:** It is the sum of the manufacturing cost, selling and distributing expenses.

14 **Selling price:** It is the sum of the total cost and profit of the company.

15 **Man-hour rate:** It is the method of distributing factory over head over each job by overheads by number of total working hours.

16 **Machine hour rate:** It is the method distributing factory over heads over each job by total hours for which the machine runs.

Allowances: This is the time allowed to the workers during their working hours. These may be:

a) Set up time.

b) Operation time.

c) Personal allowance.

d) Fatigue allowance.

e) Tool changing allowance.

f) Tool grinding time.

g) Checking time.

17 **Fixed cost:** A cost which remains constant irrespective of the volume of out put. These costs mainly depend on the time spend and do not vary directly with the rate of out put.

18 **Variable cost:** A cost which varies directly with the quantity produced.

19 **Depreciation:** The reduction of value of a fixed asset due to use or laps of time.

20 **Price:** The cost to a buyer of any product expresses in terms of money.

21 **Break Even Point:** The point at which neither profit nor loss is made

22 **Quotation:** This is a document containing the details of rates and other terms and conditions at which the jobs are performed. It is a formal statement of the estimated cost of a job.

AIMS OF ESTIMATING

1 The main aim of estimating is to help the factory owner to decide about the manufacturing and selling policies.

2 It helps in preparing quotation.

3 It helps in deciding the expenses in advance.

4 It gives a reference for setting the price.

5 It helps in taking certain favorable decisions.

Estimating Procedure

1 Engineering department decides the requirements and specifications of the product.

2 Engineering department makes out the drawing, decides the type of material and its quantity and other requirements.

3 The planning department lays down the methods and sequence of operations, decides machines to be used and schedule the operations. Estimating department is generally attached to the planning department.

4 To decide accuracy and finish required.

5 To prepare a list of the components of the product.

6 To decide which component can be made in-house and which should be procured from outside.

7 Determine the material cost.

8 Determine the machining cost.

9 Determine the labour cost.

10 Determine the prime cost.

11 Determine the factory overheads.

12 Determine the administrative overheads.

13 Determine the packing and delivery charges.

14 Calculate the total cost.

15 Decide on the profit.

16 Fix the sale price.

17 Decide on the delivery time.

The total cost is made up of three main elements. They are:

1 Material cost

2 Labour cost.

3 Expenses (over heads).

The various components of cost are:

1 Prime cost = Direct material cost+ Direct labour cost+ Direct expenses.

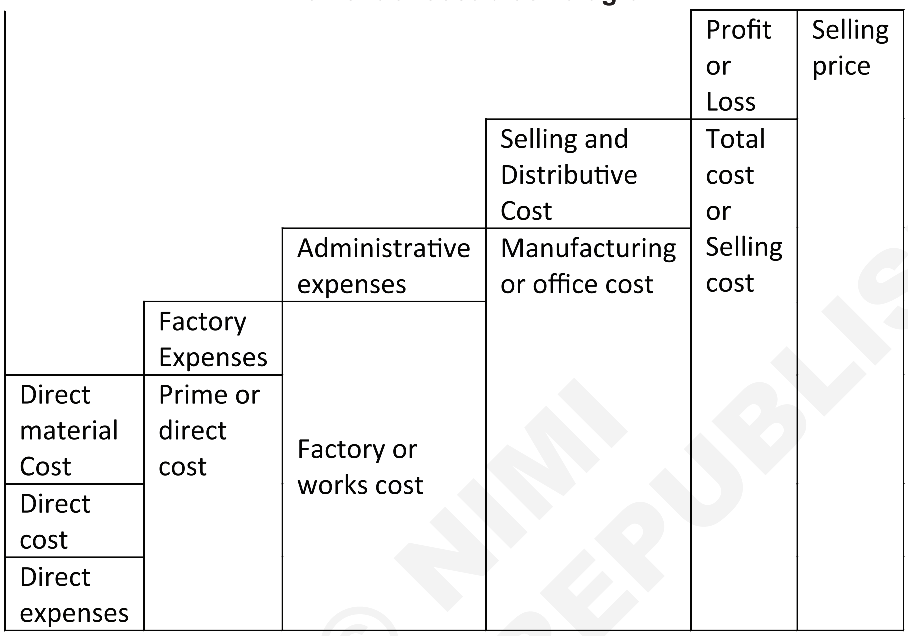
2 Factory cost = Prime cost + Factory Expenses.

3 Manufacturing cost = Factory cost+ Administrative expenses.

4 Total cost = Manufacturing cost+ Selling and Distribution cost.

5 Selling price = Total cost + Profit

Element of cost block diagram



Worked out example:

The expenditure for manufacturing a turret lathe is as given below:

Material consumed	=	Rs.55, 000.00
Indirect wages	=	Rs.8, 000.00
Consultant charges	=	Rs.3, 000.00
Advertisement	=	Rs.10, 000.00
Set profit	=	Rs.12, 500.00
Depreciation on sales department	=	Rs.1, 100.00
Printing & stationary	=	Rs.250.00
Depreciation of plant	=	Rs.4, 500.00
Direct wages	=	Rs.65, 000.00
Factory rent	=	Rs.6, 000.00
Telephone & postage charges	=	Rs.150.00
Plant electricity charges	=	Rs.500.00
Office salary	=	Rs.2, 100.00
Office rent	=	Rs.500.00
Showroom rent	=	Rs.1, 500.00
Sales man concession	=	Rs.2, 650.00
Sales deportment expenses	=	Rs.1, 500.00

Find out:

a) Direct cost

b) Factory cost

c) Office cost

d) Cost of sales

e) Selling price

Solution

a) Direct Cost

Direct cost = direct material + direct + direct expenses

= 55,000 + 65,000 = Rs.1, 20,000.

b) Factory cost

Factory cost = Direct cost + factory overheads (factory expenses)

= 1,20,000 + 8,000 + 4,000 + 6,000 + 50
= Rs.1, 39,000.

c) Office cost

Office cost = Factory cost + Admin Exp.

= 1,39,000 + 3,000 + 250 + 150 + 2,100 + 500

= Rs.1, 45,000.

d) Cost of sales (selling cost)

Selling cost = Office cost + Sales overheads (selling & distribution cost)

= 1,45,000 + 10,000 + 1,100 + 1,500 + 2,560 + 1,500

= Rs.1, 65,750.

e) Selling price

Selling price = Total cost + profit

= 1, 65,750+ 12,500

= Rs.1,74,250.

Estimate form

Description:————————

Quantity:————————

Drawing No:————————

Date :————————

Enquiry No:————————

Customer :————————-

Item	Total cost	Cost of each item
1 Material (@————————)		
Quantity (————————)		
2 Operation Labour Overhead		
(a)		
(b)		
(c)		
Total : (Factory cost)		
3 Office and administrative		
Expenses		
Total: (Manufacturing cost)		
4 Selling expenses		
(a) Packing and carriage		
(b) Advertisement and publicity		
(c) Other allied expenses		
Total : (Total cost)		
5 Profit Total: (selling price)		
Delivery date:————————		
Estimated by:————————		

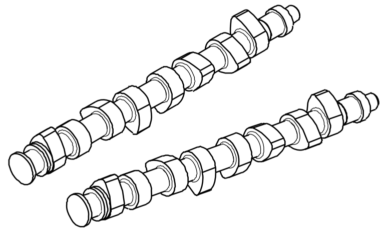
Different parts of petrol engine

Objectives: At the end of this lesson you shall be able to
- **define I.C engine.**
- **explain piston, connecting rod, spark plug & rotary gear pump.**

1 Camshaft (Fig 1)

Camshaft is a type of rotating device or apparatus used in piston engines for propelling or operating poppet valves. Camshaft comprises of series of cams that regulates the opening and closing of valves in the piston engines. The camshaft works with the help of a belt, chain and gears.

Fig 1



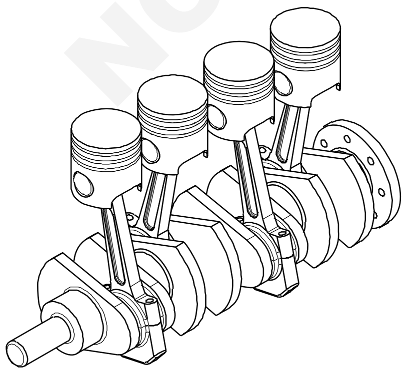
2 Crankshaft (Fig 2)

Crankshaft is a device, which converts the up and down movement of the piston into rotatory motion. This shaft is presented at the bottom of an engine and its main function is to rotate the pistons in a circular motion. Crankshaft is further connected to flywheel, clutch, and main shaft of the transmission, torque converter and belt pulley.

To convert reciprocating motion of the piston into rotary motion, the crankshaft and connecting rod combination is used. The crankshaft which is made by steel forging or casting is held on the axis around which it rotates, by the main bearings, which is fit round the main journals provided. There are always at least two such bearings, one at the rear end and another at front end. The increase in number of main bearings for a given size of the crankshaft means less possibility of vibration and distortion.

But it will also increase the difficulty of correct alignment in addition to increased production cost. The main bearings are mounted on the crankcase of the engine. The balance weight or counterweight keep the system in perfect balance.

Fig 2



The crank webs are extended and enlarged on the side of journal opposite the crank throw so as to from balance weights. The crankshaft may be made from carbon steel, nickel chrome or other alloy steel.

Connecting rod (Fig 3)

Connecting rods are made of metals, which are used, for joining a rotating wheel to a reciprocating shaft. More precisely, connecting rods also referred to as con rod are used for conjoining the piston to the crankshaft.

The load on the piston due to combustion of fuel in the combustion chamber is transmitted to crankshaft through the connecting rod. One end of connecting rod known as small end and is connected to the piston through gudgeon pin while the other end known as big end and is connected to crankshaft through crank pin.

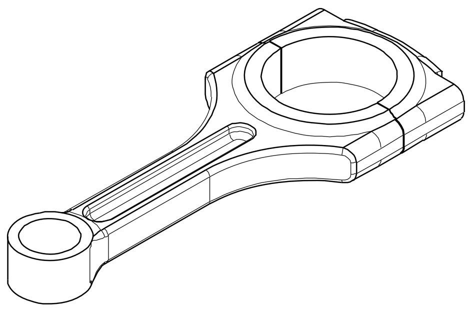
Connecting rods are usually made up of drop forged I section. In large size internal combustion engine, the connecting rods of rectangular section have been employed. In such cases, the larger dimensions are kept in the plane of rotation.

In petrol engine, the connecting rod's big end is generally split to enable its clamping around the crankshaft. Suitable diameter holes are provided to accommodate connecting rod bolts for clamping. The big end of connecting rod is clamped with crankshaft with the help of connecting rod bolt, nut and split pin or cotter pin.

Generally, plain carbon steel is used as material to manufacture connecting rod but where low weight is most important factor, aluminium alloys are most suitable. Nickel alloy steel are also used for heavy duty engine's connecting rod.

Connecting rods can be made of steel, aluminum, titanium, iron and other types of metals.

Fig 3



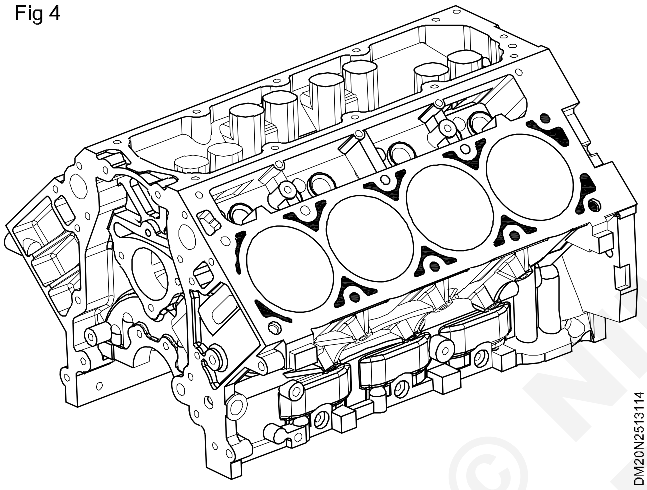
Crankcase

A crankcase is a metallic cover that holds together the crankshaft and its attachments. It is the largest cavity within an engine that protects the crankshaft, connecting rods and other components from foreign objects. Automotive crankcases are filled with air and oil, while Magnesium, Cast Iron, Aluminium and alloys are some common materials used to make crankcases.

Cylinder Heads (Fig 4)

Cylinder heads refers to a detachable plate, which is used for covering the closed end of a cylinder assembled in an automotive engine. It comprises of combustion chamber valve train and spark plugs. Different types of automobiles have different engine configurations such as Straight engine has only one cylinder head while an engine has two cylinder heads.

Fig 4



DM20N2513114

Engine Belts

Engine belts are the bands made of flexible material used for connecting or joining two rotating shafts or pulleys together. These belts work in coordination with wheels and axles for transferring energy. When the wheels or shafts are positioned at extremely different angles, then the engine belts have the ability to change the direction of a force. Engine pulley is a type of machine or a wheel having either a broad rim or groomed rim attached to a rope or chain for lifting heavy objects.

Engine Oil System

Oil is one of the necessities of an automobile engine. Oil is distributed under strong pressure to all other moving parts of an engine with the help of an oil pump. This oil pump is placed at the bottom of an engine in the oil pan and is joined by a gear to either the crankshaft or the camshaft. Near the oil pump, there is an oil pressure sensor, which sends information about the status of oil to a warning light or meter gauge.

The different parts of engine oil systems include:

- Engine Oil
- Engine Oil Cooler
- Engine Oil Filter
- Engine Oil Gaskets
- Engine Oil Pan
- Engine Oil Pipe

Engine Valve

Automobile engine valves are devices that regulate the flow of air and fuel mixture into the cylinder and assist in expelling exhaust gases after fuel combustion. They are indispensable to the system of coordinated opening and closing of valves, known as valve train. Engine valves are made from varied materials such as Structural Ceramics, Steels, Super alloys and Titanium alloys. Valve materials are selected based on the temperatures and pressures the valves are to endure.

The primary components of engine valve are:

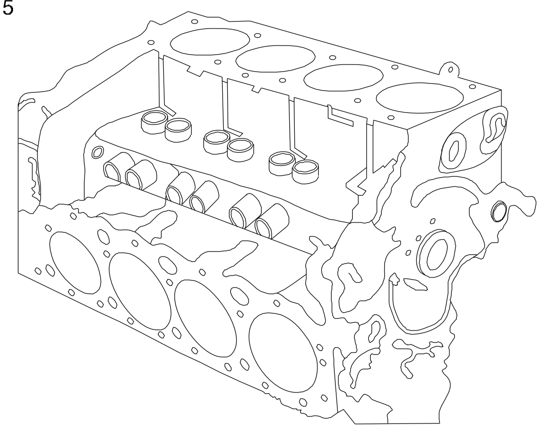
- Inlet Valve
- Exhaust Valve
- Combination Valve
- Check Valve
- EGR Valve
- Thermostat Valve
- Overhead Valve
- Valve Guide
- Schrader Valve
- Vacuum Delay Parts

Inlet Valve & Exhaust Valve-

Function-Inlet valve allow the fresh charge of air-fuel mixture to enter the cylinder bore. Exhaust valve permits the burnt gases to escape from the cylinder bore at proper timing.

Engine Block (Fig 5)

Fig 5



ENGINE BLOCK

DM20N2513115

An engine block is a metal casting that serves as a basic structure on which other engine parts are installed. A typical block contains bores for pistons, pumps or other devices to be attached to it. Even engines are sometimes classified as small-block or big-block based on the distance between cylinder bores of engine blocks. Engine blocks are made from different materials including Aluminium alloys, grey cast iron, ferrous alloys, white iron, grey iron, ductile iron, malleable iron, etc.

Engine Pulley

An engine pulley is a wheel with a groove around its circumference, upon which engine belts run and transmit mechanical power, torque and speed across different shafts of an engine. An engine houses pulley units of different sizes for cam shaft drive, accessory drive and timing belts. Moulded plastics, iron and steel are normally used to make engine pulleys.

Engine Brackets

An engine bracket is a metallic part used to join an engine mount to the power unit or the body of a vehicle. These auto parts are installed between a vehicle's body and power unit to dampen the vibrations generated by the engine, thus preventing a vehicle's body from shaking due to the vibrations. Engine brackets are made from Ductile Iron Cast, Aluminium, Polypropylene, Fiberglass and alloys.

Engine Mounting Bolts

Automotive mounting bolts secure different automobile components viz. air bags, brake fittings, etc. on to a supporting structure. Likewise, engine mounting bolts help secure an automobile's engine in place. Based on usage, a number of materials such as alloys, silicon bronze, bronze, ceramic, carbon, aluminium, nylon, phosphor bronze, nickel silver, plastic, titanium, zirconium and stainless steel are utilized to produce these bolts.

Piston

Piston is a cylindrical plug which is used for moving up and down the cylinder according to the position of the crankshaft in its rotation. Piston has multiple uses and functions. In the case of four-stroke engine the piston is pulled or pushed with the help of crankshaft while in the case of compression stroke, piston is pushed with the powerful explosion of mixture of air and fuel.

Piston comprises of several components namely:

a Piston Pins

b Piston Floor Mat

c Piston Rings

d Piston Valve

Piston rings

Piston rings provide a sliding seal between the outer edge of the piston and the inner edge of the cylinder. The rings serve two purposes:

- They prevent the fuel/air mixture and exhaust in the combustion chamber from leaking into the sump during compression and combustion.
- They keep oil in the sump from leaking into the combustion area, where it would be burned and lost.

Push Rods

Push rods are thin metallic tubes with rounded ends that move through the holes within a cylinder block and head, to actuate the rocker arms. Pushrods are found in valve-in-head type engines and are essential for the motion of engine valves. Some commonly used materials for manufacturing pushrods are Titanium, Aluminium, Chrome Moly and Tempered Chrome Moly.

Valve train

Valve train consists of various components and parts, which enables valves to operate and function smoothly. Valve train comprises of three main components: camshafts, several components which are used for turning the camshaft's rotating movement into reciprocating movement, and lastly valves and its various parts.

The primary components of valve train are:

a Tappet

b Rocker Arms

c Valve Timing System

Governor

It controls the speed of engine at a different load by regulating fuel supply in diesel engine. In petrol engine, supplying the mixture of air-petrol and controlling the speed at various load condition.

Carburettor

It converts petrol in fine spray and mixes with air in proper ratio as per requirement of the engine.

Fuel Pump

This device supplies the petrol to the carburettor sucking from the fuel tank.

Spark Plug

This device is used in petrol engine only and ignite the charge of fuel for combustion.

Fuel Injector

This device is used in diesel engine only and delivers fuel in fine spray under pressure.

Gudgeon Pin

Connects the piston with small end of connecting rod.

This pin connects the piston with small end of the connecting rod, and also known as piston pin. It is made up of case hardened steel and accurately ground to the required diameters. Gudgeon pins are made hollow to reduce its weight, resulting low inertia effect of reciprocating parts.

This pin is also known as "Fully Floating" as this is free to turn or oscillate both in the piston bosses as well as the small end of the connecting rod. There are very less chances of seizure in this case but the end movement of the pin must be restricted to score the cylinder walls. This can be achieved by using any one of the following three methods,

A One spring circlip at each end is fitted into the groove in the piston bosses.

B On spring circlip is provided in the middle.

C Bronze or Aluminium pads are fitted at both ends of the pin, which prevents the cylinder walls from being damaged.

The gudgeon pin may also be semi-floating type, in which either the pin is free to turn or oscillate in the small end bearing but secured in the piston bosses or it may secured in the small end bearing and allowed a free oscillating movement in the piston bosses. This method provides more bearing area at the bosses and hence no need for providing bushes therein, is preferred.

Crank Pin

Hand over the power and motion to the crankshaft which come from piston through connecting rod.

Sump

The sump surrounds the crankshaft. It contains some amount of oil, which collects in the bottom of the sump (the oil pan).

Distributor

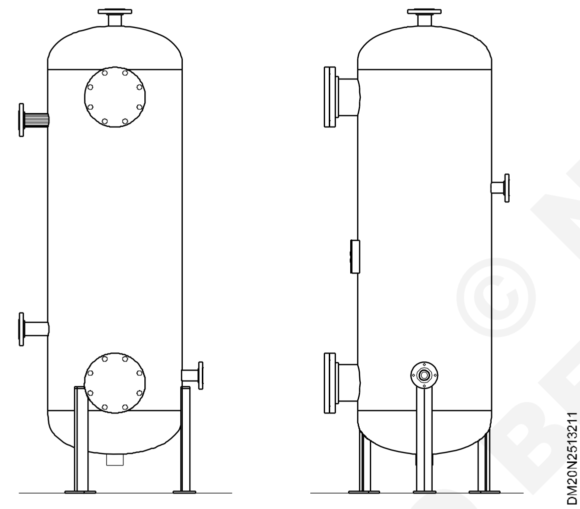
It operates the ignition coil making it spark at exactly the right moment. It also distributes the spark to the right cylinder and at the right time. If the timing is off by a fraction then the engine won't run properly.

Design manufacture and operation of pressure vessels

Objectives: At the end of this lesson you shall be able to
- **explain pressure vessels and its uses**
- **state design criteria - loads - materials and allowable stress**
- **state design formulas**
- **explain operation of pressure vessels.**

The term 'pressure vessel' conceptually represents all kinds of systems having the purpose of continuing a high amount of liquid or gas under a defined area with constant pressure. Pressure vessels can be utilized for varying purposes in many different industries, therefore they represent an essential element having a very crucial role in entire process systems. By the aim and inherent of pressure vessels, their manufacturing and operation processes may be vitally hazardous, hence it is highly significant to keep under control the process by stringent regulations.

Fig 1



Introduction to Pressure Vessels

Pressure vessels are enclosed containers used to store or transfer liquids and gasses under a pressure different from their surrounding environment. When the working principle is considered, it appears that these leak-proof tanks should be offering a wide range of improved mechanical and chemical properties to accord application conditions and generated stress inside. Requirements arising from the application indicate that vessels can be defined as a product of advanced engineering work including a well-designed production process and proper material selection.

Shapes of Pressure Vessels

As it has mentioned before, pressure vessels can be utilized in many fields, therefore it is possible to design tanks having different sizes and geometry in light of the needs of the application. Theoretically, pressure vessels can be produced in any shape however the most commonly utilized tanks are in the shape of cylinders, spheres, and cones. A typical design is a cylinder with two heads (end caps) which are generally torispherical or hemispherical. More complex shapes are usually more difficult to produce and less safe to use. Besides complexity, there are other constraints in the shape design of a pressure vessel. To illustrate. theoretically spherical vessels tend to carry higher stress than a cylindrical one having identical wall thickness therefore, spherical ones are considered more effective in holding internal loading. However, producing a spherical vessel is much more challenging and expensive than producing cylindrical vessel having two elliptical end cups is a successful example of overcoming such a dilemma

Types of Pressure Vessels

Despite that a basic pressure vessel is designed to store a liquid or gas under constant pressure, they can also be utilized for varying purposes. It is possible to define pressure tanks in five groups due to their utilization purpose.

Storage Vessels: Storage is the most common purpose of using pressure vessels, storage vessels are produced to store and limit particular products that may react with surrounding as petroleum products, chemicals, or sometimes even air and water.

Heat Exchangers: Heat may be a waste product that needs to be removed from the environment or, a requirement for a chemical process to be initiated. Heat exchangers allow us to remove or store heat depending on the need of the process.

Process Vessels: Process vessels are containers in which processes or reactions such as combining several products to create another or removing aspects from an existing product takes place. At the end of the process, the overall content in the vessel always changes.

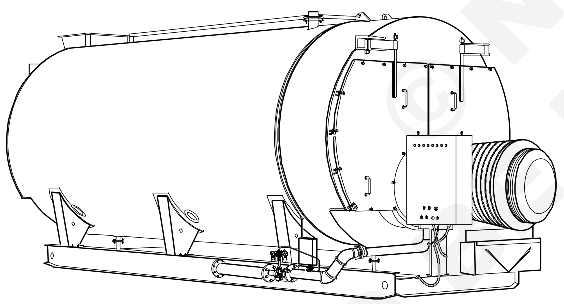
Fractional Distillation: These types of tanks are generally used to separate complex chemicals or mixtures by heating them until one component evaporates. The basis of the working principle relies on the difference between boiling points of elements within the mixture. The aim is to reach the boiling point of the compound that is aimed to be removed, and separate it by vaporizing.

Pressure Reactors: The purpose of pressure reactors is to force chemical reactions to take place, which should be above the boiling point of the solvent.

Applications of Pressure Vessels

The global pressure vessel market has recently been occupied by the three main industries as chemical and petrochemical, oil and gas, and energy generation. Moreover, the food industry. mining, water treatment, pharmaceuticals, submarine, and space ship habitats can also be included in the market as other shareholder industries. Here the food industry appears as a remarkable application since the material which pressure vessels are made of is in direct contact with food. Besides the fact that producing a pressure vessel is challenging by itself. when food contact is present, vessels also require specific surface treatments as electropolishing or mechanical polishing, which leads to the process last much longer. The requirement for pressure vessels in the food industry arises from the need for mixing. processing, storing, cooking, and refrigerating the foods and beverages in the most possible healthy manner. For this purpose, storage, process, and mixing tanks are being widely used in the entire industry. As an illustration, dairy equipment is being widely utilized for both producing and storing, and even pasteurizing milk. Industrial diversity refers to the versatility and improvability of pressure vessels. This means, by using the proper materials during construction, it is possible to store both foods like chocolate, milk, coke, and chemicals and oils like ammonia, chlorine, and LPG in pressure tanks. In other sectors, they may also appear as industrial compressed air receivers and domestic hot water storage tanks.

Fig 2



Design Constraints

As it has mentioned before, pressure vessels may constitute dangerous, even fatal accidents during production and application inherently, therefore their design and production processes should be well-designed by considering some regulations. Rules for the construction of pressure vessels have been established by The American Society of Mechanical Engineers (ASME), Regulations include materials, assembly, and safety details to ensure the production process satisfies industrial needs without causing any detrimental situation. It is possible to investigate the design requirements of a pressure vessel in three subjects.

1 **Operational Requirements:** The first stage of pressure vessel design is to identify operational requirements which represent application conditions.

Operating Pressure: Steady-state pressure and maximum pressure within a vessel should be defined.

Fluid Conditions: Since temperature change and physical and chemical properties of the fluid can influence the base material of the vessel, they should be specified in detail, and material selection should be carried on by considering these specifications.

External Loads: Besides internal loading, external loading can influence the performance of the vessel. Therefore, local loads as piping reactions and dead weights of parts that are supported by the tank, and for the cases that vessel is utilized out- door, environmental factors as rain, snow and wind should be identified.

Transient Conditions: Some vessels may be exposed to cyclic loads resulting from operating pressure, temperature, structural and acoustic vibration loading.

2 **Functional Requirements:** Functional requirements includes geometrical parameters which some of them are defined by the plant design team while, some are left to the discretion of the pressure vessel designer. The functional requirements are listed as below:

- Size and shape of the vessel
- Support design
- Location and size of attachment and nozzles

3 **Material Requirements:** Material selection may be defined as the most challenging and risky stage of pressure vessel design. Some international standards define acceptable materials with acceptable temperature and design stress. Design stress for each possible material is set by using some safety factors as:

- Yield strength at design temperature
- Ultimate tensile strength at room temperature
- Creep strength at design temperature

After defining the three properties given above, the most proper materials are determined by also considering some other important mechanical properties as ductility, toughness. embrittlement under operating conditions, and fatigue strength. Steels, especially stainless and low carbon steel are the most generally used materials, although other metal alloys as titanium alloys, nickel alloys, and Hastelloy can also be useful depending on operational requirements.

Manufacturing and Testing

Manufacture process initiates with the determination of design constructions. After the material selection has been completed, proper raw materials are supplied whether in form of plates, wires, rods, or pipes. Later on, they are cut and machined if required. Here, the most crucial point is to obtain a surface properly for welding thereby, all the precautions should be taken to avoid mechanical compromise. Machined parts are then assembled by welding in the required geometry. Depending on the material type and thickness at the weld point, some heat treatment procedures as preheating, and post-weld heating may be required. At each step, products should be inspected by the authority. During construction, some non-destructive test methods are applied to check whether the test piece satisfies the standards or not. For detecting weld surface flaws, magnetic particle or dye penetrant methods are utilized, so that discontinuities on the surface, or near the surface can be identified. X-ray inspection may be an alternative to detect subsurface cracks, however since it is a highly expensive method, it is not commonly preferred unless a very critical weld point is not present. Ultrasonic inspection is a more common and relatively easy way to detect both surface and subsurface defects.

Standards

Pressure vessels are designed to be operated under specific pressure and temperature. Since they hold high amounts of fluids under high pressure and temperatures, their operation and production may lead to the occurrence of significant hazardous situations. Therefore, the design, fabrication, and operation conditions of pressure vessels have been regulated and standardized by several international organizations. Some of the highlighted standards are listed below:

- ISO 11439: Compressed natural gas cylinders.
- AS 1210: Australian Standard for the design and construction of pressure vessels.
- BS 4994: Specification for design and construction of vessels and tanks in reinforced plastics.
- B51-09: Canadian Boiler, pressure vessel, and pressure piping code,
- ASME Boiler and Pressure Vessel Code Section VIII: Rules for construction of pressure vessels.
- EN 13445: The current European standard, harmonized with the pressure equipment directive.

Proper measurement practice in workshop

Objectives: At the end of this exercise you shall be able to
- **state different types of measuring instruments and their applications in work shop**
- **state different types of gauge and its applications.**

Measuring instruments

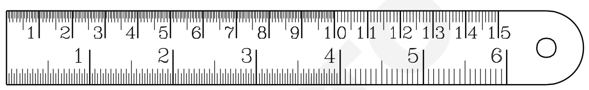
Measuring instruments have an important role in a mechanical workshop. The quality of work is based on the accuracy and precision of the instruments used for inspection. There are different types of measuring instruments are used in a workshop; some of them are given below.

1 Steel rule
2 Calipers
3 Vernier caliper
4 Micrometer
5 Vernier height gauge
6 Dial test indicator
7 Screw thread pitch gauge
8 Screw cutting gauge

Steel rule

Steel rule is a measuring instrument having a long, thin stainless steel strip with marked scale of unit division such as in centimeters or inches, used for drawing lines, measuring distances between two points, etc. These are available in different sizes, such as in 15cm, 30cm, 60cm, 1m, 1.5m, 2m, 3m, 4m, 5m & 6m. Generally least of a steel rule is 0.5mm. (Fig 1)

Fig 1



Calipers

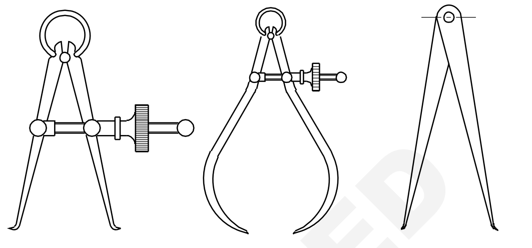
A caliper (British spelling also caliper) is a device used to measure the distance between two opposite sides of an object. An ordinary caliper may be classified as the following: (Fig 2)

1 **Outside caliper:** Used to measure outside diameter of a round shaped objects or to measure distance between two points.

2 **Inside caliper:** Used for measuring inside diameter of a pipe or to measure inside dimensions hollow sections.

3 **Jenny caliper:** It is also known as odd leg caliper or hermaphrodite caliper. It used for scribe a line at a distance from the edge of a work piece.

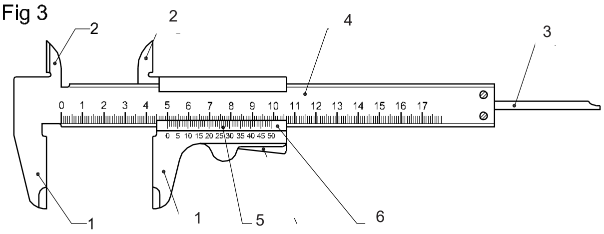
Fig 2



Vernier caliper (Fig 3&4)

The vernier caliper is a precision instrument used for measuring internal and external distances between two points extremely and accurately. It has two versions, manual and digital. The manual version has both an imperial and metric scale. The digital version requires a small battery where as the manual version does not need any power source. Vernier calipers are available in the range of 0-100mm, 0-150mm, 0-200mm, 0-300mm, 0-600mm and 0-1000mm. Accuracy of metric scale vernier caliper is 0.02mm and imperial scale vernier caliper is 0.001".

Fig 3



1 **Outside jaws :** used to measure external diameter or width of an object

2 **Inside jaws :** used to measure internal diameter of an object

3 **Depth probe :** used to measure depth of an object or a hole

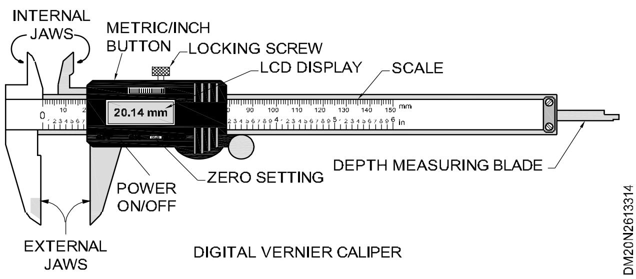
4 **Main scale :** The main scale is a graduated scale that is used to measure the overall length of an object scale marked every mm (metric scale) scale marked in inches and fractions (imperial scale)

5 **Vernier scale :** The vernier scale is a second scale that is used to measure small increments of length give interpolated measurements to 0.1 mm or better gives interpolated measurements in fractions of an inch

6 **Retainer :** used to block movable part to allow the easy transferring of a measurement

7 **Locking screw :** used to lock movable jaw with main scale. (Fig 4)

Fig 4



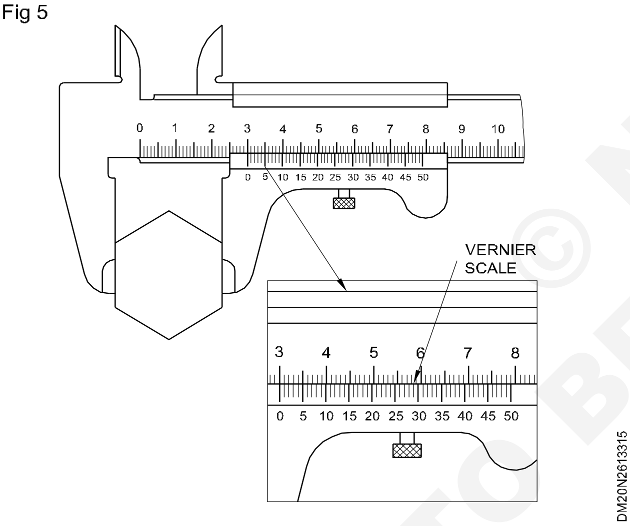
Least count (LC) : Least Count is the smallest value that can be read directly in that scale.

Least Count (L.C) = 1 Main Scale Division (MSD) - 1 Vernier Scale Division (VSD)

1 MSD	= 1mm
1VSD	= 49/50mm = 0.98mm
Therefore, **LC**	= MSD - VSD = 1-0.98mm
	= **0.02mm**

How to take measurements (Fig 5)

Fig 5



Each division on the main scale is 1mm. The metric Vernier scale is 49mm long and divided into 50 equal parts. Each division is 49/50, which is equal to 0.98mm. The difference between one division on the main scale and one division on the metric vernier scale is 1/50 or 0.02 mm which is the least Count.

Procedure

- Note the main scale reading, immediately preceding the zero line on vernier scale.
- Here, zero of the vernier scale immediately preceding 28mm.
- This (28mm) must be added with decimal reading on the vernier scale.
- Note the line on the vernier scale, which is coinciding, with a line on the main scale.
- 31[th] line coincides with a line on the main scale.

  So, the reading is 28mm plus 31 divisions of 0.02mm

  TOTAL : 28mm + 0.62 = 28.62mm

Outside micrometer (Fig 6)

A micrometer is a precision instrument used to measure a job, generally within an accuracy of 0.01 mm.

Micrometers used to take the outside measurements are known as outside micrometers.

The parts of a micrometer are listed here.

Frame

The frame is made of drop-forged steel or malleable cast iron. All other parts of the micrometer are attached to this.

Barrel/Sleeve

The barrel or sleeve is fixed to the frame. The datum line and graduations are marked on this.

Thimble

On the beveled surface of the thimble also, the graduation is marked. The spindle is attached to this.

Spindle

One end of the spindle is the measuring face. The other end is threaded and passes through a nut. The threaded mechanism allows for the forward and backward movement of the spindle.

Anvil

The anvil is one of the measuring faces which is fitted on the micrometer frame. It is made of alloy steel and finished to a perfectly flat surface.

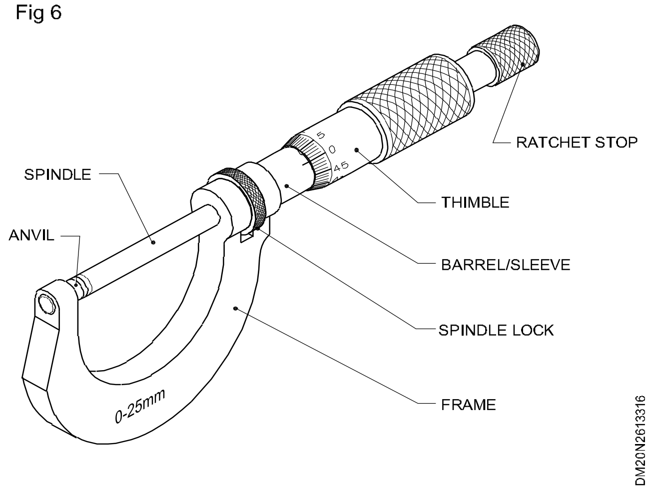
Spindle lock nut

The spindle lock nut is used to lock the spindle at a desired position.

Ratchet stop

The ratchet stop ensures a uniform pressure between the measuring surfaces.

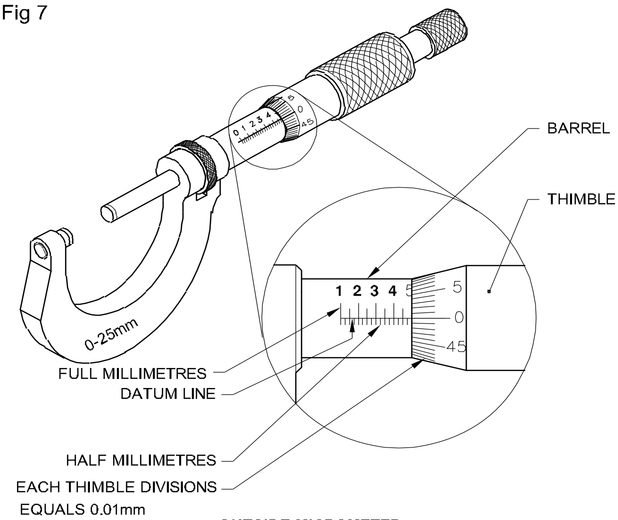
Fig 6



Working principle (Fig 7)

The micrometer works on the principle of screw and nut. The longitudinal movement of the spindle during one rotation is equal to the pitch of the screw. The movement of the spindle to the distance of the pitch or its fractions can be accurately measured on the barrel and thimble.

Fig 7



OUTSIDE MICROMETER

Graduations

In metric micrometers the pitch of the spindle thread is 0.5 mm.

Thereby, in one rotation of the thimble, the spindle advances by 0.5 mm.

On the barrel a 25 mm long datum line is marked. This line is further graduated to millimetres and half millimetres (i.e. 1 mm & 0.5 mm). The graduations are numbered as 0, 5, 10, 15, 20 & 25 mm.

The circumference of the bevel edge of the thimble is graduated into 50 divisions and marked 0-5-10-15 .... 45-50 in a clockwise direction.

The distance moved by the spindle during one rotation of the thimble is 0.5 mm.

Movement of one division of the thimble = 0.5 x 1/50

= 0.01 mm

Accuracy or least count of a metric outside micrometer is 0.01 mm.

Ranges of outside micrometer

Outside micrometers are available in ranges of 0 to 25 mm, 25 to 50 mm, 50 to 75 mm, 75 to 100 mm, 100 to 125 mm and 125 to 150 mm.

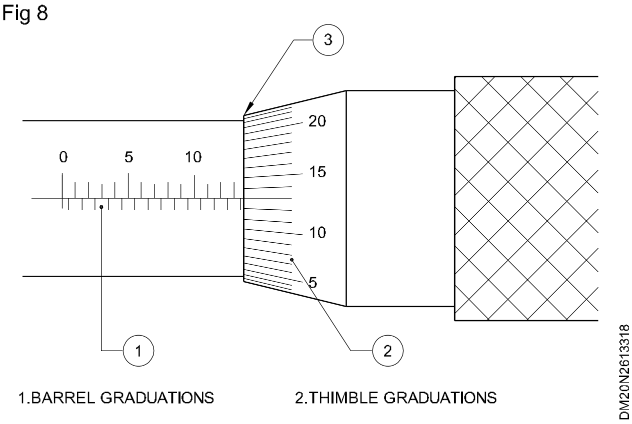
For all ranges of micrometers, the graduations marked on the barrel is only 0-25 mm.

Reading micrometer measurements (Fig 8&9)

How to read a measurement with an outside micrometer?

First note the minimum range of the outside micrometer. While measuring with a 50 to 75 mm micrometer, note it as 50 mm.

Fig 8



Then read the barrel graduations. Read the value of the visible lines on the left of the thimble edge.

13.00 mm (Main division reading on barrel)

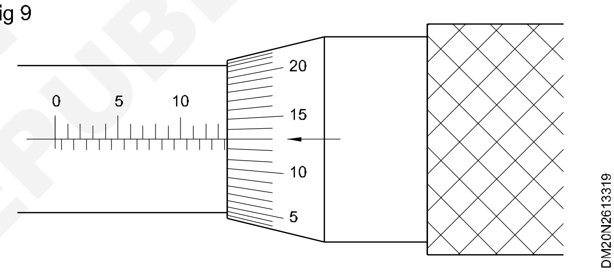
+ 00.50 mm (Sub division reading on barrel)

13.50 mm (Main division + sub - division value)

Next read the thimble graduations.

Read the thimble graduations in line with the barrel datum line, 13th div.

Fig 9



Multiply this value with 0.01 mm (least count).

13 x 0.01 mm = 0.13 mm.

Add

Minimum range	50.00 mm
Barrel reading	13.50 mm
Thimble reading	00.13 mm
Total	63.63 mm

The micrometer reading is 63.63 mm.

Vernier height gauge (Fig 10&11)

A vernier height gauge is a measuring device used either for repetitive marking of items to be worked on. The pointer is sharpened to allow it to act as a scriber and assist in marking on work pieces. Figure below shows details and working arrangement of a vernier height gauge.

Dial test indicator (Fig 12)

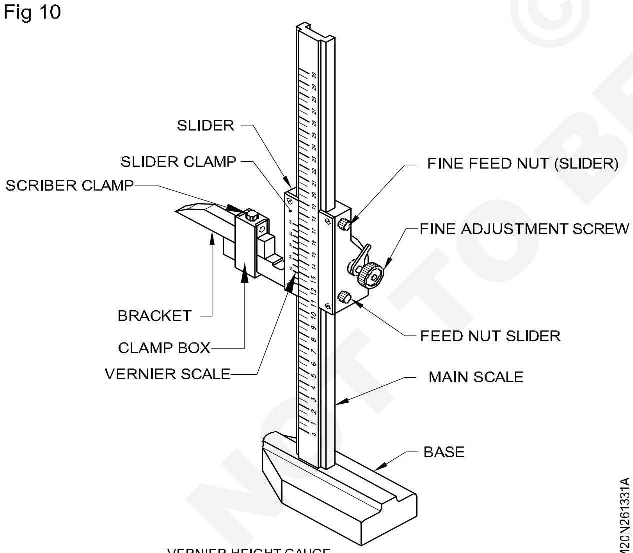
Dial test indicator have been used in the machine shop to test alignment and rotation measurement of machine parts. The dial indicator is a very precise instrument that measures distance between two parts and can be used to measure distances between two or locations. Dial test indicators typically measure ranges from 0.25mm to 300mm (0.015

inch to 12 inch). with graduations of 0.001 mm to 0.01mm (metric) or 0.00005 inch to 0.001 inch (imperial). Contact points of test indicator most often come with a standard spherical tip of 1, 2, or 3mm diameter. Many are of steel (alloy tool steel or HSS); higher - end models are of carbides (such as tungsten carbide) for greater wear resistance. Other materials are available for contact points depending on application, such as ruby (high wear resistance) or Teflon or PVC (to avoid scratching the work piece). These are more expensive and are not always available, but they are extremely useful in applications that demand them. Figure gives and idea about the dial test indicator gauges.

Various ranges of micrometers available

Metric Micrometer (mm)		Imperial Micrometer (mm)	
0-25mm	250-275mm	0-1”	10”-11”
25-50mm	275-300mm	1”-2”	11”-12”
50-75mm	300-325mm	2”-3”	12”-13”
75-100mm	325-350mm	3”-4”	13”-14”
100-125mm	350-375mm	4”-5”	14”-15”
125-150mm	375-400mm	5”-6”	15”-16”
150-175mm	400-425mm	6”-7”	16”-17”
175-200mm	425-450mm	7”-8”	17”-18”
200-225mm	450-475mm	8”-9”	18”-19”
225-250mm	475-500mm	9”-10”	19”-20”

Fig 10

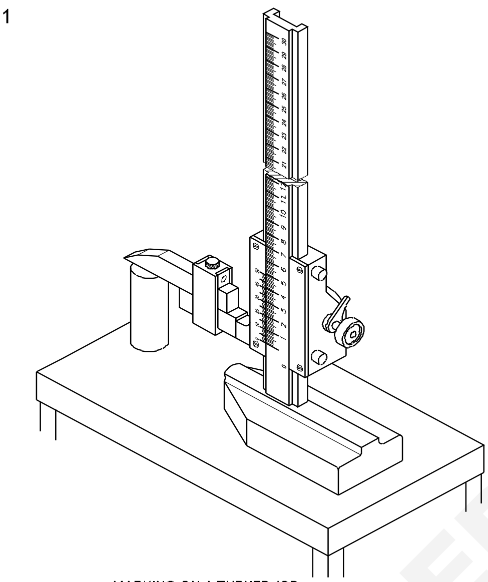


VERNIER HEIGHT GAUGE

Screw thread pitch gauge (Fig 13)

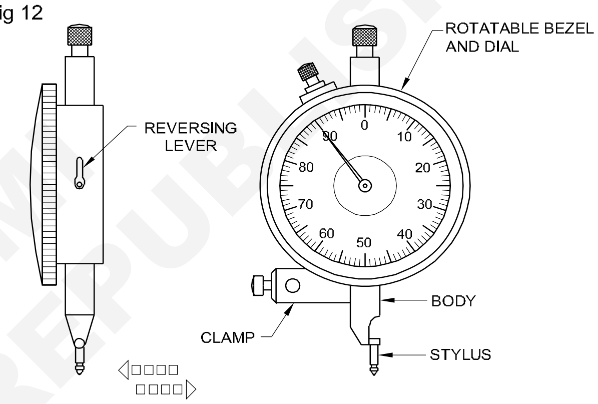
A screw thread pitch gauge is used to check or find the pitch of a thread. It is a series of thin marked blades which have different pitched teeth. Thread pitch gauges also come in the standard thread forms of metric, Whitworth, etc. which allows both the pitch of the thread to be gauged and the form or shape of the thread, to be checked. Each set of screw pitch gauge has the thread form stamped on it.

Fig 11



MARKING ON A TURNED JOB

Fig 12



How to measure pitch of the thread with screw pitch gauge? (Fig 14&15)

First, measure the approximate pitch of the thread with a steel rule. To be this for metric threads:

Put the steel rule on the thread parallel to the thread axis.

Line up a major division on the rule with top or crest of the thread.

Count the number of crests to another major division, usually 20 - 30mm.

Divide the length between the major divisions by the number of crest counted.

The answer is the pitch of the thread.

Then choose the pitch gauge closest to this pitch for the first try.

For imperial threads, the method is similar, except that the pitch is given as threads per inch (TPI) and the numbers of crests in one inch are counted (TPI = 25.4/P).

Example : If the major diameter is 10mm and pitch of the thread (P) is 1.25mm, then the thread is M10x1.25.

Fig 13

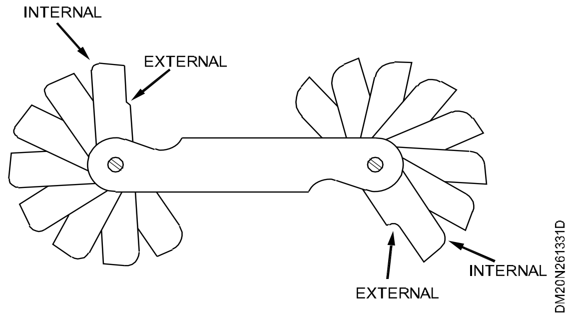
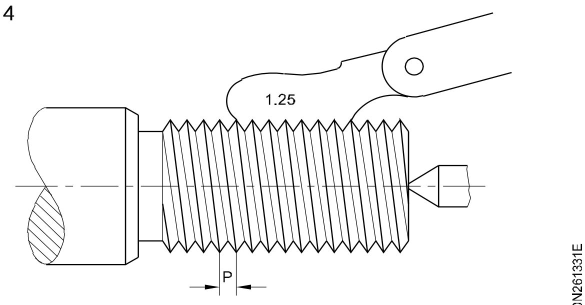


Fig 14



CHECKING THE PITCH OF THREAD

Fig 15

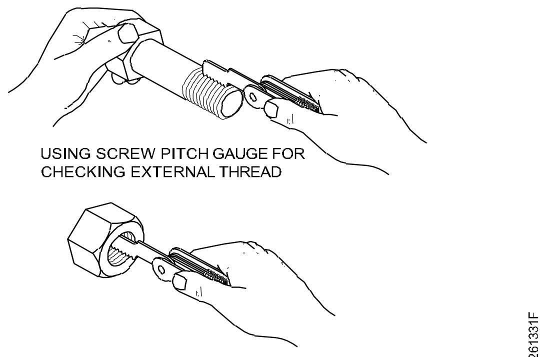
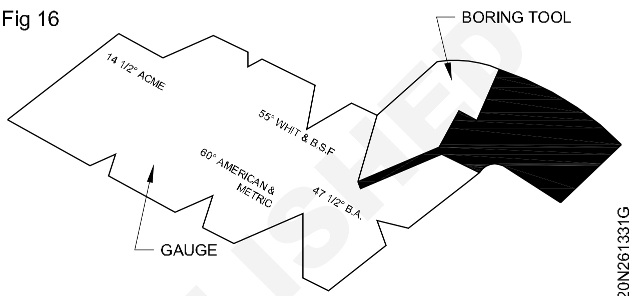


Fig 16



SCREW CUTTING GAUGE

Screw cutting gauge (Fig 16)

Screw cutting gauge in an important tool used in a machine shop, made from hardened and polished stainless steel. It is also known as Centre gauge or Fish tail gauge. It is used for checking tool angles while machining threads in metal turning lathes. Metric, BSW, BSF, BA, American National and Acme thread angles are clearly etched on the V slots in the gauge as shown in figure.

Function of gauges

Objectives: At the end of this lesson you shall be able to
- **explain the main function of gauges**
- **explain the principle of go and no gauges.**

Main function of gauges: Components manufactured using mass production methods are checked only to ensure that the sizes are within the prescribed limits. The most economical method of checking such components is by using limit gauges. These gauges are used in inspection because they provide a quick means of checking.

Gauges are tools which are used for checking the size shape and relative positions of various parts but not provided with gradated adjustable members. Gauges are there fore understood to be single size fixed type measuring tools.

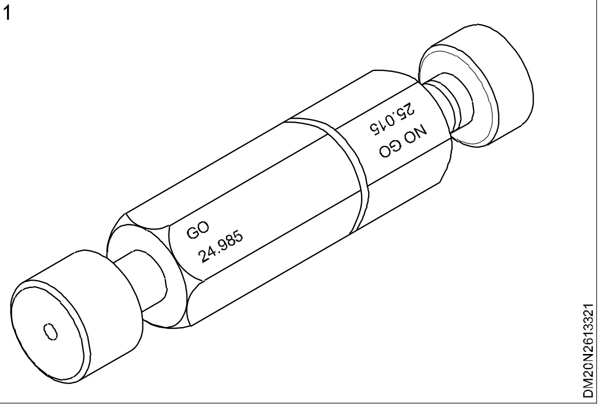
Principle of Go and No-Go gauges (Fig 1)

The Go and No-Go principle of gauging is that the Go-end of the gauge must go into the feature of the component being checked and the No-Go end must not go into the same feature. The dimensions of the Go and No-Go ends of gauges are determined from the limits stated on the dimension of the component to be gauged. The dimension of the Go-end is equal to the minimum permissible dimension and that of the No-Go end is equal to the maximum permissible dimension.

BIS covers the requirements for Go and No-Go gauging members for plain plug gauges for the required size.

The material for plain gauges prescribed in IS 7018 (Part 1) 1983.

Fig 1



Types of gauges and their essential features

Objectives: At the end of this lesson you shall be able to
- **state different types of gauges and explain them**
- **explain the essential features of gauges**

Depending on the elements to be checked, gauges are also classified into:

1 gauges for checking holes;

2 gauges for checking shafts;

3 gauges for checking tapers;

4 gauges for checking threads;

5 gauges for checking forms;

The following gauges represent those most commonly used in production work. The classification is principally according to the shape or purpose for which each is used.

1 Plug
2 Ring
3 Snap
4 Thread
5 Form
 a Template
 b Screw pitch
 c Radius and fillet
6 Thickness
 a Precision gauges blocks
 b Feeler
 c Plate
 d Wire, etc
7 Indicating
8 Air-operated

Gauge materials: High carbon and alloy steels have been the principal materials used for many years. Objections to steel gauges are that they are subjected to some distortion because of the heat-treating operation and that their surface hardness is limited. These objections are largely overcome by the use of chrome plating or cemented carbides as the surface material. Some gauges are made entirely of cemented carbides or they have cemented carbide inserts at certain wear points.

Plug gauges

Plug gauges are used for checking holes of many different shapes and sizes. There are plug gauges for straight cylindrical holes, tapered, threaded square and splined holes.

Fig 1 shows a standard plug gauge used to test the nominal size of a cylindrical hole.

Fig 1

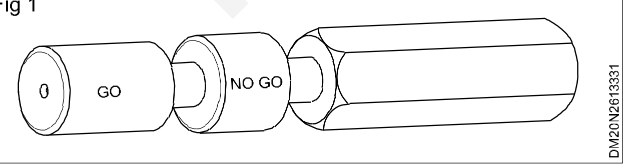
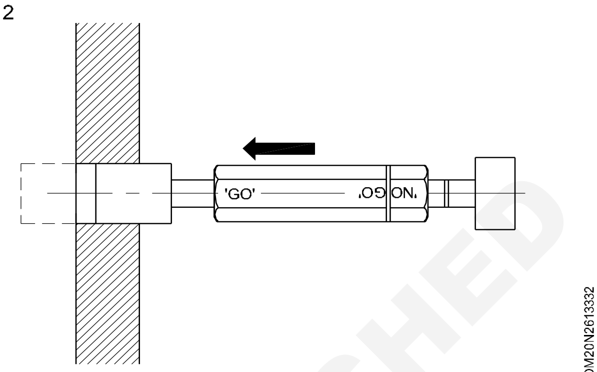


Fig 2 shows a double ended limit plug gauge used to test the limits of size. At one end it has a plug of minimum limit size, the "go" end; and at the other end a plug of maximum limit, the "no go" end. These ends are detachable from the handle so that they may be renewed separately when worn. In a progressive limit plug gauge (Fig 3) the "go" and "no go" sections of the gauge are on the same end of the handle.

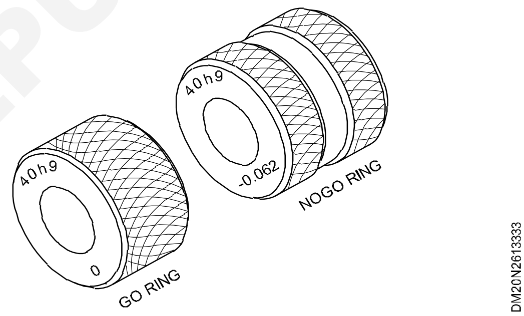
Fig 2



Plain ring gauges (Fig 3)

These are used to check the outside diameter of the work pieces. Separate gauges are used for checking Go and No-Go sizes. The No-Go gauge is identified by an annular groove, cut on the knurled surface.

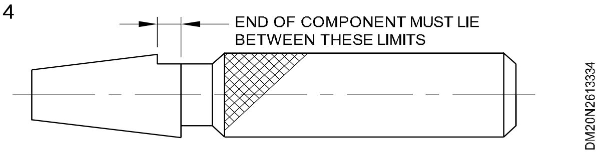
Fig 3



Taper plug gauges (Fig 4)

These gauges are made with standard or special tapers and are used to check the size of the hole and the accuracy of the taper. The gauge must slide into the hole for a prescribed depth and fit perfectly. An incorrect taper is evidenced by a wobble between the plug and the hole.

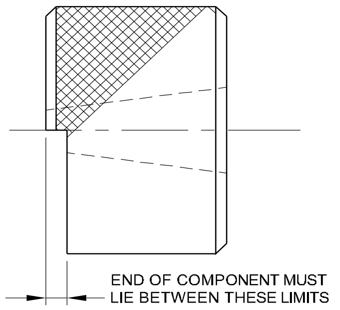
Fig 4



Taper ring gauges (Fig 5)

These gauges are used to check both the accuracy and the outside diameter of a taper. Ring gauges often have scribed lines or a step ground on the small end to indicate the 'Go' and 'No-Go' dimensions.

Fig 5



Essential features: These gauges are easy to handle and are accurately finished. They are generally finished to one tenth of the tolerance they are designed to control. For example, if the tolerance to be maintained is at 0.02mm, then the gauge must be finished to with in 0.002 mm, of the required size.

These gauges must be resistant to wear, corrosion and expansion due to temperature. The plugs of the gauges are ground and lapped.

The Go-end is made longer than the 'No-Go' end for easy identification. Sometimes a groove is cut on the handle near the 'No-Go' end to distinguish it from the 'Go' end.

The dimensions of these gauges are usually stamped on them.

IS 9529-1980 has provided specification for taper plug gauges and taper ring gauges.

IS 2251-1986 has provided specification for plug and ring gauges for self holding tapers.

Snap gauges

Snap gauges are used for checking external dimensions. Shafts are mainly checked by snap gauges. They may be solid and progressive or adjustable or double ended. The most usual types illustrated are as follows:

1 Solid or non-adjustable caliper or snap gauge with "go" and "no go" ends is used for large size.

2 Adjustable caliper or snap gauge (Fig 6) is used for larger sizes. This is made with two fixed anvils and two adjustable anvils, one for the "go" and the other for the "no go". The housing of these gauges has two recesses to receive the measuring anvils secured with two screws. The anvils are set for a specified size within an available range of adjustment of 3 to 8mm. The adjustable gauges can be used for measuring series of shafts of different size provided the diameters are within the available range of the gauge.

3 Double ended solid snap with "go" and "no go" ends is used for smaller sizes.(Fig 7)

IS 8023:1991 provides informations about single ended progressive type plate snap gauges.

IS study material regarding snap gauges gives complete data for preparation of moving drawing. While making working drawing these informations should be applied.

IS 7606-1982 gives specification for plain adjustable snap gauges. This study material of IS gives complete parts and function of each part. These information incorporated in this study material should be applied in preparation of working drawing.

Fig 6

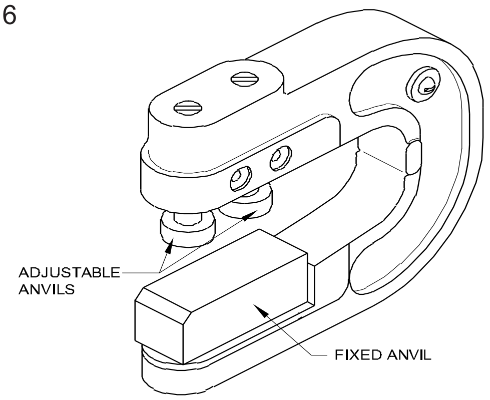
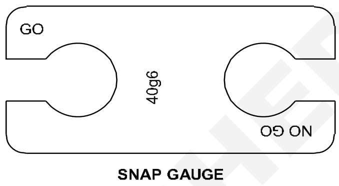


Fig 7



Thread gauges

Threads (pitch diameter of threads) are checked with thread gauges. For checking internal threads (nuts, bushes, etc.) plug thread gauges are used, while for checking external threads (screws, bolts) ring thread gauges or snap gauges are used. Single-piece thread gauges serve for measuring small diameters. For large diameters the gauges are made with removable plugs machined with a tang. Standard gauges are made single-piece.

Feeler gauges

Feeler gauges are used for checking clearance between mating surfaces. They are made in the form of a set of steel, precision-machined blade 0.03 to 1.0mm thick and 100mm long. The blades are pivoted in a holder. Each blade has an indication of its thickness.

Principles of good measurement

The basic principle for correct measurements is to ensure that all those involved in manufacturing are skilled in measuring, and that the measuring instruments are Correctly managed and cured.

These basics make up an initiative known as Measurement control which i a core concept of quality control.

Right measurement

A good instrument will produce consistent scores. An instrument's reliability is estimated using a correlation coefficient of one type or another.

Right tools

The choice of instrument can directly impact the accuracy, reliability and validity of the results. Inaccurate measurements can lead to incorrect conclusions. Accuracy refers to how close a measurement is to the true or acceptable value.

Right sketching

It is widely accepted that obtaining actual measurements is a very important part of observation. This is because the goal of such measurements in to precisely draw on a sheet of paper.

Layout of machine foundations and types of machine foundations

Objectives: At the end of this lesson you shall be able to
- **define foundation plan layout**
- **describe types of foundation plans**
- **state the purpose of foundation**
- **state the use of wooden templates as wooden forms**
- **write the procedure to prepare concrete foundation.**

Foundation plan layout

Foundation plan layout is the process of marking out of the installation area for the machine tool and its foundation bolts to be erected as per foundation plan supplied by the manufacturer.

Free space may be ensured around the machine for operation and maintenance purpose as per manufacturers recommendation.

Types of machine foundation

Machine foundation design, which is also known as machinery foundation design is accomplished to protect the adjacent foundations of the structure from the vibration of the rotating or vibrating machine. There are four types of machine foundations generally used. Each of them is discussed briefly below.

1 Block Type

2 Box Type

3 Wall Type

4 Framed Type

Block Type (Fig 1A)

Block type machine foundations consist of a pedestal resting on a footing. The footing has a large mass and a small natural frequency.

Box Type (Fig 1B)

Box type machine foundation consists of a hollow concrete block. The mass of the foundation is less than the block type and the natural frequency is increased.

Wall Type (Fig 1C)

It consists of a pair of walls having a top slab. The machine rests on the top slab. it is economical for smaller projects. Wall type machine foundation is made by homogeneous material in case of both horizontal and vertical member.

Frame Type (Fig 1D)

Frame type consists of vertical columns having a horizontal frame at their tops. The machine is supported on the frame. It is economical for larger projects. In frame type machine foundation, vertical and horizontal member is made by different materials.

From the practical point of view, the following requirements should be fulfilled.

1 The groundwater table should be as low as possible and groundwater level deeper by atleast one fourth of the width of foundation below the base plane. This limits the vibration propagation, groundwater being a good conductor of vibration waves.

2 Machine foundations should be separated from adjacent building components by means of a expansion joints.

3 Any steam or hot air pipes, embedded in the foundation must be properly isolated.

4 The foundation must be protected from machine by means of acid resisting coating or suitable chemical treatment.

5 Machine foundations should be taken to a level lower than the level of the foundations of adjacent buildings

The following general requirements of machine foundations shall be satisfied and results checked prior to detailing the foundations

1 The foundation should be able to carry the super imposed loads without causing shear or crushing failure.

2 The settlements should be within the permissible limits

3 The combined centre of gravity of machine and foundation should as far as possible, be in the same vertical line as the centre of gravity of the base plane.

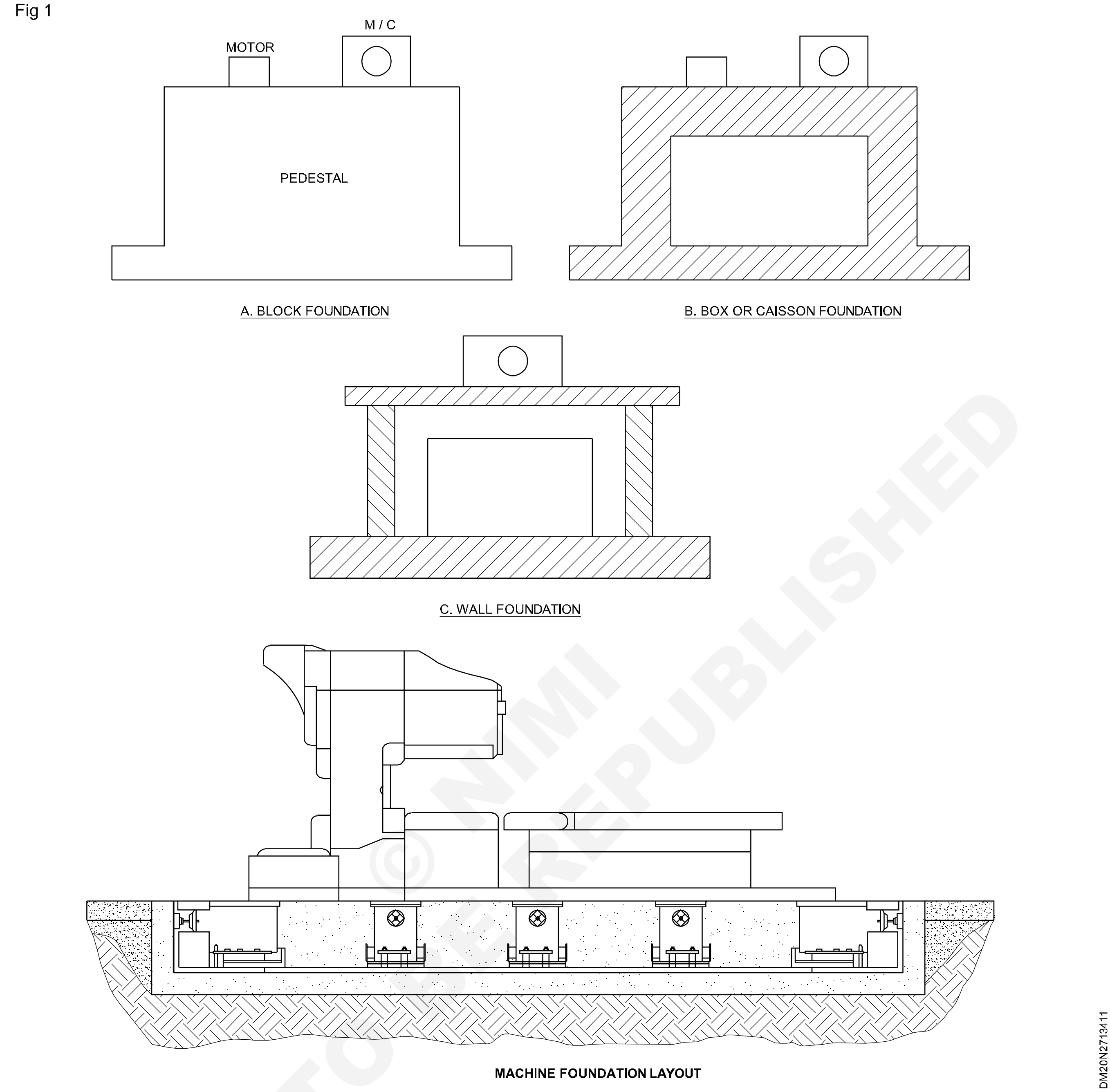
4 No resonance should occur, hence the natural frequency of the foundation soil system should be either too large or too small compared to the operating frequency of the machine. For low-speed machines the natural frequency should be high.

5 The amplitudes under service conditions should be within permissible limits which are prescribed by the machine manufacturers.

6 All rotating and reciprocating parts of a machine should be so well balanced as to minimize the unbalanced forces or moments.

7 Where possible the foundation should be planned in such a manner as to permit a subsequent alteration of natural frequency by changing base area or mass of the foundation as may subsequently be required.

Fig 1



Purpose of foundation

Machinery foundation is a built up structure designed to support the machine and to take up the static and dynamic load of the machine, besides keeping the machine in alignment.

The machine foundation must fulfil the following requirements.

It must support the machines at a given height and must be able to take up the static and dynamic loads

It should preserve the alignment of the machine

It should absorb the vibration of the moving parts

The size of the foundation will be decided by:

The type of the soil

The weight of the machine

The vibration when it is operating

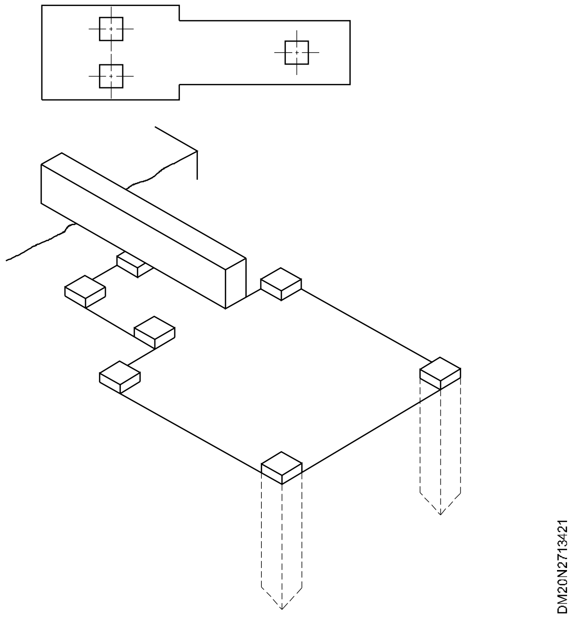
Foundation

The position of the foundation is first determined, marked off and wooden pegs are driven if it is in the soil (Fig 2)

The size of the excavation is drawn with chalk if it is on a concrete floor.

Excavating the hole should be done as neatly as possible but should the soil persist in falling into the hole it may be advisable to shore this up by the use of shuttering. The excavation should be made a few millimeters deeper than the required foundation depth. The bottom surface is well rammed prior to and after placing a layer of clean bottoming stones or broken bricks.

Fig 2



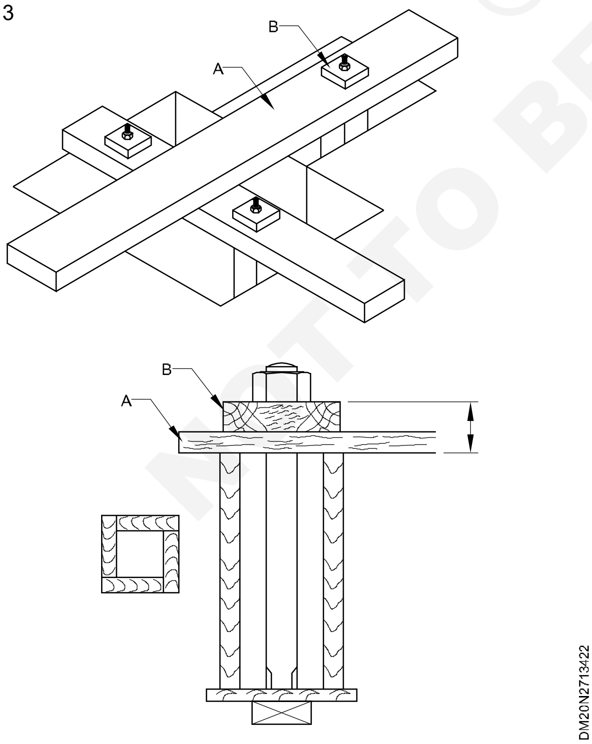
Wooden template

A wooden template is formed as shown in Fig 3 to represent the base of the machine and to support bolts over the excavation as shown. The combined thickness of the template frame A and blocks B should equal the thickness of the foot of the machine as shown. These boxes are formed of light timber and are suitably nailed for easy removal later.

Wooden forms

Wooden forms for concrete foundations are made and placed over the excavation.

Fig 3



Bracing the wooden form

After placing the wooden form in position in the excavation. it is firmly braced from the outside so as to withstand the pressure of the concrete and prevent any movement when the concrete is being poured.

Concrete

Should be prepared from clean cement on a wooden surface. Proportions for the mixture vary. A good average mixture is 1:2:4. ie 1 part cement, 2 parts sand and 4 parts stone. This is mixed thrice when dry and thrice after wetting and is immediately placed on the excavated area after a good spraying with water on the excavated area.

The foundation should be given a day at least to set before the template is removed.

Machine Foundation Design

As the structural engineer who recently designed the machine foundation for one of the largest vertical turning and milling centers in the country, in addition to over 250 other machine foundations worldwide,

When an owner selects a specific machine to meet the milling needs of their company, it is paramount to construct a foundation that properly supports the machine. Without a properly designed and built foundation, the machine will not function properly. Machine tool suppliers request the foundation to maintain deflections measured in microns, and with the cost of some foundations exceeding a million dollars, the design process needs to be carefully and precisely worked out. Utility layouts, trenches, pits, safety railings and numerous other items need to be planned for a complete foundation package. Larson & Darby Group has worked with industrial clients and machine tool suppliers worldwide for 30 years, designing foundations for large milling machines. Over that time span, we have developed a checklist to ensure the foundation design meets the needs of the owner and also meets the requirements of the machine tool supplier. The following is a partial hackliest of items for the owner, machine tool supplier and foundation designer to consider:

Ergonomics

Objectives: At the end of this lesson you shall be able to
- **state correct posture and proper grip of load**
- **explain to handle load manually according to its type**
- **state safety factors while handling load manually.**

Plant layout incorporate ergonomics and human factors to enhance worker well-being and performance

Benefits of ergonomic plant layout

An ergonomic plant layout can provide several benefits for workers and organizations, such as reducing the risk of musculoskeletal disorders, injuries, and fatigue. It can also improve worker comfort, satisfaction, and motivation, which can boost morale, engagement, and loyalty. Furthermore, ergonomic layouts can enhance the efficiency, accuracy, and quality of work by minimizing errors and defects. Additionally, it can increase the flexibility, adaptability, and innovation of the plant by enabling workers to adjust their workstations, tools, and methods to changing needs.

Principles of ergonomic plant layout

Designing an ergonomic plant layout requires following some general principles, such as involving workers in the planning, implementation, and evaluation of the layout to meet their needs and preferences. A user-centered and systems approach should be taken to understand the characteristics, goals, and tasks of the workers, and how they interact with the equipment, materials, processes, and environment. Additionally, optimizing the physical layout can reduce the distance, time, and effort required to move people, materials, and information within and between workstations. Adequate space, lighting, ventilation, noise control, and temperature regulation should be provided to create a comfortable, safe, and healthy work environment. Adjusting the workstations, equipment, and tools should fit the anthropometric, physiological, and psychological capabilities and limitations of the workers. Finally, implementing work organization and management practices can balance the workload, pace, and variety of work while promoting teamwork, learning, and participation.

Examples of ergonomic plant layout

To illustrate how plant layout can incorporate ergonomics and human factors, here are some examples of good practices from different industries. In manufacturing, the layout follows the natural flow of materials and processes, from raw materials to finished products, with adjustable chairs, tables, monitors, keyboards, and other devices to suit the height, reach, and posture of workers. In a hospital setting, the layout facilitates access and delivery of patients, staff, equipment, and supplies from the emergency room to the operating room to the wards. Workstations are equipped with ergonomic carts, beds, chairs, and instruments to reduce physical strain and injury of staff. Retail stores have layouts designed to attract customers while providing enough space and visibility for staff. Workstations are equipped with ergonomic cash registers, scanners, shelves, and carts for handling and displaying merchandise. Staff can also vary their tasks to interact with customers and colleagues.

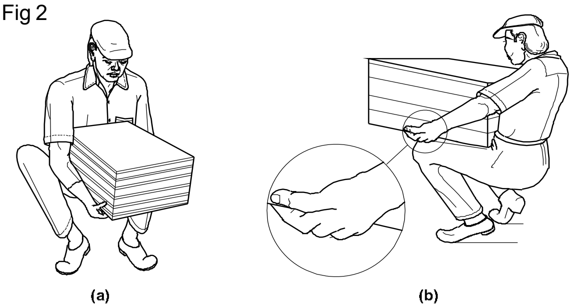
- **Correct grip:** Hold the load firmly on one side using the roots of the fingers as in Fig 1 but not with the finger tips.

Fig 1

DM20N2713434

- Lift the load on the knees (Fig 2a)
- Adjust the hand position if necessary and make sure that the body and load are balanced before you stand erect. (Fig 2b)

Fig 2

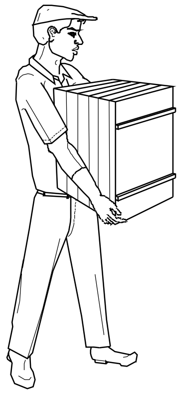


DM20N2713435

- **Moving with load:** Move with load steadily by taking short flat footed steps to have proper balance and to avoid risk of slippage. (Fig 3) Walk with steady steps forward by taking fairly straight path.

- Remove obstruction if any, from the path wherever possible.

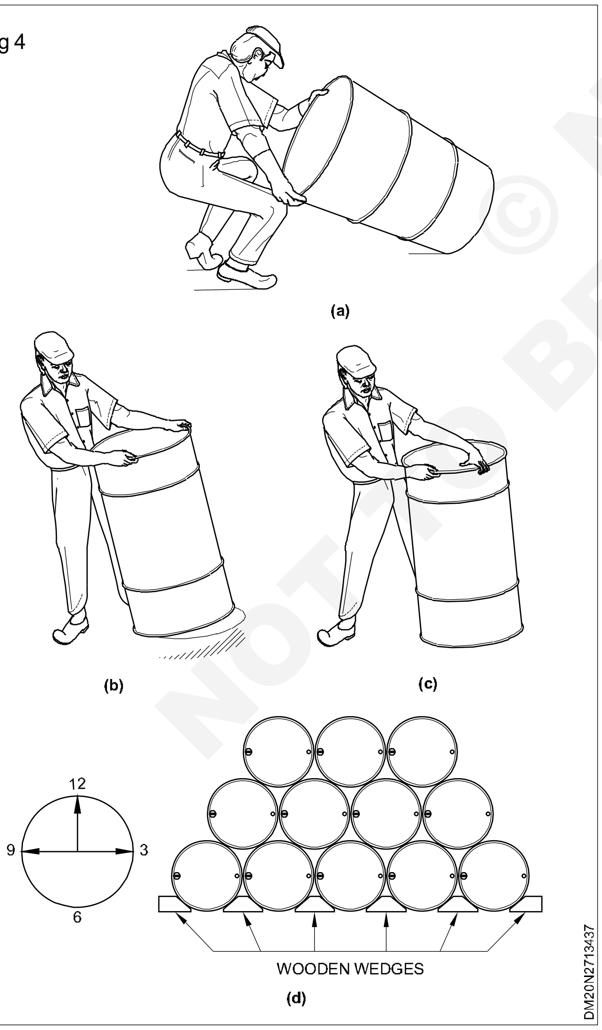
Fig 3



Handling of drums

- Position your feet a slightly apart with one forward for balance. Hold (clasp) the drum firmly by palms and fingers of both hands and continue to support the drum to lift.
- Raise the drum to its balanced condition then adjust the position of the hand so that the fingers grip the edge of the drum. Use the palm of the hand to continue the support to the drum Fig 4a.

Fig 4

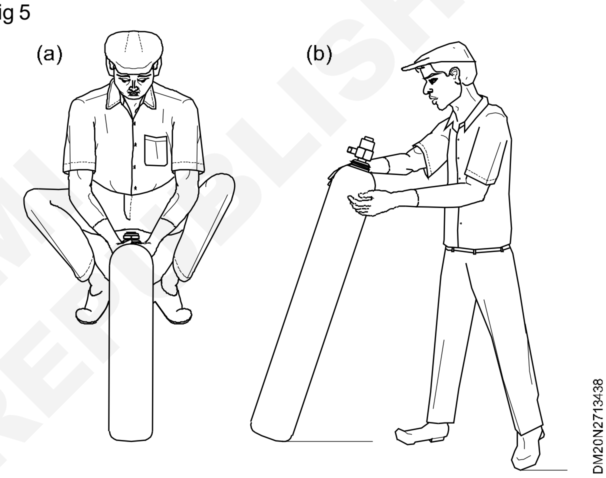


- As the load is lifted, now shift the hands to the top of the rim (Fig 4b). As the drum being settled to erect position, the left hand to be adjusted as shown in Fig 4c. So that the risk of toppling the drum again is avoided.
- For lowering the drum the procedure may be reversed.
- While storing the oil filled drum in the store, always it should be kept 3 O' clock position with proper wooden wedge at the ends as shown in Fig 4d to avoid spillage of oil.

Handling of gas cylinder

- Take your position (as shown in Fig 5a) by 30 cm gap between two feet, bent knees, keep arm straight with elbows and chin drawn in to hold the cylinder by both hands.
- Hold the valve portion of the cylinder from underneath straighten your legs and step forward to lift the cylinder gradually to its balanced in upright position as in Fig 5b.

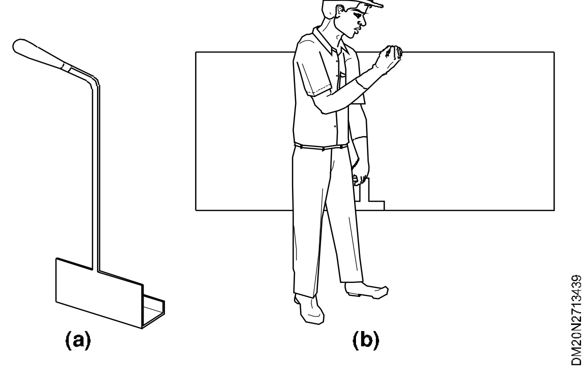
Fig 5



Handling of sheet metal (Fig 6)

- Hold the sheet metal firmly by a long handled hook (Fig 6a) and place the other arm on the top edge of the sheet and shift as shown and carry the sheet metal by keeping the balance of the sheet slightly towards the body Fig 6b.
- Use hand gloves while handling sheet metal.

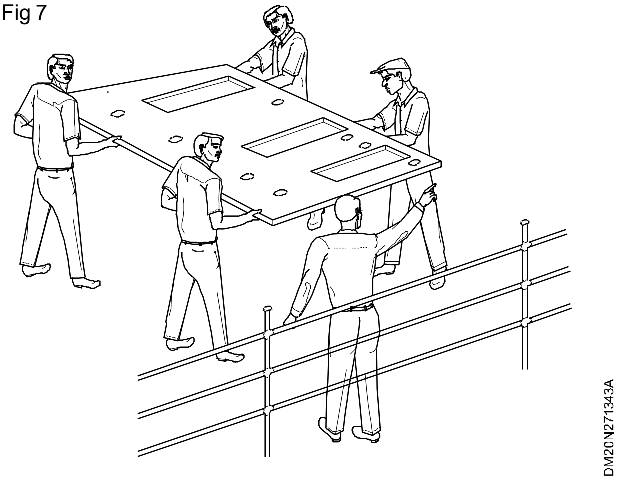
Fig 6



Team lifting

- Heavy and irregular loads to be carried by more than one person as shown in Fig 7.

Fig 7

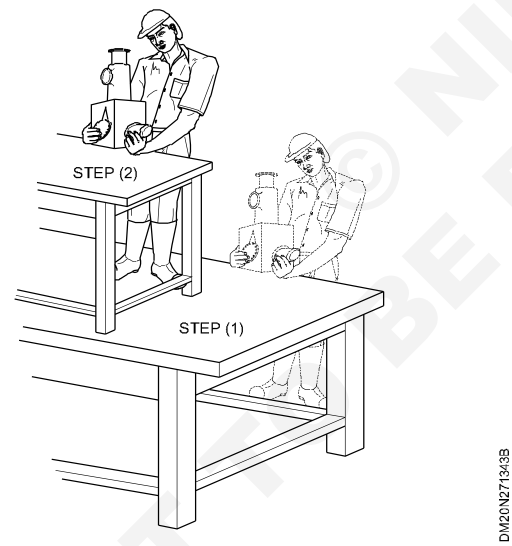


- Team members must be nearly of same height and strength to share the load evenly.
  - use protective clothing and gloves for safe handling.
  - ensure that the movement path is free from obstruction and clear.

Move load to higher position

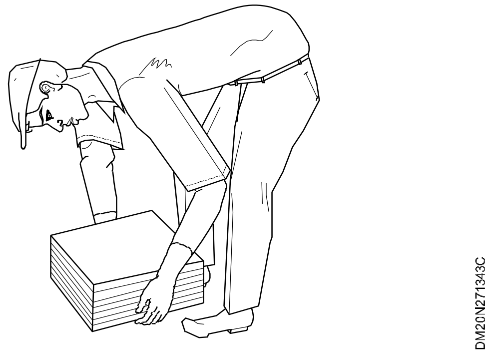
- For shifting heavy loads to a higher position, step lifting is required as in Fig 8. The load is lifted to step-1 and then lifted to the final step 2.

Fig 8



- Wrong way to lift the load as shown in (Fig 9) can strain backbone etc.

Fig 9



- As angle between two limbs of sling increased, the load carrying capacity of the sling decreases. Maximum sling angle should not be more than 120°.
- While handling liquid in buckets, care should be taken to avoid spillage of liquid which can lead to an accident.
- Use of body weight
- Position the body in such a way to counter balance the load to get greater mechanical advantage. Bending the back forward will not counter balance the load, instead, it will reduce mechanical advantage.

Introduction to Solidworks/AutoCAD Inverter/3D Modeling

Objectives: At the end of this lesson you shall be able to
- **know about the use of solidworks, AutoCAD invertors and 3D modeling.**

Solidworks

Solidworks is a mechanical design automation software package used to build parts. assembles and drawings that takes advantage of the familiar Microsoft windows graphical user interface.

Solidworks is an easy to learn design and analysis tool (Solidworks simulation, Solidworks motion, Solidworks flow simulation etc.). Which makes it possible for designers to quickly sketch 2D and 3D concepts, create 3D parts and assemblies and detail 2D drawings.

In Solidworks, you create 2D and 3D sketches, 3D parts, 3D assemblies and 2D drawings. The part, assembly and drawing documents are related.

AUTOCAD Inventor

Autodesk inventor is a professional grade 3D CAD solution for 3D mechanical design engineers and other manufacturing professional. It provides improved product performance through powerful 3D modeling and simulation capabilities.

Inventor - 2024

The latest release of inventor 3D CAD software is packed with user - requested updates and enhancements to help manage your design process, speed your connected engineering workflows and reduce repetitive tasks.

More features of inventor

Product design

Collaboration

Design automation

Modeling

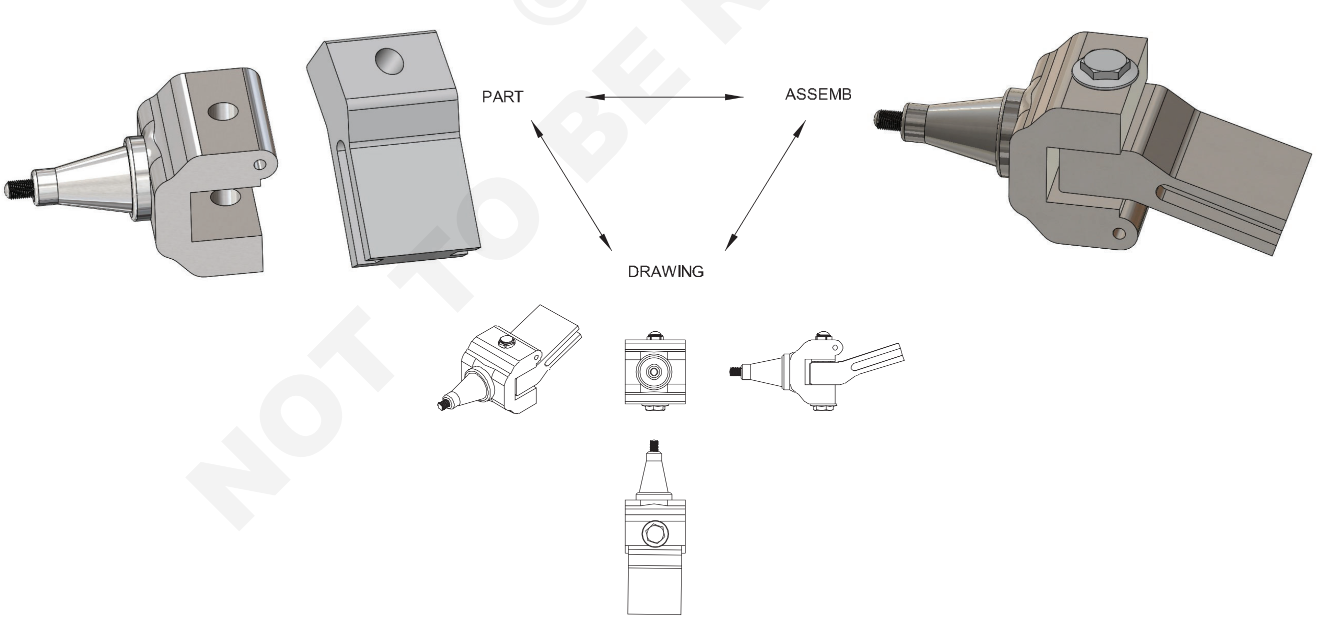
Connected data

Simulation and visualization

3D Modeling

3D Modeling is a computer graphics process of creating a mathematical representation of a 3 dimensional object as shape using specialized 3D modeling software. During the 3D modeling process you can determine an objects size, shape and texture.

Fig 1



Solidworks-user interface, menu bar, command manager

Objectives: At the end of this lesson you shall be able to
- **work on user interface, task pane, manager panels and settings.**

The solid works used for designing models quickly and precisely.

Solid works designs are:

- Defined by 3D design
- Based on components

Solid Works uses a 3D design approach. As design a part from the initial sketch to the final model, a 3D entity is to be created.. From this 3D entity, it can be created 2D drawings, or mate different components to create 3D assemblies. It can also be created 2D drawings of 3D assemblies.

One of the most powerful features in the Solid Works application is that any change in a part is reflected in any associated drawings or assemblies.

User interface (Fig 1)

The solid works application includes a variety of user interface tools and capabilities to create and edit models efficiently. These tools and capabilities include the following:

- Windows functions
- SolidWorks document windows
- Function selection and feedback

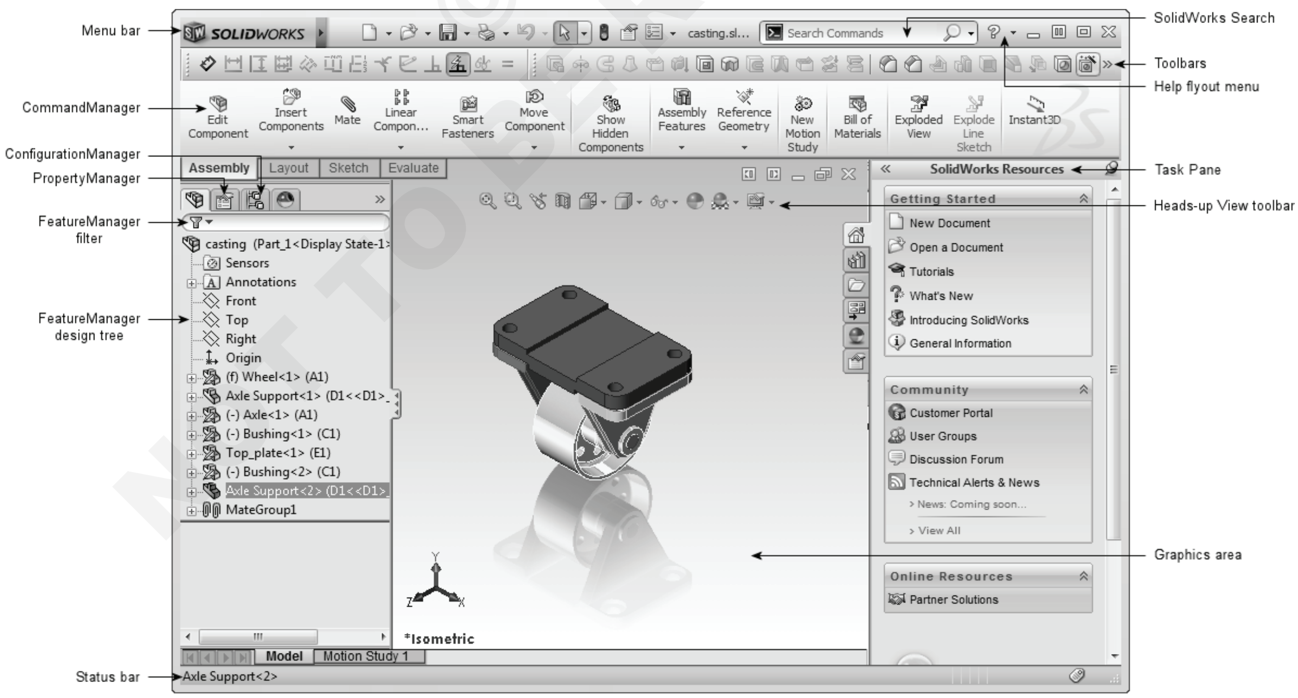
Menu Bar

The Menu Bar contains a set of the most frequently used tool buttons from the Standard toolbar, the SolidWorks menus, the Solid Works Search, and a fly out menu of Help options.

Frequently used tool buttons

By clicking the down arrow next to a tool button, it can be expanded to display a fly out menu with additional functions. This lets to access most of File menu commands from the toolbar. For example, the Save fly out menu includes Save, Save As, and Save All.

Fig 1



This toolbar can be customized in the same way.

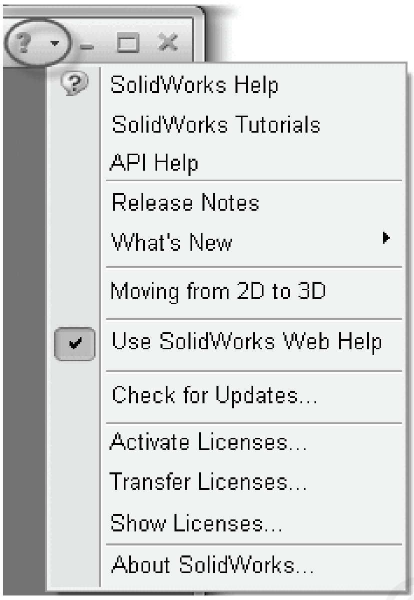
Solid works menus

The menus are visible when moves the mouse over or click the Solid Works logo. Pin the menus to keep them visible at all times. The toolbar moves to the right when the menus are pinned.

Solid works search

Fly out menu of Help options (Fig 2)

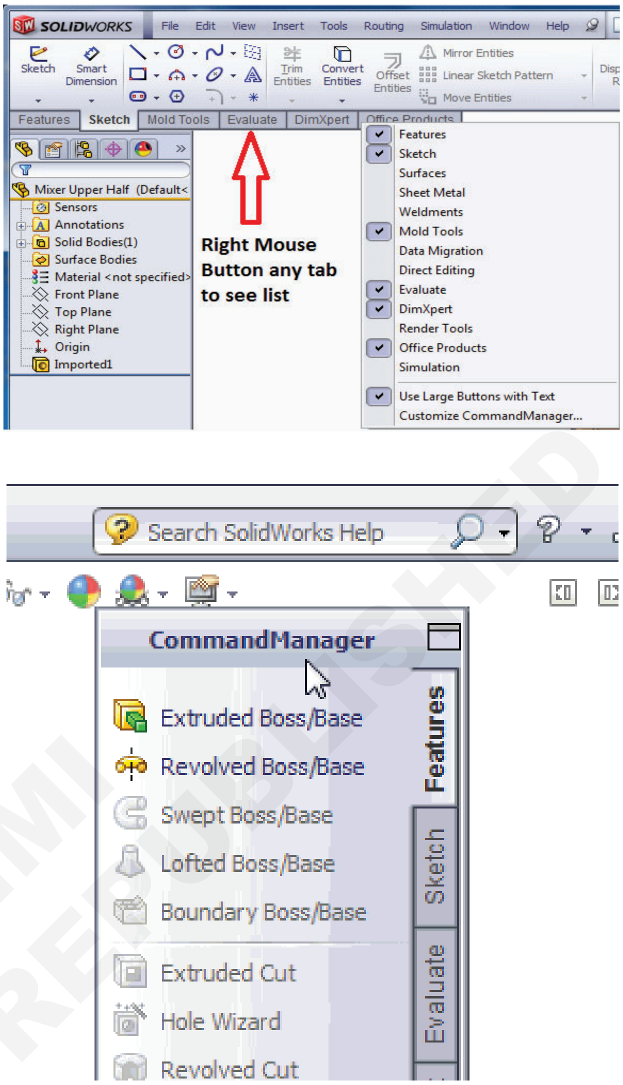
Fig 2



Command manager

The Command Manager provides access to the Solid Works tools. (Fig 3)

Fig 3

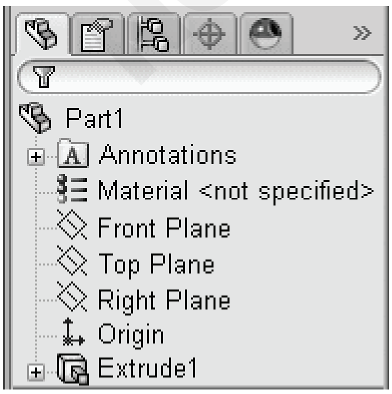


Feature manager

Objectives: At the end of this lesson you shall be able to
- **work on feature manager design tree**
- **set on default option suggested settings**
- **keyboard shortcuts**
- **create best profile and sketch with new part.**

Feature Manager- Design Tree (Fig 1)

Fig 1



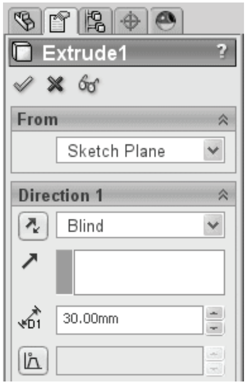
Names of features are displayed from top to bottom in the order created in the Feature Manager design tree, unless recorded them. (Features can be considered as components of parts.)

The Feature Manager design tree in assemblies displays components (parts or subassemblies and their features), a Mates folder, and assembly features.

The Feature Manager design tree in drawings contains an icon for each sheet. Under each sheet are icons for the sheet format and each view. Under each view are the parts and assemblies that belong to the view.

Property Manager (Fig 2)

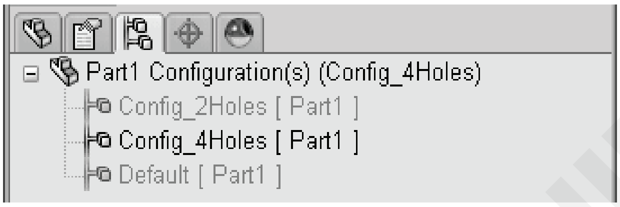
Fig 2



Most sketch, feature, and drawing tools in Solid Works open a Property Manager in the left panel. The Property Manager displays the properties of the entity or feature to specify the properties without a dialog box covering the graphics area.

Configuration Manager (Fig 3)

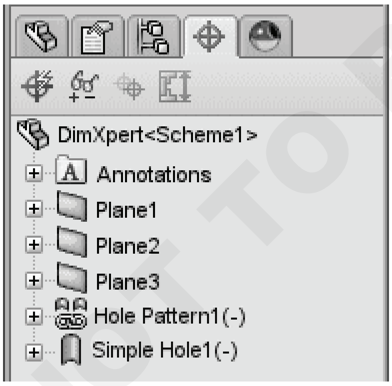
Fig 3



The Configuration Manager is a means to create, select, and view multiple configurations of parts and assemblies.

Dim Xpert Manager (Fig 4)

Fig 4

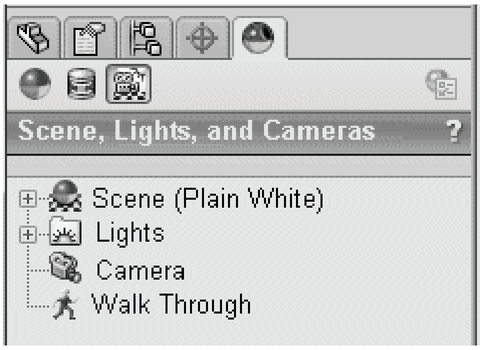


The Dim Xpert Manager lists the tolerance features defined by Dim Xpert for parts. It also displays Dim Xpert tools that you use to insert dimensions and tolerances into parts. These dimensions and tolerances can be imported into drawings.

Display Manager (Fig 5)

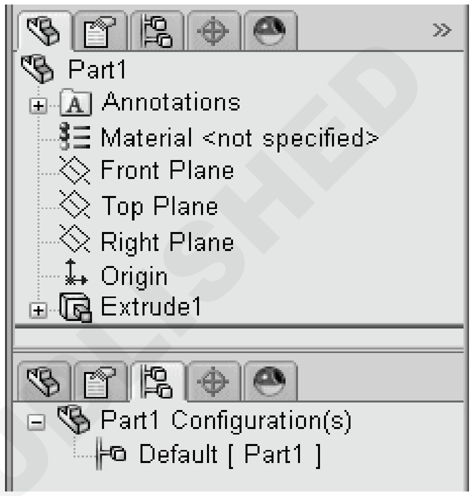
The Display Manager lists and provides editing access to appearances, decals, scene, lights, and cameras that are applied to the current model. When Photo View 360 is added in, the Display Manager provides access to Photo View Options.

Fig 5



Manager Display (Fig 6)

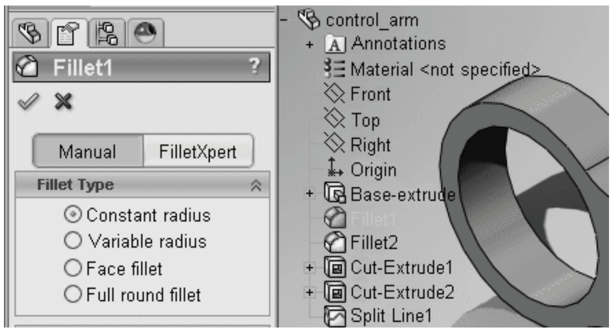
Fig 6



To switch between the Feature Manager design tree, property manager, configuration manager, and display manager can be done by clicking the tabs at the top of the left panel in the solid works window.

The panel and display can be split more than one manager or multiple copies of one manager. (Fig 7)

Fig 7



In a property manager to view a fly out feature manager design tree, click simultaneously.

Splitting the manager pane

Split the manager pane to the left of the graphics area.

Keyboard shortcuts

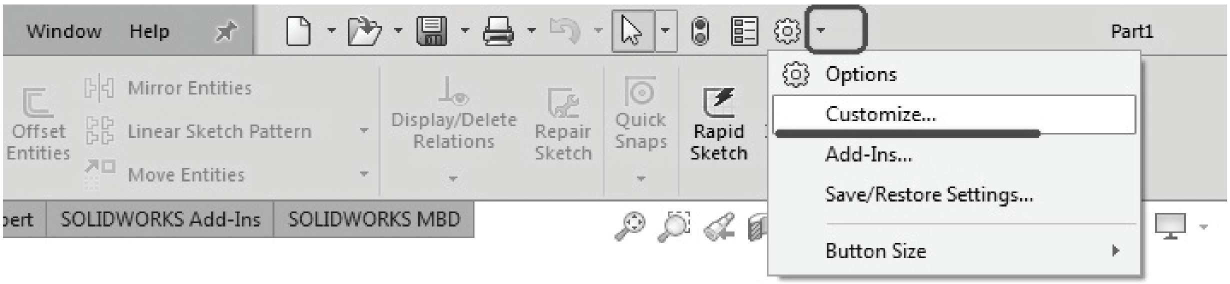
To view all existing SOLIDWORKS shortcuts, start out by opening a part, drawing or assembly. (must have a file open to access the CUSTOMIZE menu).

Next, access the CUSTOMIZE menu. typically access this via the triangle pull down, next to the options button.

Accessing the Keyboard tab in the Customize menu and choosing to show commands with keyboard shortcuts. (Fig 8)

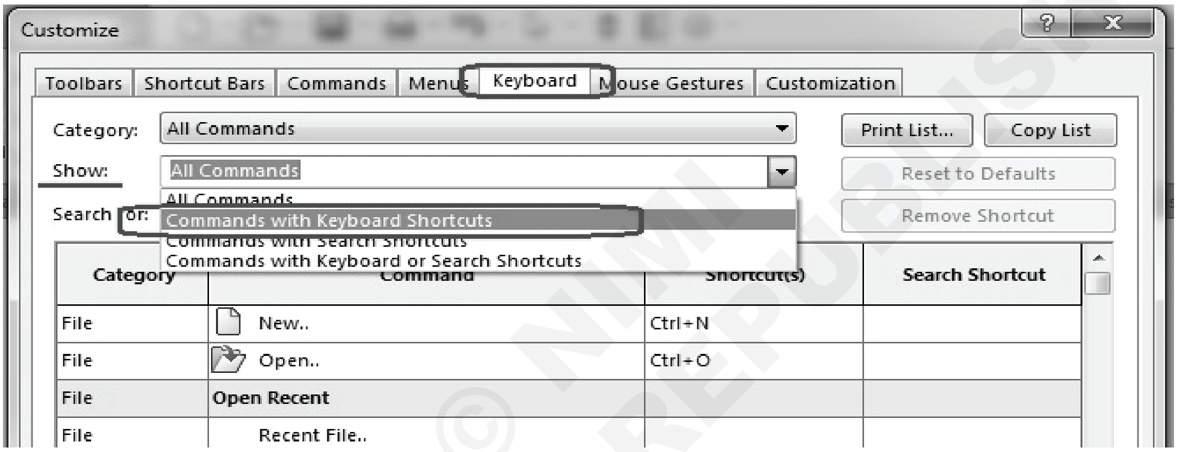
Click on the tab which says KEYBOARD. In the section labelled SHOW, choose to show COMMANDS WITH KEYBOARD SHORTCUTS.

Fig 8



This list shows all of the commands in the software which have a KEYBOARD SHORTCUT ASSIGNED and the list shows the associated keyboard shortcut.(Fig 9)

Fig 9



Create a sketch (Fig 10)

- Start new part
- Sketch on front plane
- Use "symmetric" and "equal" constraints
- Add dimensions
- Close sketch and save part

Create new part file front plane selected (Fig 11)

Feature Manager Design Tree Views

In part documents you can set the Feature manager design tree to show features in the order they were created. Instead of hierarchically Right - click in the Feature Manager design tree and click Tree Display > Show Flat Tree view in Flat three view. Curves 2 D sketches and 3D sketches are not absorbed into the features that reference them instead they are shown in the order creation

Flat Tree view is only available for parts

All regular feature manager design tree functionality is available in Flat Tree View. With the exception of user created folders. You can reorder features in flat Tree view. changing design intent.

Fig 10

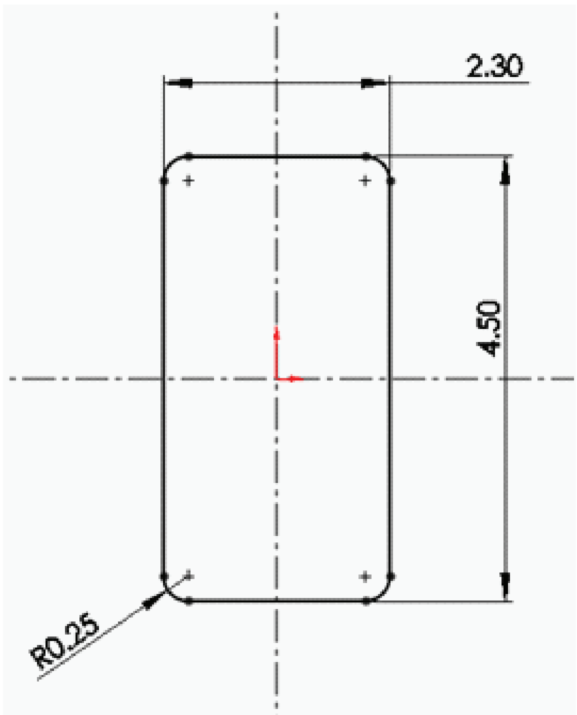
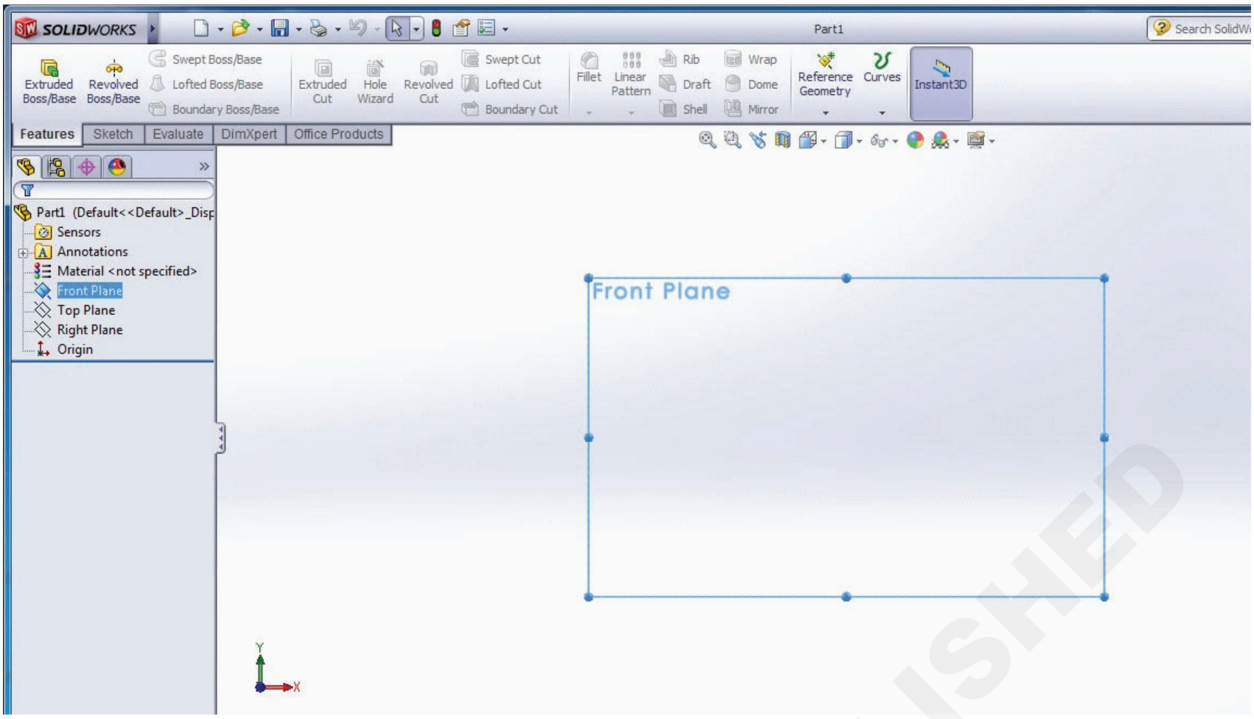


Fig 11



Not all items are unabsorbed in Flat Tree View The following features continue to absorb items in Flat Tree View. (Fig 12).

- Simple hole
- Hole wizard hole
- Mounting boss
- Lip/ groove
- Snap hook groove
- Vent
- Snap hook
- Sheet metal feature
- Library feature
- Weldment structural member
- Sketch block

In the following example the same part is shown in Normal view and flat Tree view.(Fig 13).

Fig 12

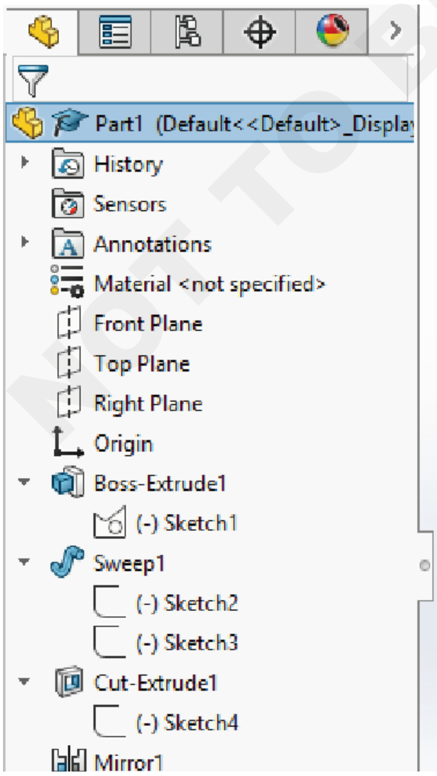
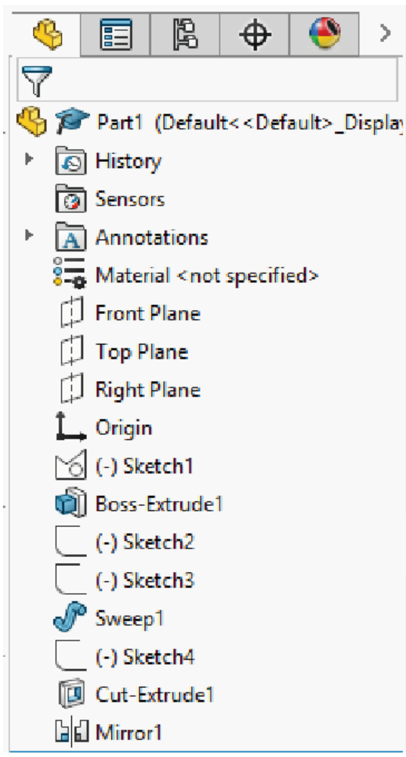


Fig 13

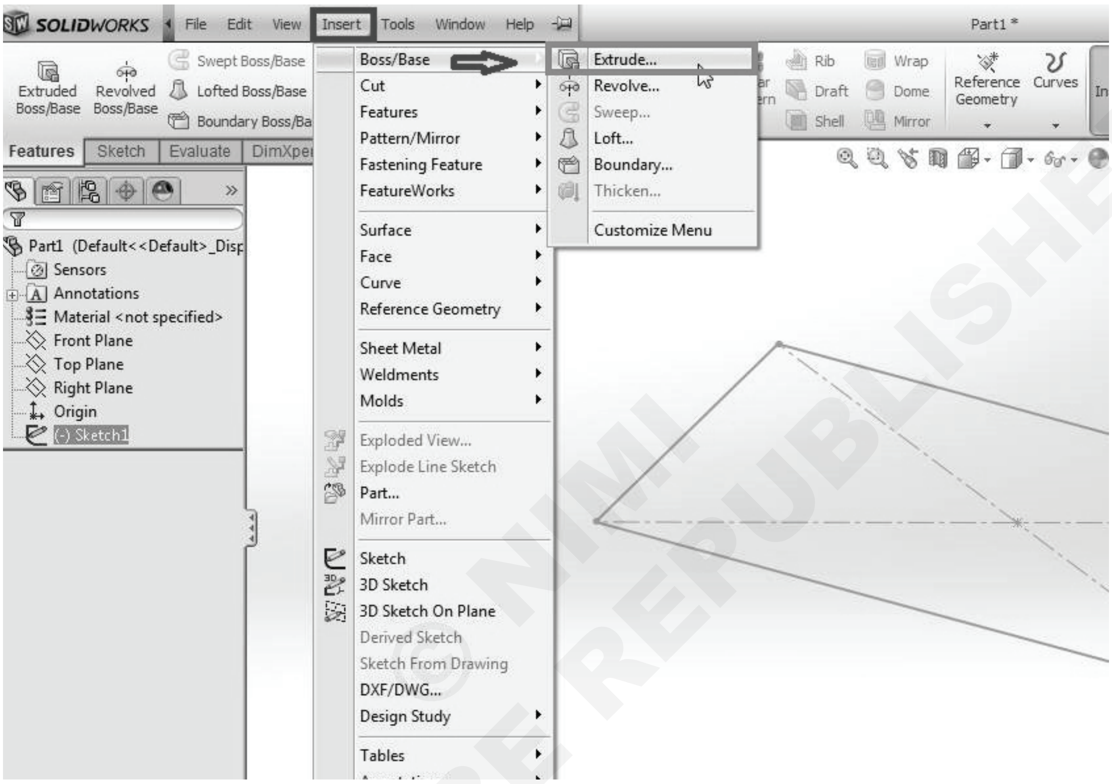


Solidworks-extrude bosses and revolved features

Objectives: At the end of this lesson you shall be able to
- **do extrude, cut, fillet, chamfer and changing dimension**
- **do revolve features using axes, circular pattering changes and rebuild process**
- **do bottom up assembly modelling.**

Extrude boss / base (Fig 1)

Fig 1

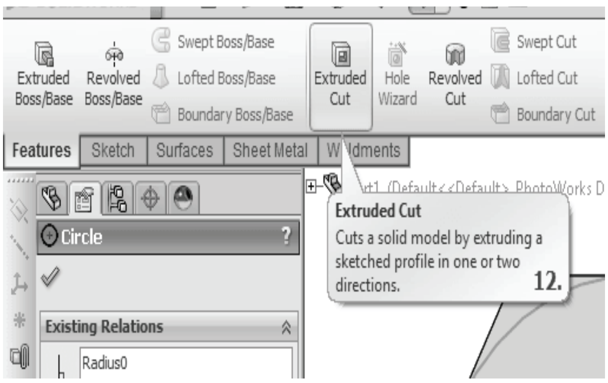


Extrude Boss/Base is the tool in Solid works to create solid 3D models like block, cube, cylinder, 3D polygon, 3D elliptical shapes, etc. It extrudes a sketch or selected sketch contours in one or two directions to create solid feature. This feature is located in "Features command manager" or "Insert Menu".

Extrude Cut

Extrude cut helps to remove materials from the 3D model. It cuts a sketch profile while extruding in both directions and mainly used for creating holes, channels, slots, etc. This feature tool is also located in command manager or can access it from the Insert menu bar. (Fig 2,3)

Fig 2

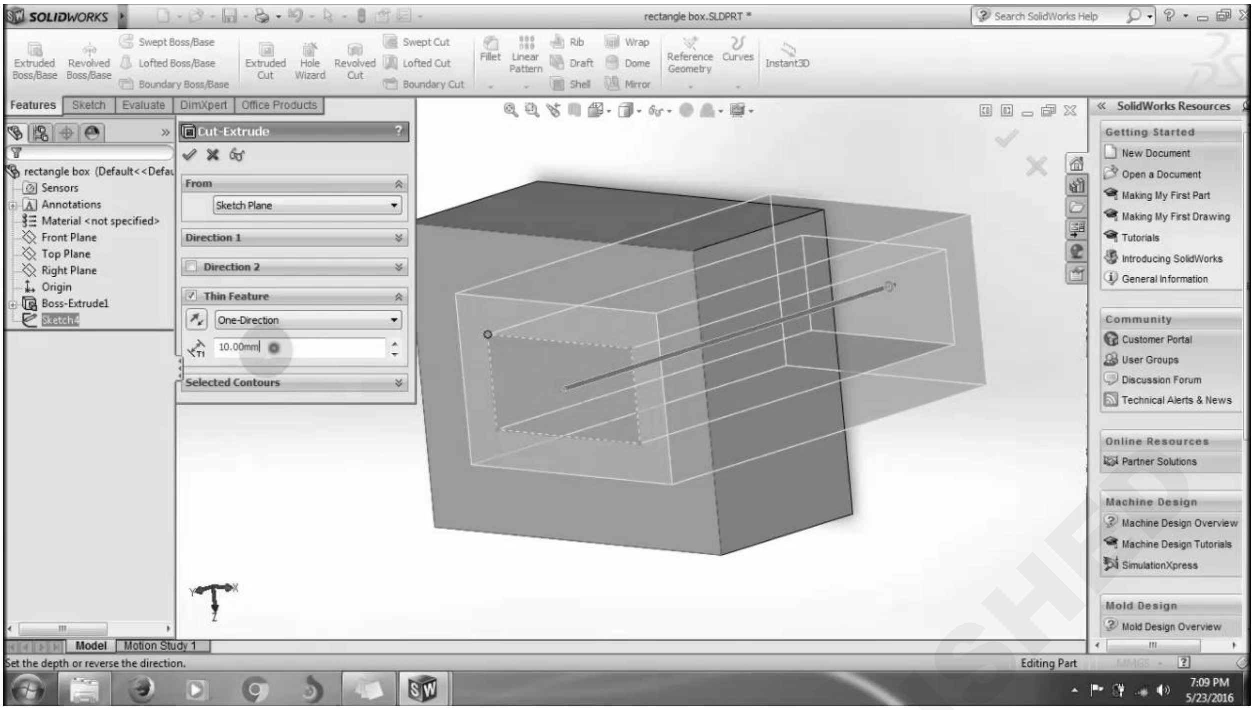


Fillet

Open the fillet property manager by clicking on the fillet features tool and select "face fillet".

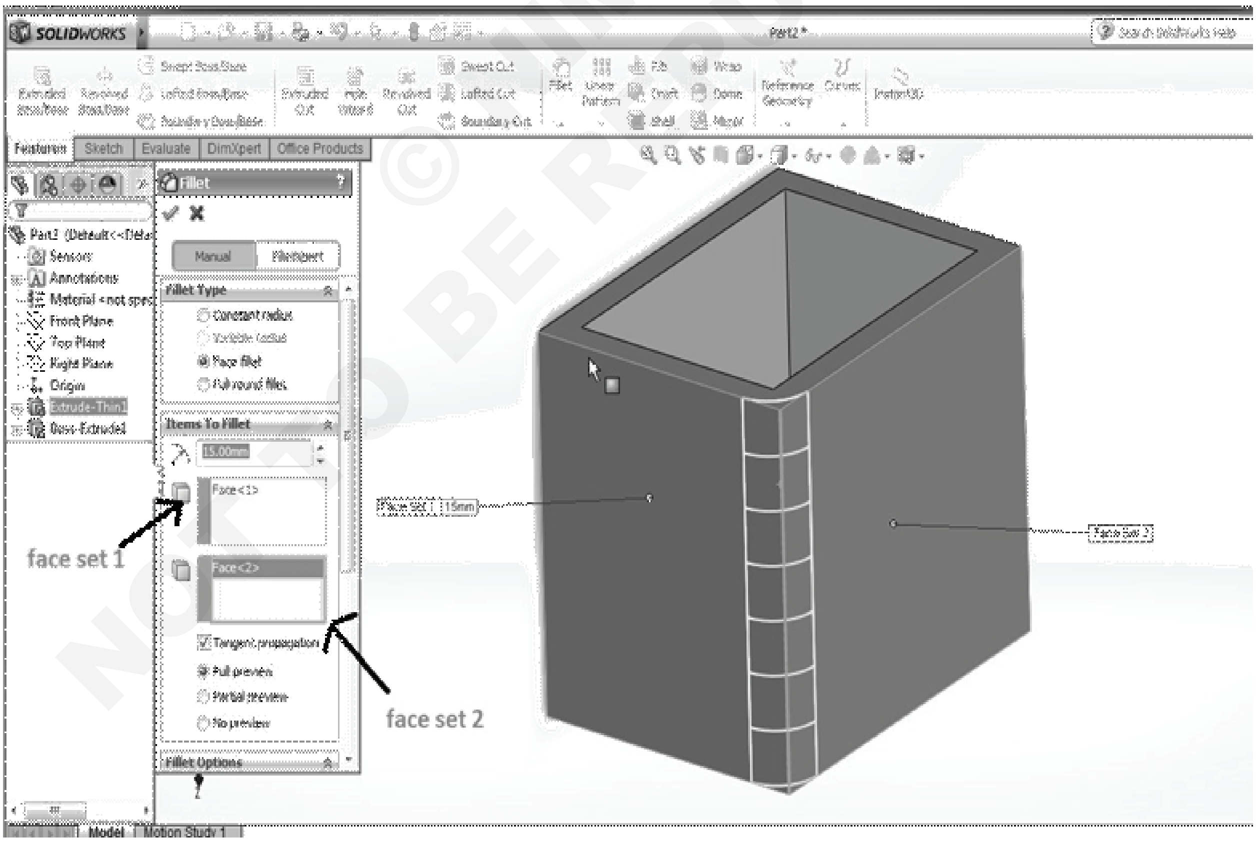
In "Items to Fillet" set the fillet radius and click on model part face 1 and face2

Fig 3



Click on the green tick button to get final face filleted design part.(Fig 4)

Fig 4



Chamfer

Angle distance chamfer tool is located in Chamfer Property Manager and which is used to create chamfered corner or age in sharp 3D object. The chamfering is depends on the angle and distance from the age or corner. But default 45° is cutting plane angle and the distance is 10 mm.(Fig 5,6)

Fig 5

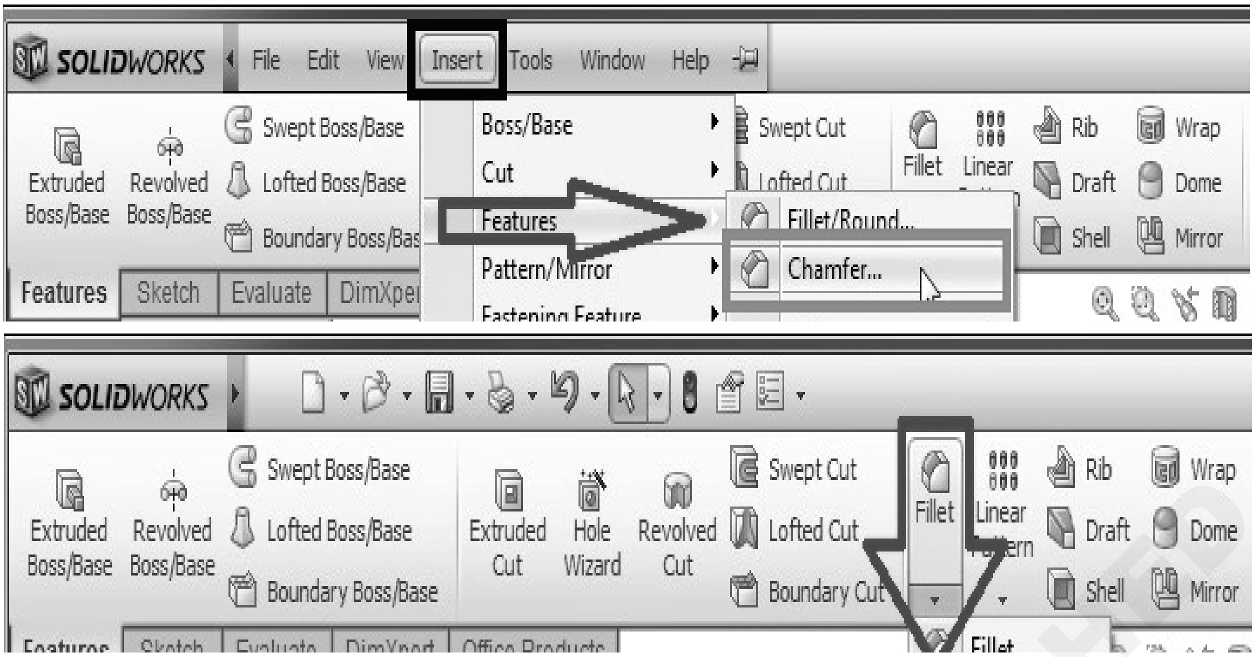
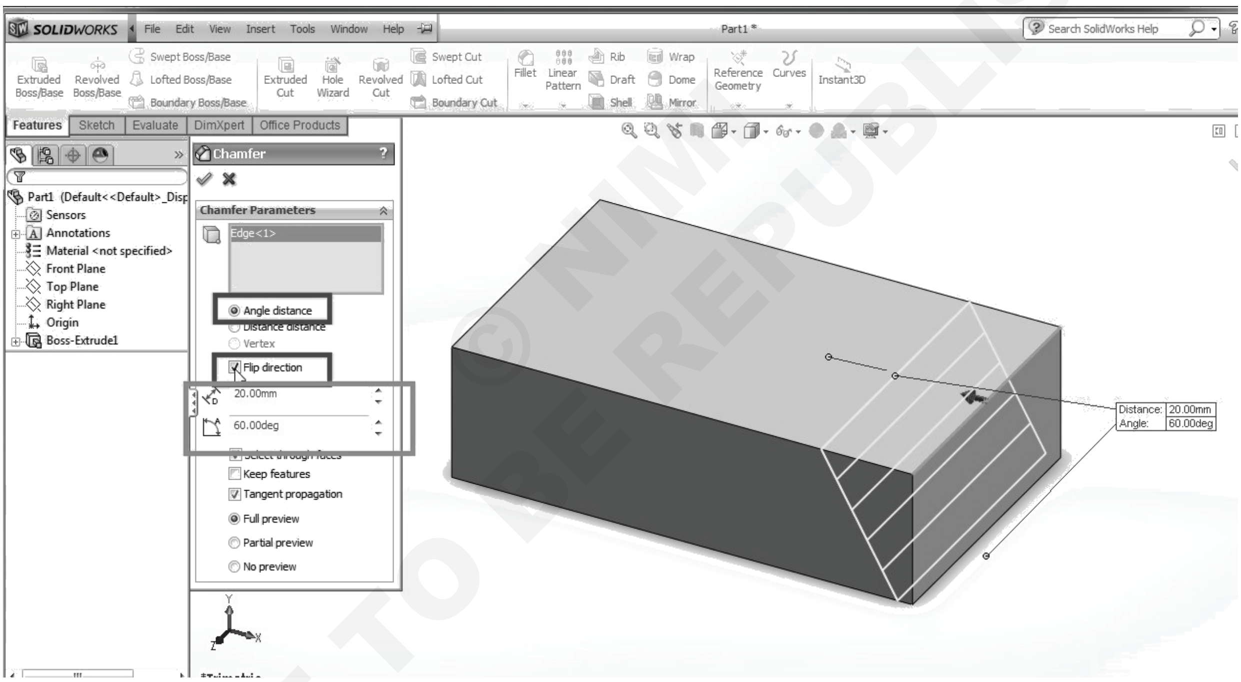


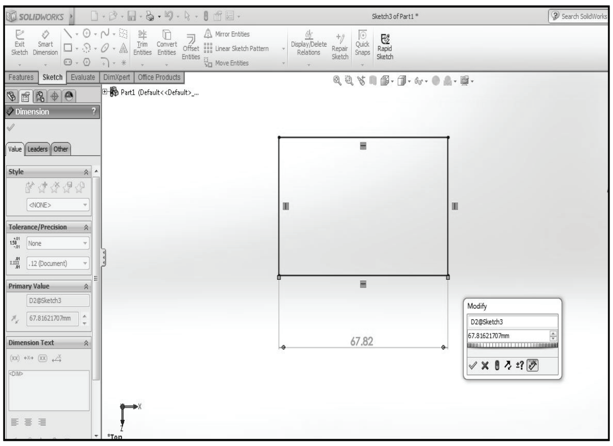
Fig 6



Changing dimensions

Changing dimension (smart dimension) helps to correct or modify the dimension for sketched part. This tool at the sketch toolbar manager also helps to notate the dimensions of the design part or product. First select the first point then select the second point. Then drag the mouse button up or down to fix the dimension marking and click left mouse button. Then a small dialog box will appear and named as modify. Here it can be changed the dimension name, enter the length of the line and reverse the sense of the dimension. Then reset the spin increment value. (Fig 7)

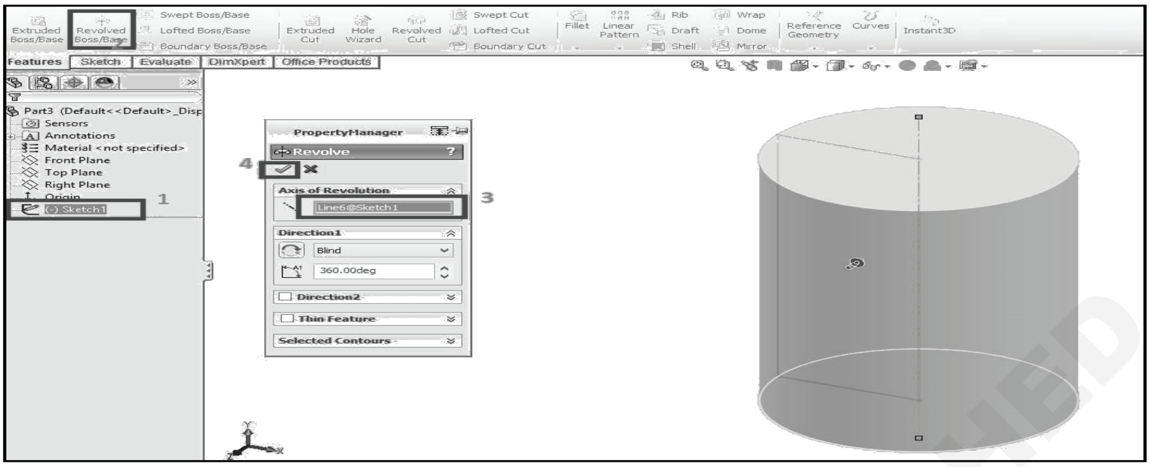
Fig 7



Revolve features

Go to sketch and select the line or center line sketch tool from the sketch command manager. First draw a line through origin of the drawing part. There is no dimension restriction for this center line. After sketching rectangle or any sketch and exit the sketch. Then go to feature command manger and click revolved boss/base feature. Select the axis line then select the rectangular profile for creating 3D cylinder. (Fig 8)

Fig 8



Linear patterning

Linear pattern features tool is a placed features tool which is used to create patterns of features in linear manner. For linear patterning there is parent pattern (base pattern) which used to create the array of patterns in one or two dimension. The pattern should follow the exact shape of the main pattern. (Fig 9)

Fig 9

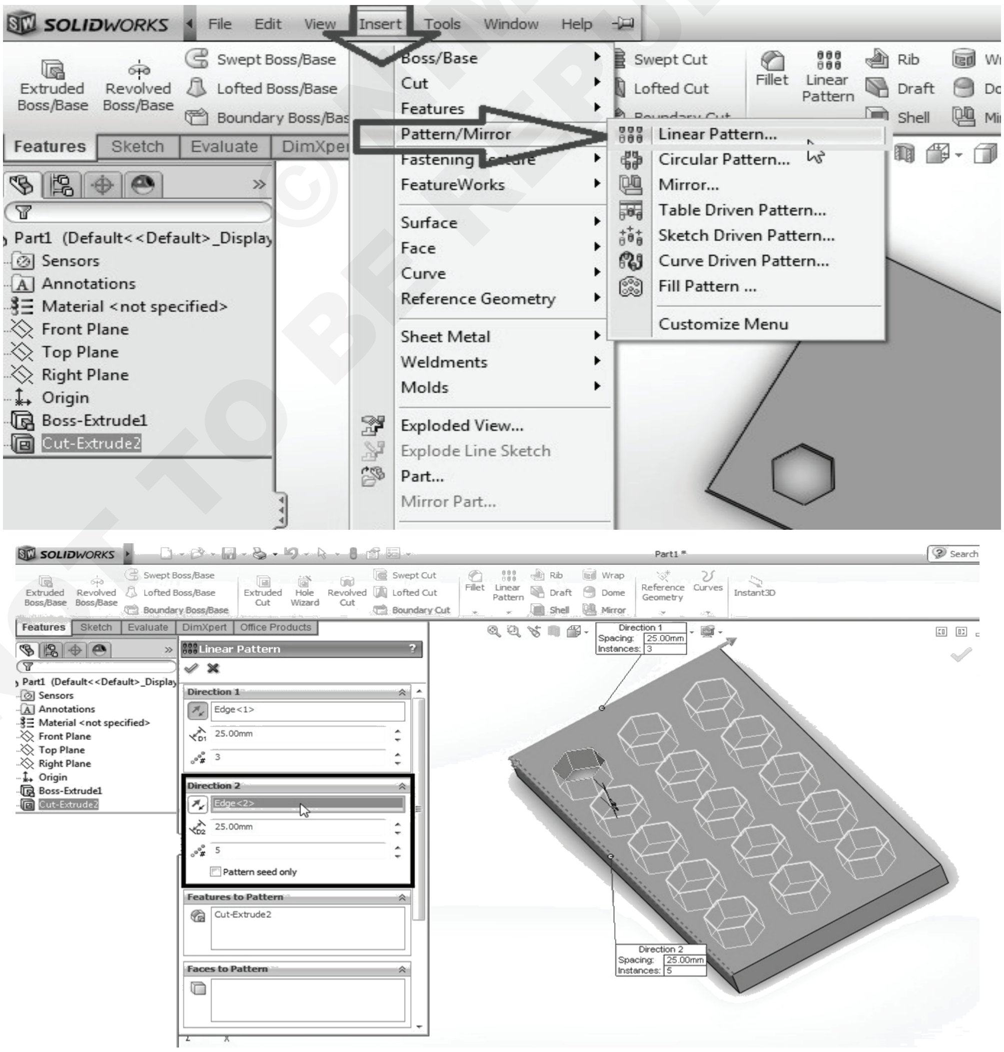
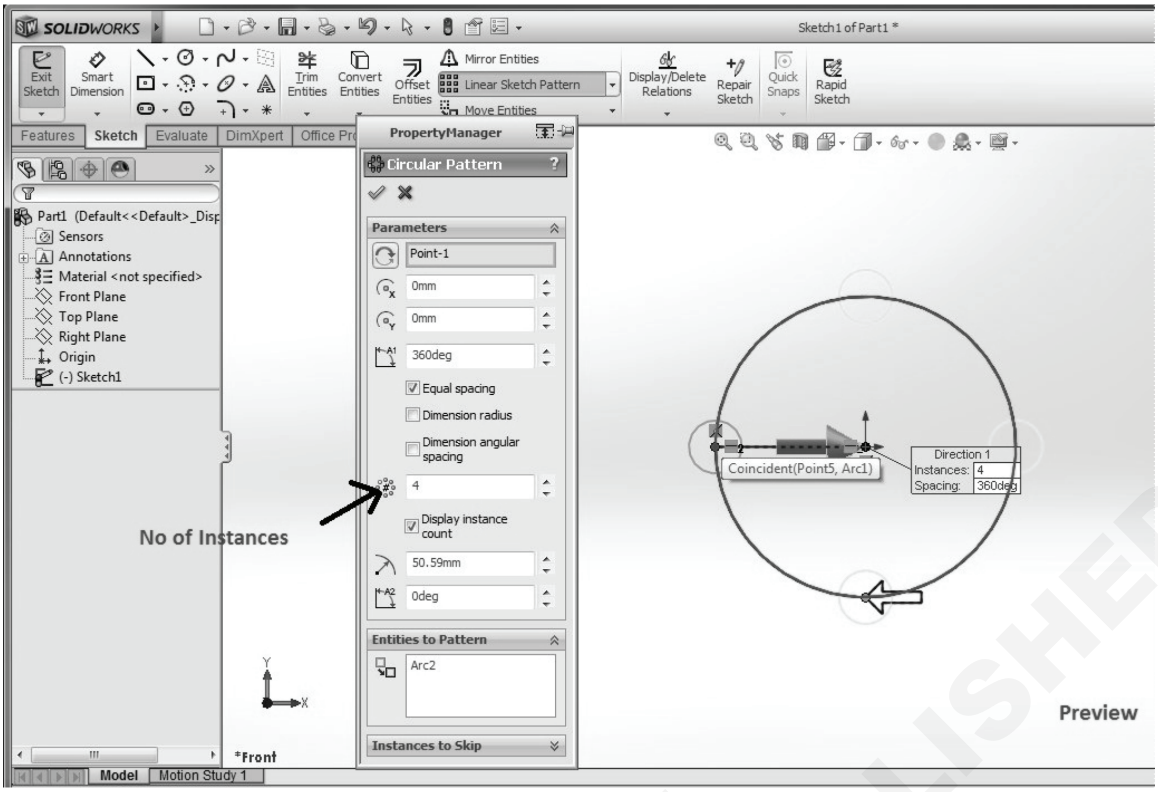
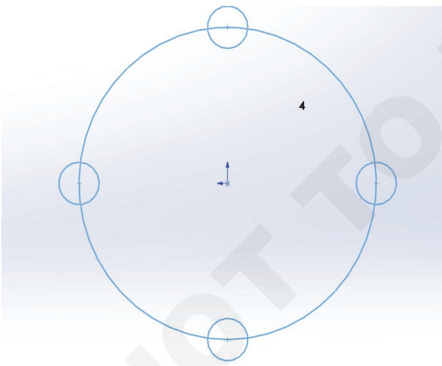


Fig 10



Circular patterning: Circular sketch pattern is sketch tool which helps to make sketch of circular pattern by adding different closed profiles like circle, rectangle, etc. this tool is mainly located in the sketch command manager with linear sketch pattern tool. It can also be accessed from the Tools menu within the sketch tools. After selecting the base circle and rotating object fix the number of items by entering in the number of instances section in the circular pattern property manager. To get equally spaced pattern tick on equal spacing.(Fig 10,11)

Fig 11



Final circular pattern with base circle

Final circular pattern with base circle

Changes and rebuild: The rebuild tool will refresh the model after a change. Sometimes this is done automatically; sometimes this must be done manually. The rebuild traffic light symbol will be seen in the bottom left hand corner of the SW window as well as attached to a particular part or feature. When this appears, either select the corresponding traffic light icon from the Standard toolbar or use CTRL + B from your keyboard.

The CTRL + B rebuild will only rebuild the last few changes that have been made to the model. A more thorough rebuild, which rebuilds every item in the tree in sequence is the CTRL + Q rebuild. This has no corresponding toolbar icon and is keyboard shortcut only. CTRL Q has been known to highlight errors not previously seen, but also solve errors that just require a rebuild. (Fig 12)

"Verification on Rebuild" controls the level of error checking during rebuilds, it has been recommended in the past that this be cleared except when troubleshooting a problematic part. In fact, on the topic of "Verification on Rebuild", Solid Works Help states that "the default setting (cleared) is adequate and results in a faster rebuild of the model".

At some point usually after the creating additional features, a rebuild may eventually display multiple rebuild errors. Trying to fix all the rebuild errors can be quite difficult. If "Verification on Rebuild" is turned on, from Tools > Options > System Options > Performance.

Bottom-up assembly approach (Fig 13)

- Allows designer to use part drawings that already exist (off the shelf)
- Provides the designer with more control over individual parts.
- Multiple copies (instances) of parts can be inserted into the assembly.
- The approach is ideal for large assemblies consisting of thousands of parts.
- The approach is used to deal with large designs including multiple design teams.
- It lends itself well to the conceptual design phase e.g. : Piping and fittings, welds, lock pins

Fig 12

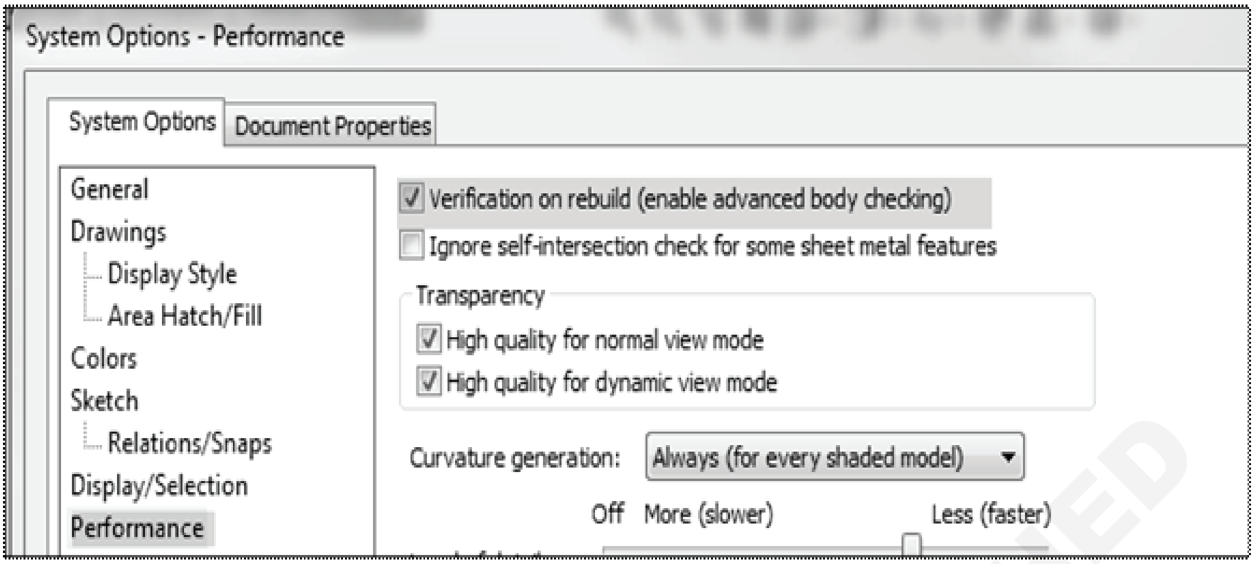
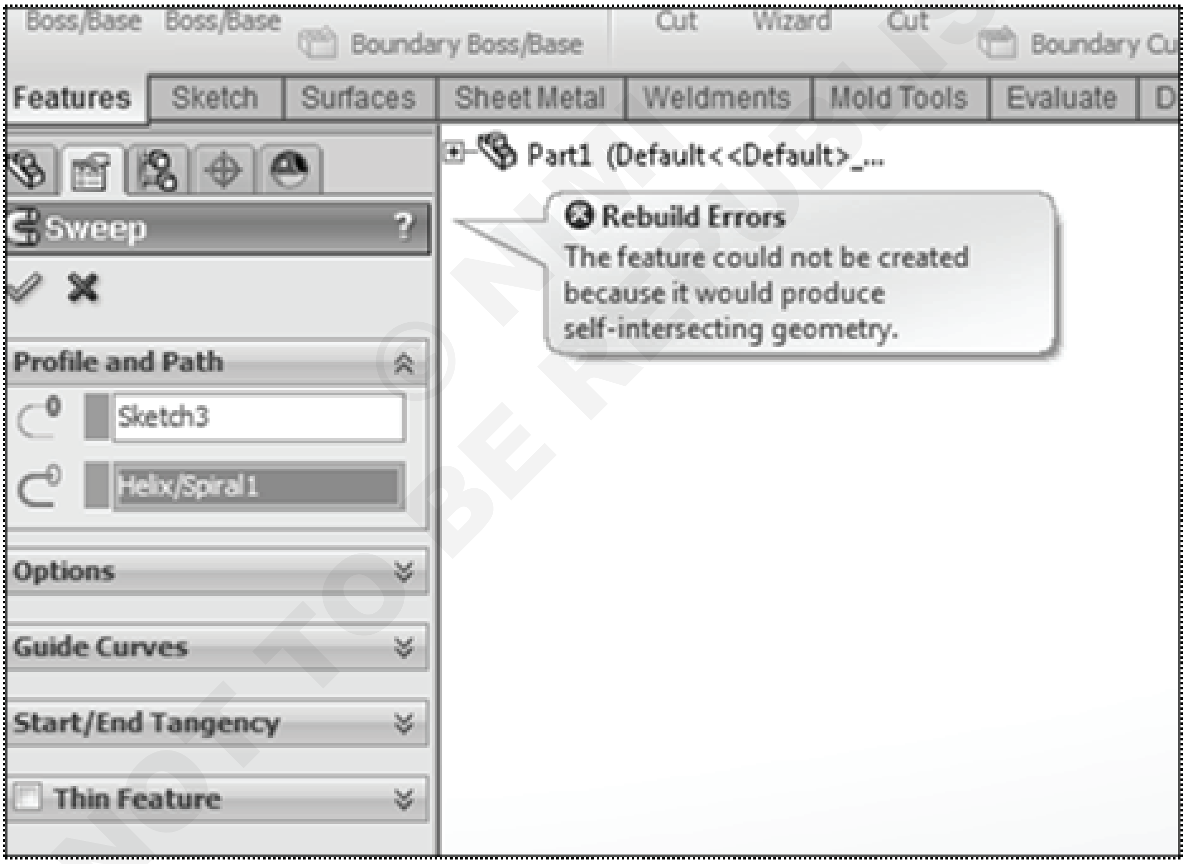

System Options - Performance
System Options
Document Properties
General
Drawings
Display Style
Area Hatch/Fill
Colors
Sketch
Relations/Snaps
Display/Selection
Performance
Verification on rebuild (enable advanced body checking)
Ignore self-intersection check for some sheet metal features
Transparency
High quality for normal view mode
High quality for dynamic view mode
Curvature generation:
Always (for every shaded model)
Off
More (slower)
Less (faster)

Fig 13


Boss/Base
Boss/Base
Boundary Boss/Base
Cut
Wizard
Cut
Features
Sketch
Surfaces
Sheet Metal
Weldments
Mold Tools
Evaluate
Part1 (Default<<Default>_...
Sweep
Rebuild Errors
The feature could not be created
because it would produce
self-intersecting geometry.
Profile and Path
Sketch3
Helix/Spiral1
Options
Guide Curves
Start/End Tangency
Thin Feature

Bottom up assembly modelling (Fig 14)

Fig 14

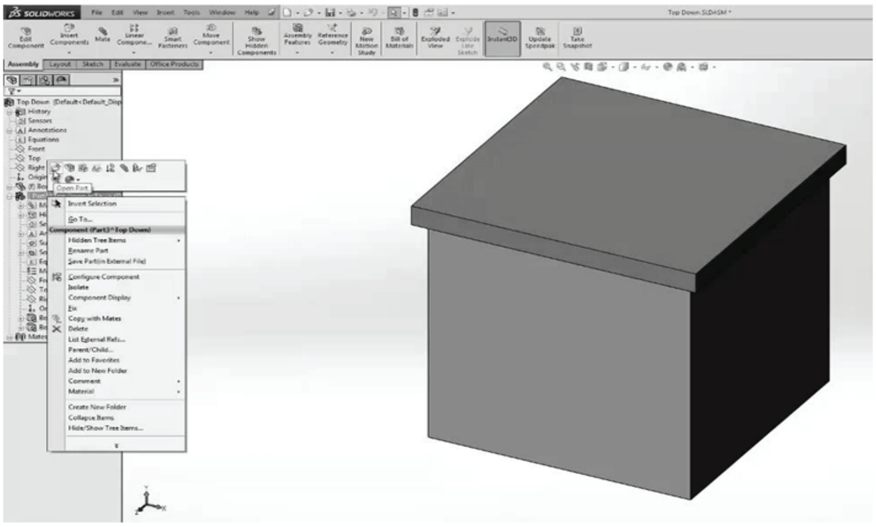
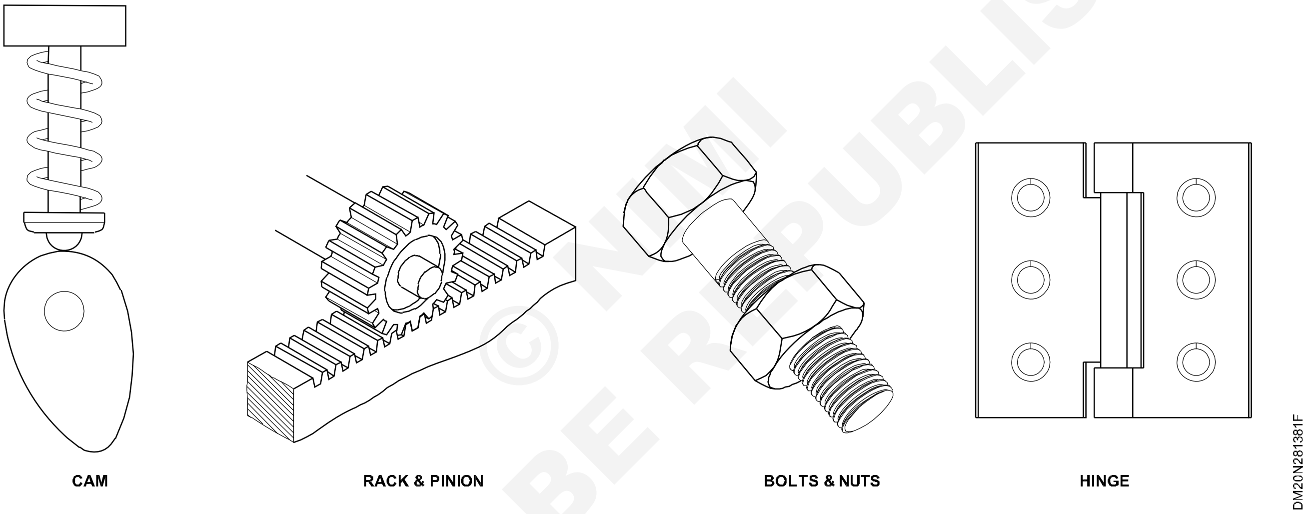


Fig 15



Solidworks-components configuration in an assembly, subassembly, interference detection

Objectives: At the end of this lesson you shall be able to
- **draw assembly and insert subassembly and interference detection**
- **make detailing of drawing items, add items, named views, 3-views, auxiliary views, sectional**
- **work on views and detailed views in a drawing sheet.**

Components configuration in an assembly

1 Right-click the . component and select **Component Properties** .

To specify configurations for more than one component, hold down Ctrl and select the components, then right-click and select **Component Properties** . .

Properties that are common to all the selected components appear in the dialog box.

2 Set the following options, then click **OK**.

Configuration specific properties

Referenced configuration. Select a configuration from the list. If the selected component is an instance of a component pattern, select one of the following:

- **Use same configuration as pattern seed component.** If the selected component is an instance of a component pattern, this is the default setting.
- **Use named configuration.** Select to specify a configuration that is different from the seed component, and select a configuration from the list.

Change properties in. (Only available in assemblies with more than one configuration.) Sets properties in this configuration, All configurations, or Specify configurations.

Suppression state. Controls the suppression state of the component.

Solve as. Sets the component as Rigid or Flexible.

Exclude from bill of materials. Omits this component from the bill of materials (BOM). Applies to only table-based BOMs, not Excel-based BOMs .

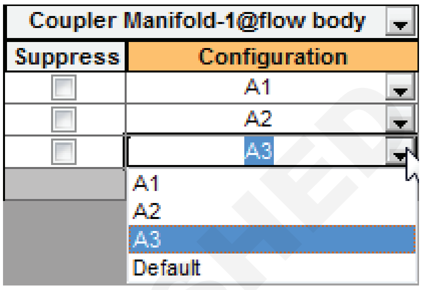
1 In an assembly, right-click a component and click Configure Component .

2 In the Modify Configurations dialog box, you can:

- Create new assembly configurations.
- Change the component configuration used in each assembly configuration.
- Suppress or unsuppressed the component for each assembly configuration.

Changing the Part configuration after dropping it into assembly.

Once the part is inside the Assembly, go to component properties by either doing a left or right click on the part directly from the graphic's area or from the feature manager design. (Fig 1)



After selection of the component properties it will open a dialog box as shown below where it can be selected the required configuration and the part till automatically update. (Fig 2)

To insert a new subassembly

1 Do one of the following:

- In the Feature Manager design tree, right-click either the top-level assembly icon or the icon for an existing subassembly, and select Insert New Subassembly.
- Click New Assembly (Assembly toolbar) or Insert > Component > New Assembly.

In the Feature Manager design tree, an empty subassembly is inserted as the last component of the selected assembly. Virtual subassemblies appear with a name in the form [Assemn^assembly_name]. Externally saved subassemblies appear with a name in the form Assembly. (Fig 3&4)

2 Add components to the subassembly:

- To move a component that is already in the assembly into the subassembly, see Drawing Components to Edit the Assembly Structure or Assembly Structure Editing.
- To add an existing, saved component to the subassembly, right-click the subassembly icon in the Feature Manager design tree, and select Edit Subassembly. Then insert components using any of the methods in Adding Components to an Assembly.
- To insert a new component into a subassembly, you must edit the subassembly in its own window. It cannot be insert a new component into a subassembly while editing the top-level assembly. Also, it cannot be insert a new component while editing the subassembly in the context of a higher level assembly. Right-click the subassembly icon in the Feature Manager design tree, and select Open Assembly to open the subassembly in its own window. Then add a new component.

Fig 1

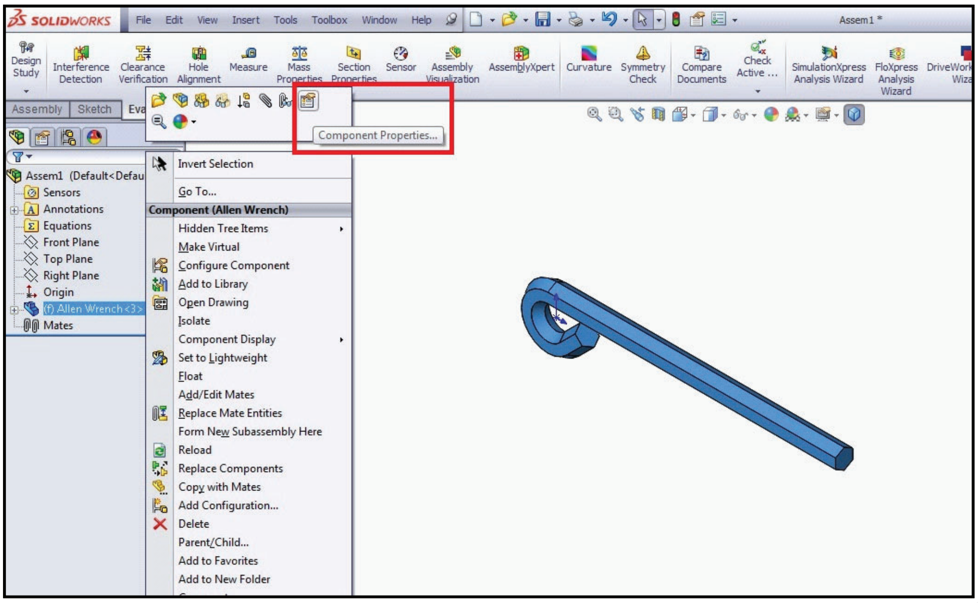


Fig 2

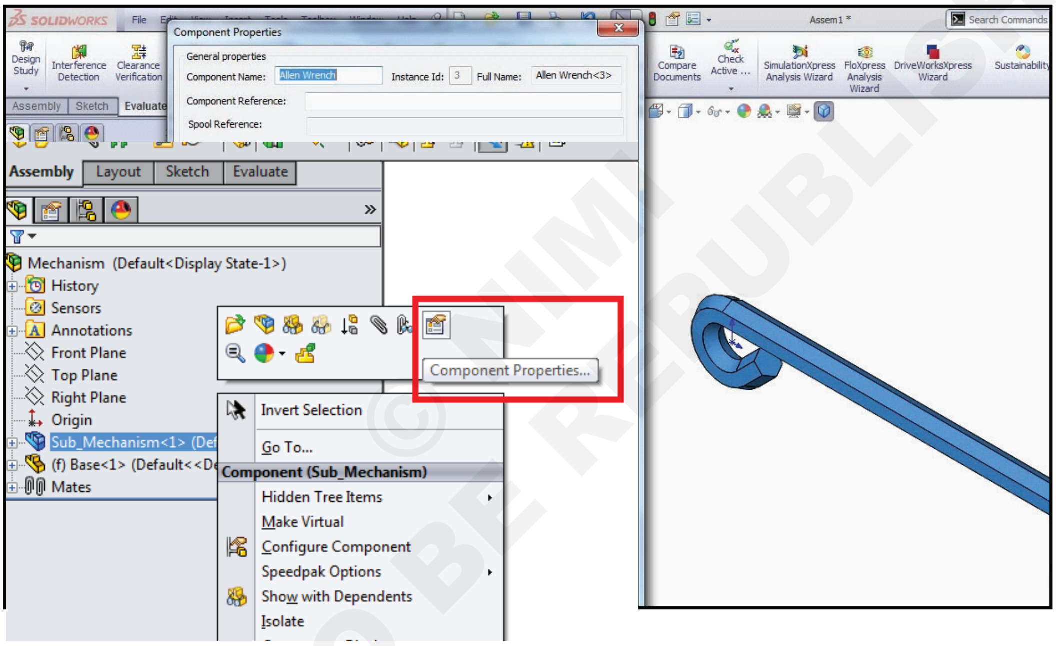


Fig 3

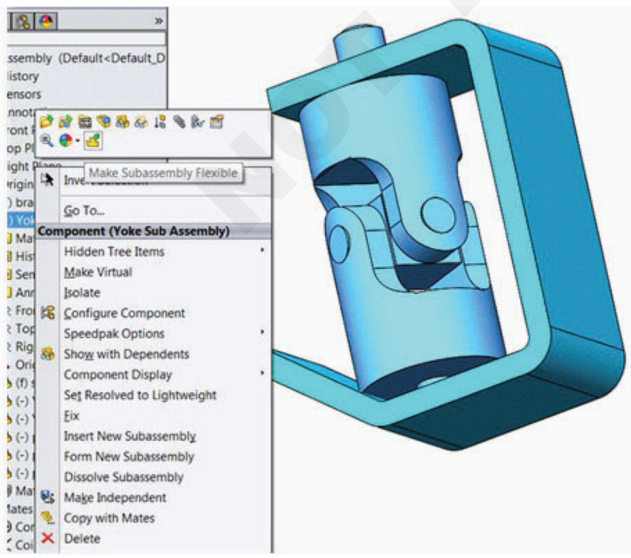
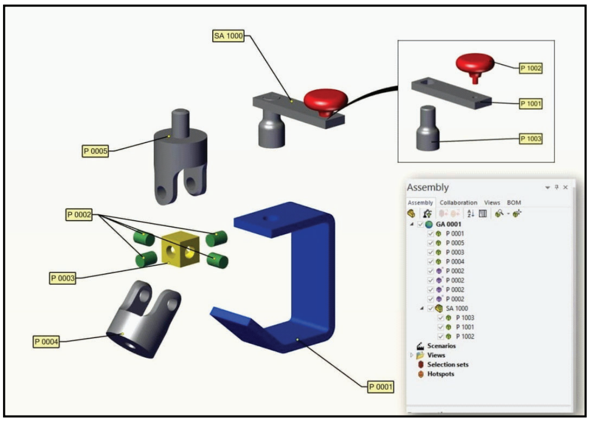


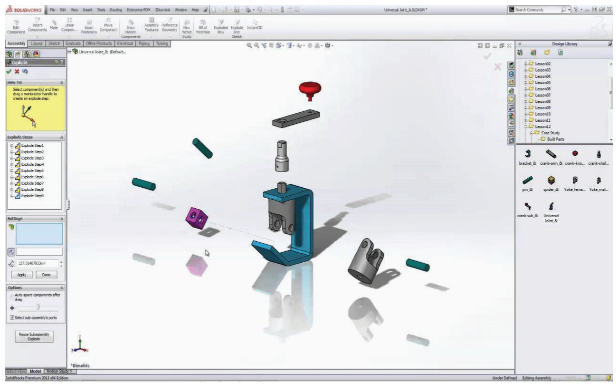
Fig 4



Interference detection

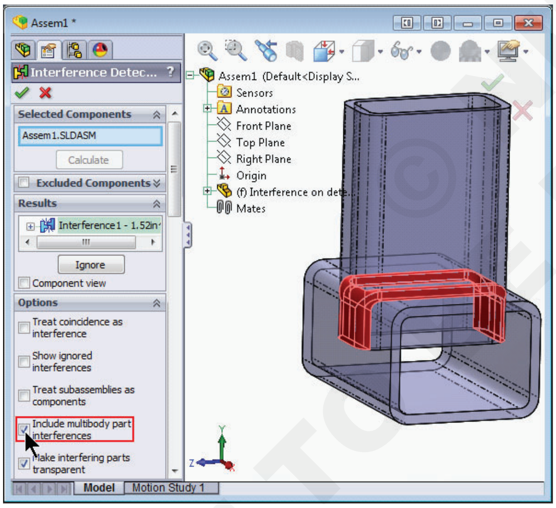
To check for Interference in between multiple weldment structural members in a Soli works Part, there is no interference detection tools available while working on a part. (Fig 5)

Fig 5



1 Simply create an assembly with the weldment part (no other parts are needed) and run Interference Detection from the pull-down Tools/Interference Detection or from the Evaluate tab on the Command Manager. Make sure to use the following option, 'Include Multi-body part interferences'. (Fig 6)

Fig 6



2 In the weldment part file use the Combine Feature to check between 2 structural members. From the pull-down Insert/Features/Combine, simply select the 'Common' option and select 2 structural members to check if there is any overlapping volume between them. Use the Preview button in the command and see if there is any interference. If there are none, following message will appear: "Unable to create single body common to the input bodies" which would mean that there is no interference". (Fig 7)

Drawing and detailing

Work through numerous activities to create multiple-view, multiple-sheet, detailed drawings, and assembly drawings. Develop Drawing templates, Sheet formats, and Custom Properties. Construct drawings that incorporate part configurations, assembly configurations, and design tables with equations. Manipulate annotations in parts, drawings, assemblies, Revision tables, Bills of Materials and more. (Fig 8)

Fig 7

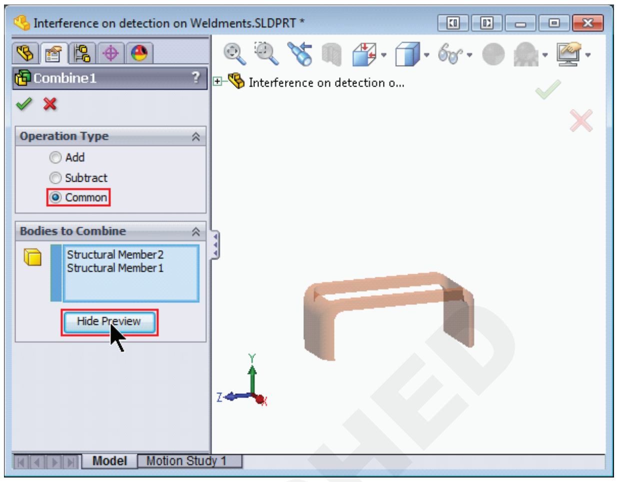
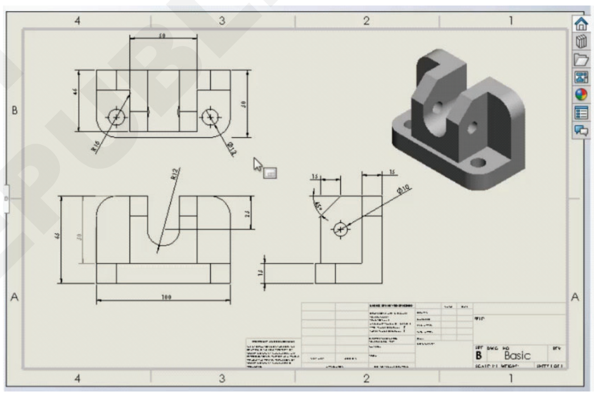


Fig 8



Create Drawing Sheet

The Sheet Format/Size dialog box defines the sheet format and the paper size.

The U.S. default Standard Sheet Format is A-Landscape standard. The Display sheet format option toggles the sheet format display on/off. (Fig 9)

Add drawing Items (Fig 10)

To insert existing model items into a drawing:

1 Click Model Items  (Annotation toolbar), or click Insert > Model Items.

You can also preselect views, features, or components to which you want to add model items. Select features or components from the Feature Manager design tree or the graphics area.

2 Set options in the model Items property manager.

Dimensions are inserted for unabsorbed model sketches only if the sketch is visible in the drawing. To insert dimensions for an unabsorbed sketch, right-click the sketch in the Feature Manager design tree and select Show before inserting the dimensions. Dimensions belonging to an unabsorbed sketch are shown or hidden depending on the state of Show or Hide.

Fig 9

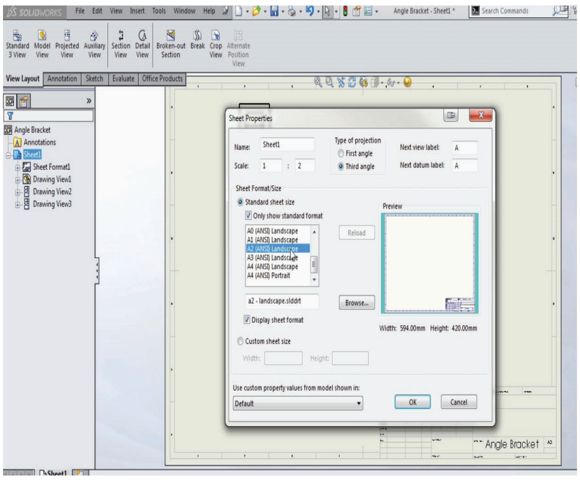
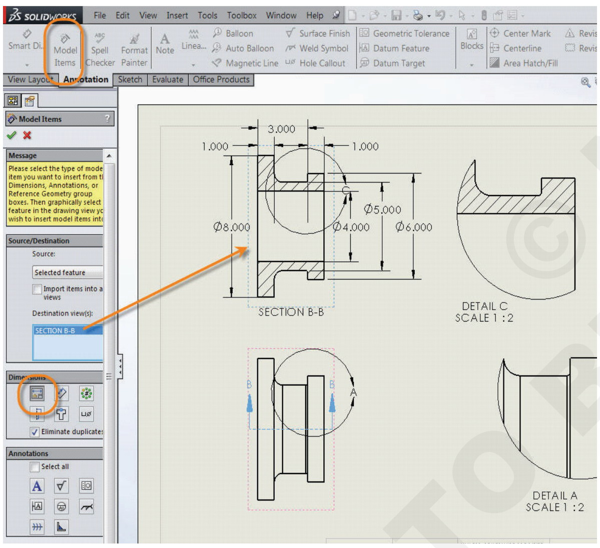


Fig 10



3 Click ✓.

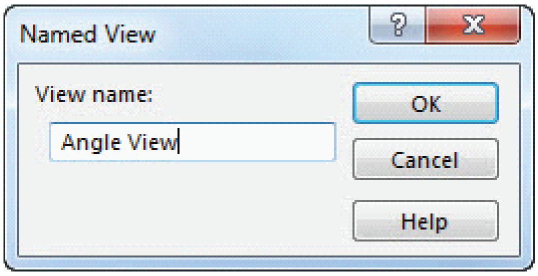
Toggle the visibility of individual reference geometry items. Right-click the item, and select Hide or Show.

Imported annotations display in the Annotations (Imported) color; reference annotations (added in the drawing) are displayed in the Annotations (Non Imported) color. These colors are specified in Tools > Options > System Options > Colors.

Named views (Fig 11)

Pick the New View icon . The Named View dialog box will appear (note: the model will revert to the view to be saved.) Enter the name for the new view in the View Name box. Hit OK.

Fig 11



A Named View has been successfully created.

To generate standard 3 views:

1 In a part or assembly document, click Make Drawing from Part/Assembly on the Standard toolbar and select a template in the Sheet Format/Size dialog box.

The View Palette opens on the right side of the window.

2 Click to pin the View Palette.

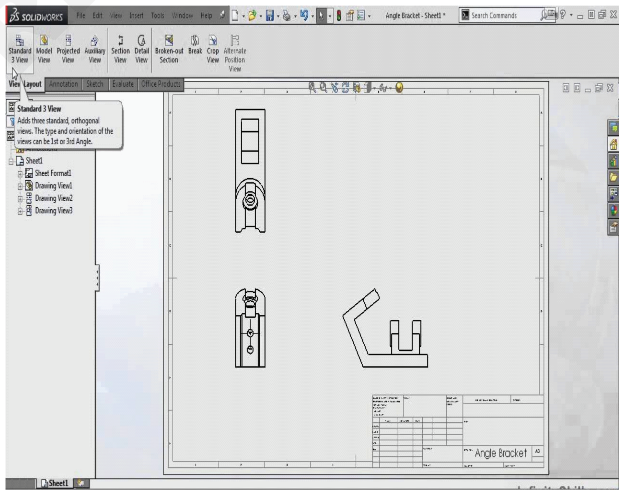
3 Drag a view from the View Palette onto the drawing sheet.

4 In the Drawing View or Projected View Property Manager, set options such as orientation, display style, scale, etc. then click ✓.

5 Repeat steps 3 and 4 to add views.

Auxiliary views (Fig 12)

Fig 12



The Auxiliary View and the Auxiliary View Label fonts specify the font type and size used for the letter labels on the auxiliary arrow and the auxiliary view label text.

An Auxiliary View in general is similar to a Projected view, but it is unfolded normal to a reference edge in an existing view. The reference edge can be an edge of a part, a silhouette edge, an axis, or a sketched line. If you sketch a line, activate the drawing view first.

Sectional views (Fig 13 & 14)

The Section View and the Section View Label fonts specify the font type and size used for the letter labels on the section lines and the text below the Section view. A Section view is generally used to create a new drawing view that is defined by cutting an existing view with a section line (Sketch).

Fig 13

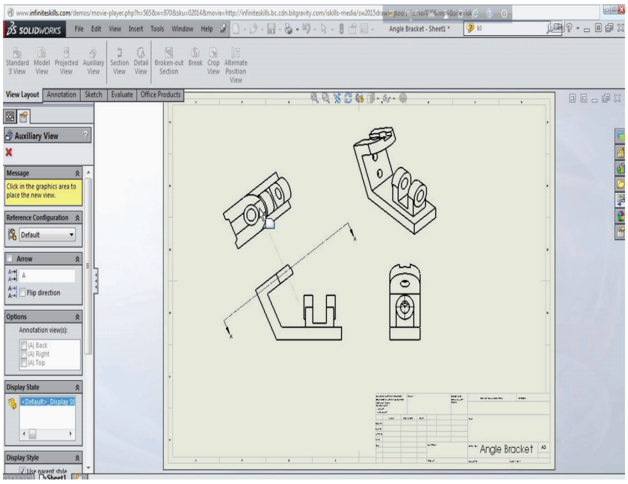
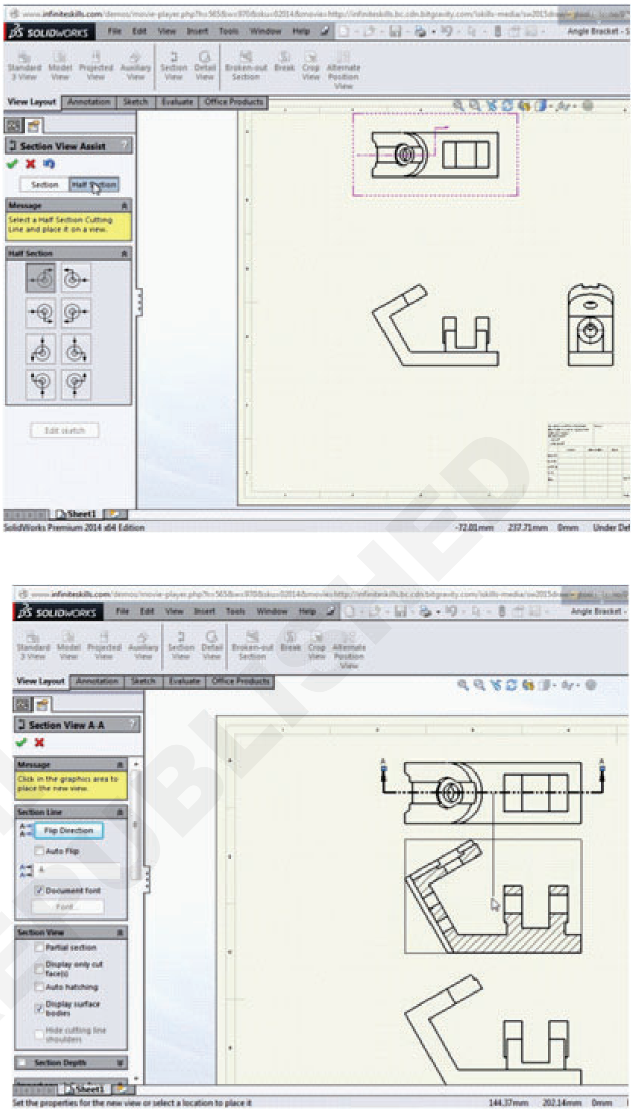


Fig 14

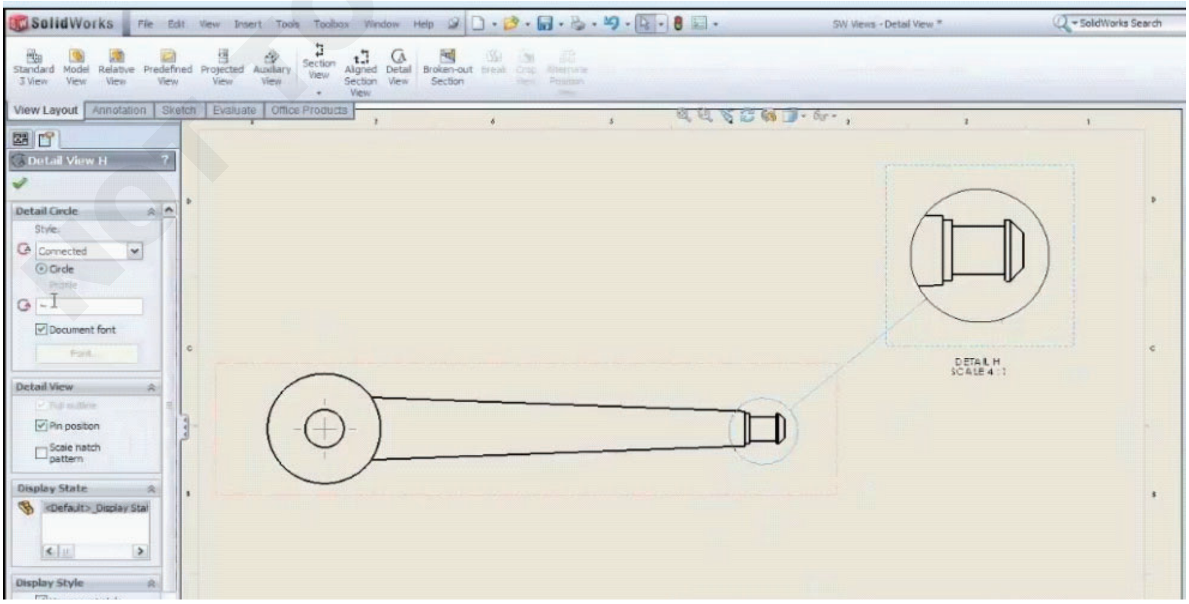


Detail views (Fig 15)

The detail view and the detail view label fonts specify the font type and size used for the letter labels on the detail circle and the text below the detail view.

A Detail View in general is used to create a new drawing view, which is an enlarged portion of an existing view. The enlarged portion is enclosed using sketch geometry, usually a circle or other closed contour like a spline.

Fig 15



Bottom up assembly modelling and components

Objectives: At the end of this lesson you shall be able to
- **explain bottom up assembly using assembly concepts.**

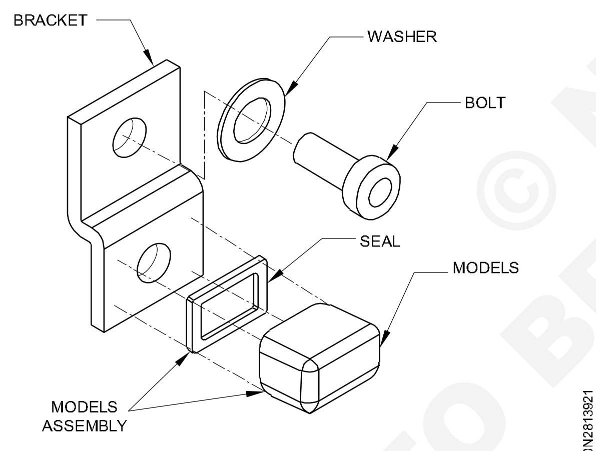
Assembly Concepts

When components are additional to an assembly, parent and child relationships are created. These relationships are displayed by graphically as an assembly tree. Parts are parametrically connected by position constraints. These constraints have data about how a part should be placed within the assembly hierarchy and how it should respond if other components are edited. (Fig 1)

Functioning within the framework of an assembly is prepared easier by accepting to apply more commands to other parts and sub-assemblies. These contain the Annotation Text, Inquire, Point, Datum Plane and Pattern Component commands. Bigger assembly performance is improved by removing unwanted redraws and improved display management while zooming.

Assembly models have additional data than simply the sum of their components. With assembly modeling interference verifies between parts and assembly: specific data such as mass properties.

Fig 1

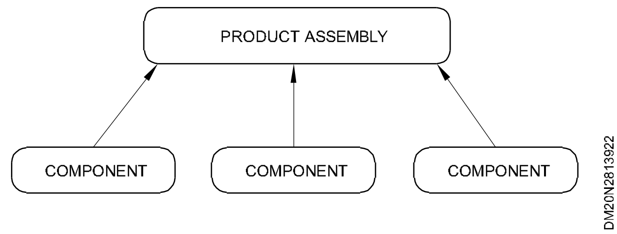


ASSEMBLY OF PARTS

Bottom up Assembly design

In a 'bottom up'assembly design, complex assemblies are divided interminor subassemblies and parts. Every part is considered as individual part by one or more designers. The parts can be archived in a library in one or more 30 Files. This is the high effective way to generate and manage complex assemblies. (Fig 2)

Fig 2



Every part is included into the active part making a component request and thus an assembly. The component will be the child of the active part and then it will be the active part. Hence an instance of the actual part is applied; it revises automatically if the archived part is edited by activating.

It is a design methodology in which each component is designed as a separate part without any reference to other components in the assembly.

The individual parts are designed to fulfil the intended function and then put together to form assemblies of a product. After the assembly is in place, problems are identified and modifications to individual components are made. As components are independent of each other, if one component is modified, the related components have to be changed manually. It is a manual approach to ensure that components fit properly and meet the design criteria.

Advantages

1 Design work on a product can be jump started

Disadvantages

1 Detecting the problems related to form and fit is a difficult process

2 Considerable amount of time is consumed for fixing individual components.

3 Due to placement constraints in an assembly, components are dependent on each other so a component cannot be removed, suppressed, or replaced without affecting other components.

Manufacture drawing

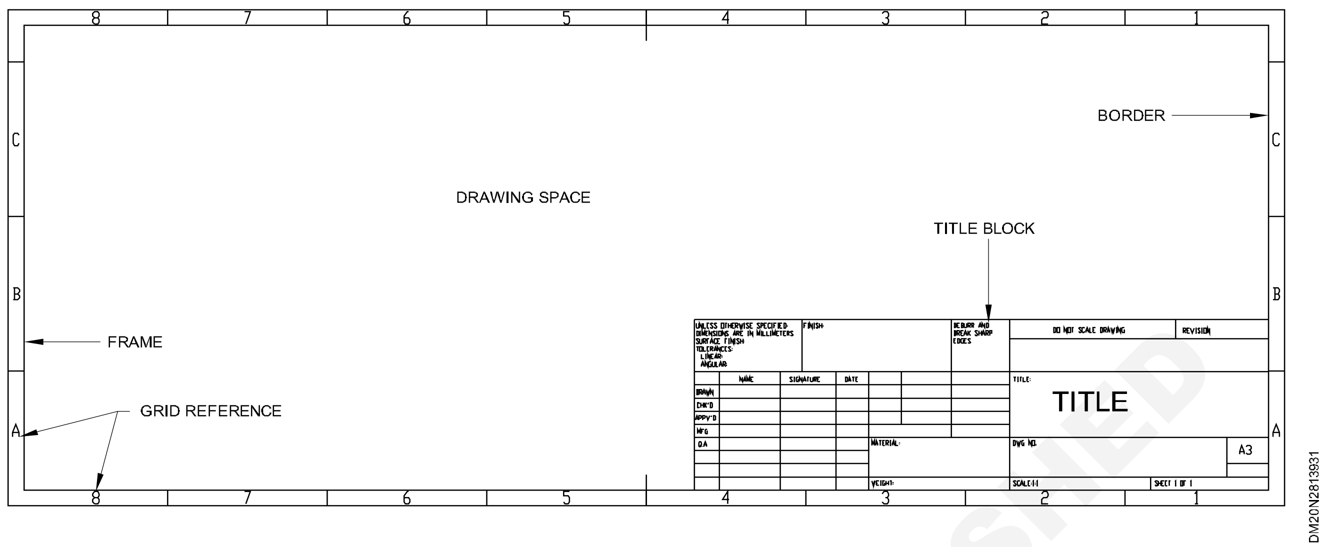
Objectives: At the end of this lesson you shall be able to
- **draw manufacture drawings**
- **draw title blocks orthographic drawing**
- **estimate bill of material.**

Understanding of manufacturing drawing can seem quite difficult compare to no symbols indicated on drawing sheet for manufacturing process of component. Sheet based on types of projection angles either they may be in first angle project.

These projections indicate types of view of component on drawing sheet. As drawing standards like scale, angles, gd& t symbols and paper size.

Drawing template having two line structures called outer frame. This outer frame including two lines alphabets and two numerical. (Fig 1)

Fig 1



Two lines are like horizontal and vertical lines while lines are continue to other end but in the template lines are not shown. Because of types of view of parts located in between manufacturing drawing sheets so lines are not shown like dark.

This case mostly used when understanding the manufacturing drawing may be in that having any typically identified part of details then designers are this alphabets and numerical to identify the part of details at the end of lines. Designers are mentioned there typical part of details.

Title block

- Name company name who prepared the drawing.
- **Name and date:** Responsible designer who drew, checked, and approved the drawing.
- **Part name/description:** Describes what the part name.
- **Part/drawing number:** Assigned number to identify the part in assembly part list.
- **Revision:** Identifies the correct version of the drawing.
- **Scale (optional):** Ratio of actual size of the part compared to the size of the part on the drawing.
- It can be shown as 1:1 or 1+1. The first number represents the actual size of the part and the second number represents the print. In other words, 1:2 means the print is double the actual size. Whereas 2:1 indicates the actual size is two times what is shown on the print.
- Note: Use the dimensions to create drawing template.

Size: Specifies the drawing sheet size

A0 = 841 X 1189,

A1 = 594 X 841,

A2 = 420 X 594,

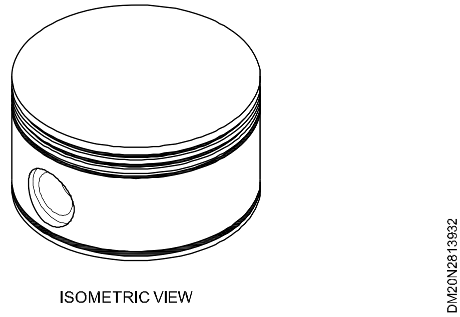
A3 = 297 X 420

A4 = 210 X 297 (in mm).

Isometric view of manufacturing drawing (Fig 2)

The representation of the object in figure is called an isometric drawing view. This is three - dimensional views called drawings. In the isometric view drawing show width, top view and height planes are placed on horizontal plane and isometric view shown 3d view of the object.

Fig 2



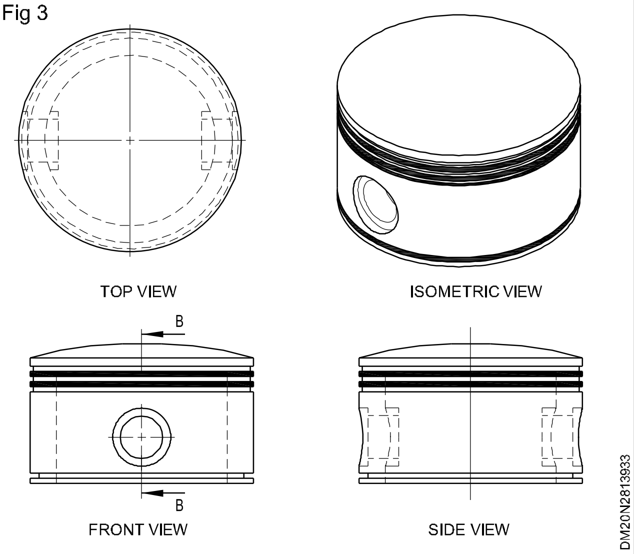
ISOMETRIC VIEW

Orthographic drawing views (front view, right side view, top view,) (Fig 3)

- Orthographic views are easy to understanding of actual visualization of the component.
- Projection is a way of visualizing different views of an object from there different sides such as a top view, front view, Right side view, the object is rotated based on 90 (degrees) clockwise and so that the viewer viewing the object can see each side as the part is rotated.
- These views are appearing then drawn on a drawing sheet or on paper, enough views are drawn of the object to help the person manufacturing of the part to get a good visualization of what the part looks like after manufacturing.
- The most common views drawn of an object in an orthographic drawings are the front view, and right side

view. After the views have been drawn on a sheet of paper notes and dimensions are then added for requirement of part.

Fig 3



Section views (half section views, cross section views) (Fig 4&5)

- Section views are represents the intricate views of the component
- A half section view help of an object showing one- half of the view in section of component, The diagonal lines on the section drawing are used to indicate the area that has been theoretically cut.
- These lines are called "hatching". The lines are thin and are usually at a s45-degree angle to the major outline of the object.
- The indicating hatching on the drawing view it is a thickness of part. Sectioning of the components to see the internal parts location, depth of holes, length of cut portions.
- Section views are mainly used for Assembling of parts, internal joints components and welding parts of details according to joining of particular part.
- Section views are enough to drawn of component to help of joining of components by welding and fitting.
- Geometrical dimensioning and Tolerancing is language of accurately communicate geometry requirement for associated features on assembly and individual manufacturing component drawings.
- GD & T consist of dimensioning, tolerances, symbols, definitions, rules and it is used for precisely communicate the functional requirements for the location, orientation, size, and form of each feature of the design models.
- GD & T symbols provides accurate dimension from point to point of requirement of model. Manufacturing of model based on the GD & T symbols.
- Manufacturing of the drawing having concise of GD & T symbols to help of understanding the drawing.

Fig 4

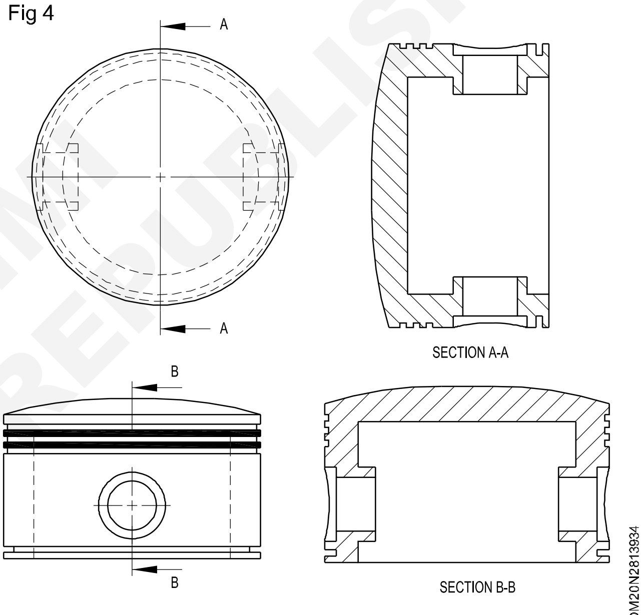
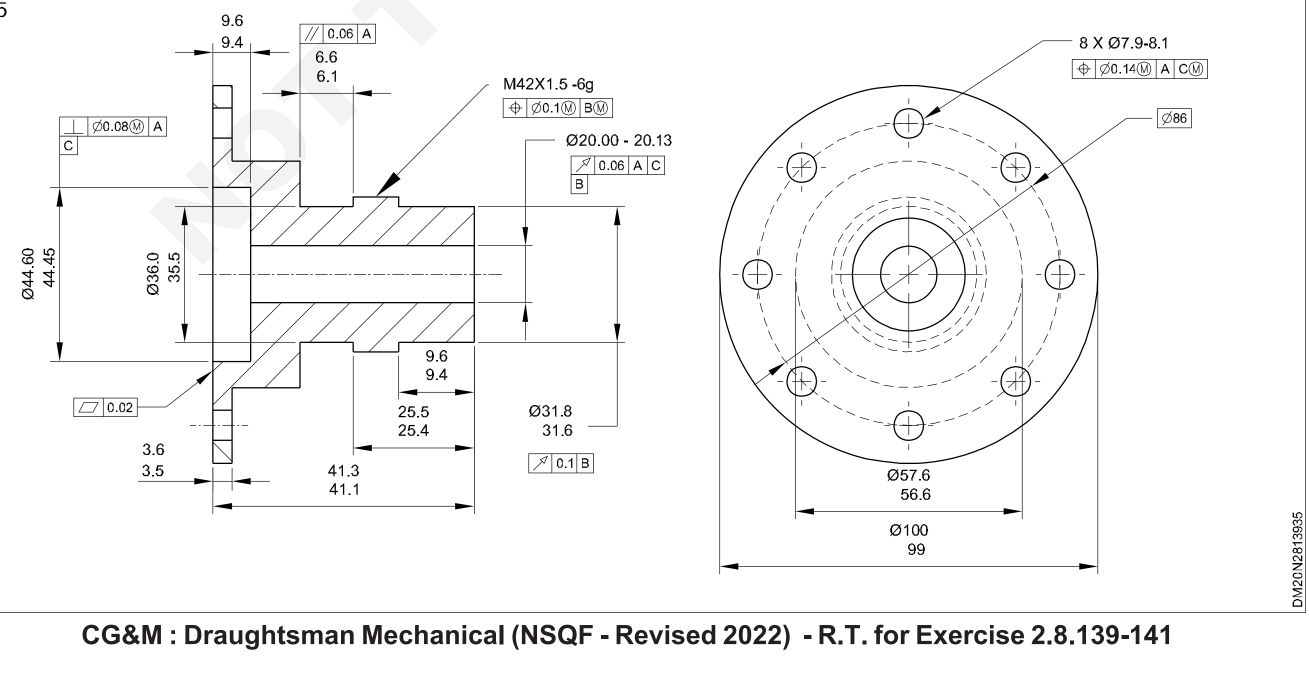


Fig 5



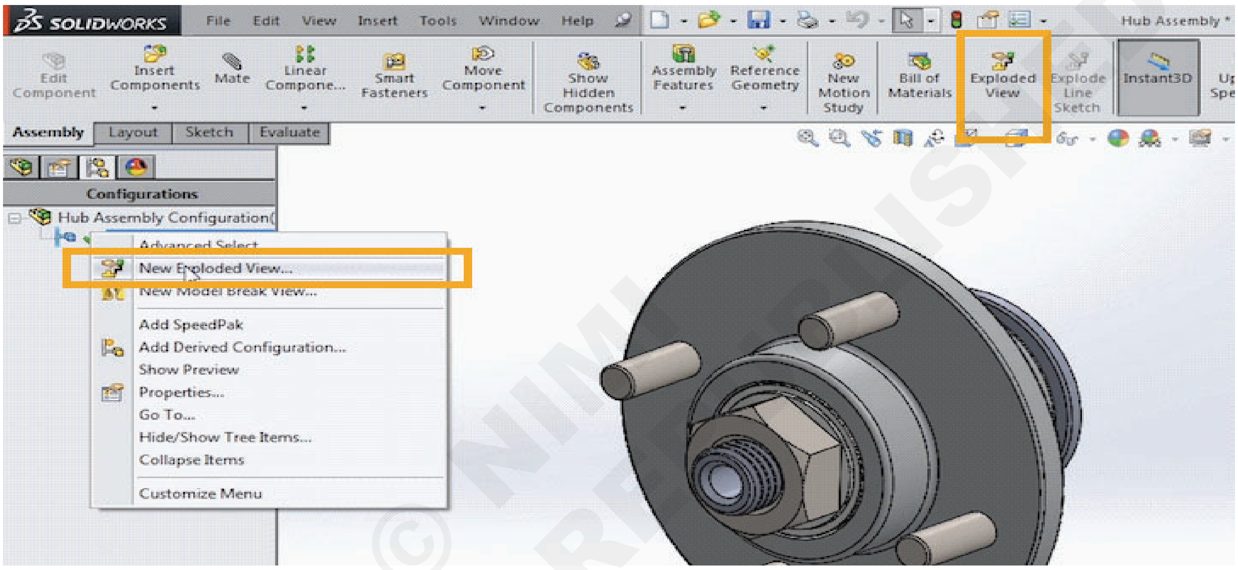
SolidWorks-creation of exploded view - Animation - Annotating holes & threads

Objectives: At the end of this lesson you shall be able to
- **create exploded view, animation controller, annotating holes and threads**
- **create center lines, symbols and leaders, simulation.**

Exploded views (Fig 1&2)

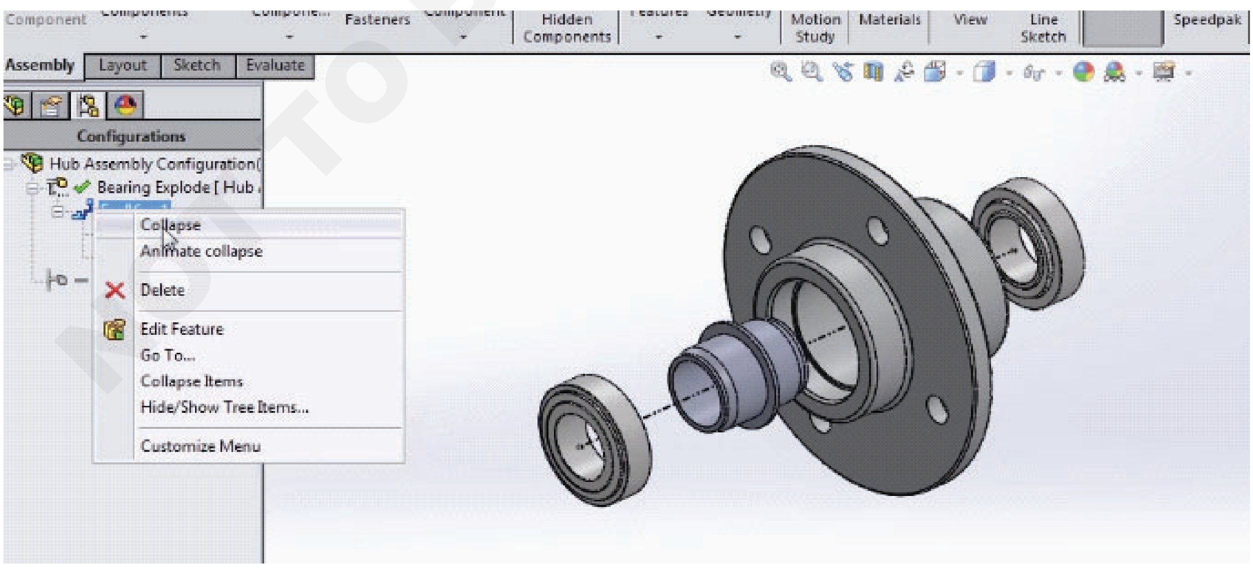
SolidWorks makes creating exploded views relatively easy; the process is in many ways automated, but also includes additional configuration options for getting it just right. To get started, go to Configuration Manager and right click on the configuration would like to display. From the context menu, simply choose New Exploded View, or choose Exploded View from the Assembly Tab at the top of the screen.

Fig 1



If the current configuration contains bolts or minor elements do not wish to include, it can also be created a new configuration and suppress those features.

Fig 2



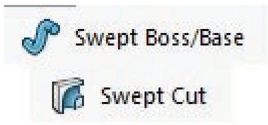
Animation controller

Assembly file that allows to create animations based on mates. This command is called Mate Controller. This function allows to move the assembly through a range of motion based on the limits set forth in the mates added to the assembly level. It can be moved a assembly based on range of motion and control several mates at one time.

Sweep (Fig 3)

Sweep is an extrusion tool that allows you to extrude a profile such as a circle or a square or a complex shape along a sketched path. When you think of swept features, their k of complex pipe routing or guard rails or springs. Because swept features are made up of a swept profile and a path that profile follows, the y generally require two

Fig 3



sketches (except when the profile is a simple circle or tubular shape).

Sweep has four main applications:

- Circular profile along a simple path
- Tubular profile along a simple path
- Custom profile along a simple path
- Profile along a helical path

LOFT (Fig 4)

- Loft is a tool that can be used to create some complex curvatures and shapes without reverting to surface modeling. Some example designs are heat shields, exhaust manifolds, vacuum and hair dryer attachments. We won't have an extensive section on this feature (this chapter is long enough) bu will link to some quality tutorials created by SolidWorks now that you have become familiar with the software.

Fig 4

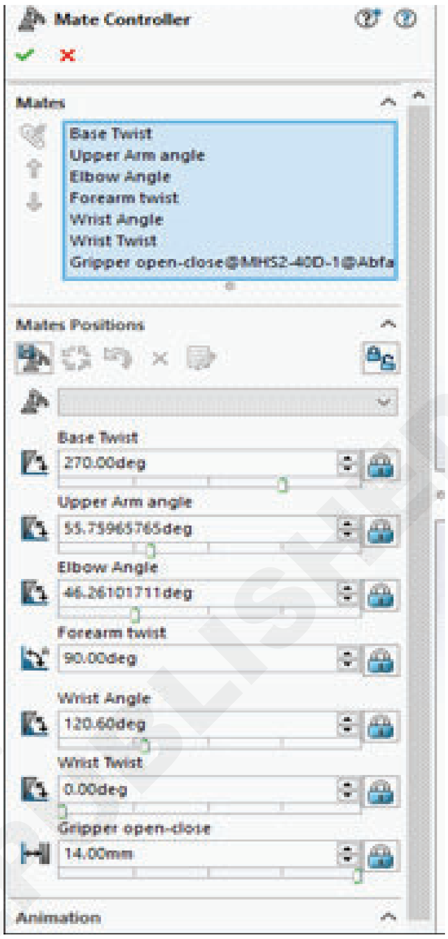
Difference between loft and sweep

Loft - Loft creates a feature by making transitions between profiles. A loft can be a base, bos:, cut, or surface. Sweep - Sweep create a base, boss, cut, or surface by moving a profile (section) along a path.

The mates that are available to use are: (Fig 5)

- Angle
- Distance
- Limit Angle
- Limit Distance
- Slot
- Width

Fig 5

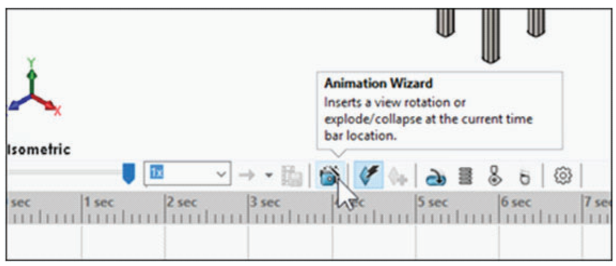


To setup a simple animation show range of motion, then take this mate controller feature and use this in a SOLIDWORKS Animation study to add camera positions, zoom factors, and other animation based functions.

Here's how this works

Switch to the Motion Study Tab at the bottom of the SOLIDWORKS screen. Next, click on the icon for the Animation Wizard: Fig 6

Fig 6



The next screen is going to ask about the length of the animation. Now this will take 10 or so seconds but get to choose when to start the actual animation of the mates. Usually to set this at 0 so that it starts right away, but it could have it wait for a second or two if it is required to zoom in first or something like that:

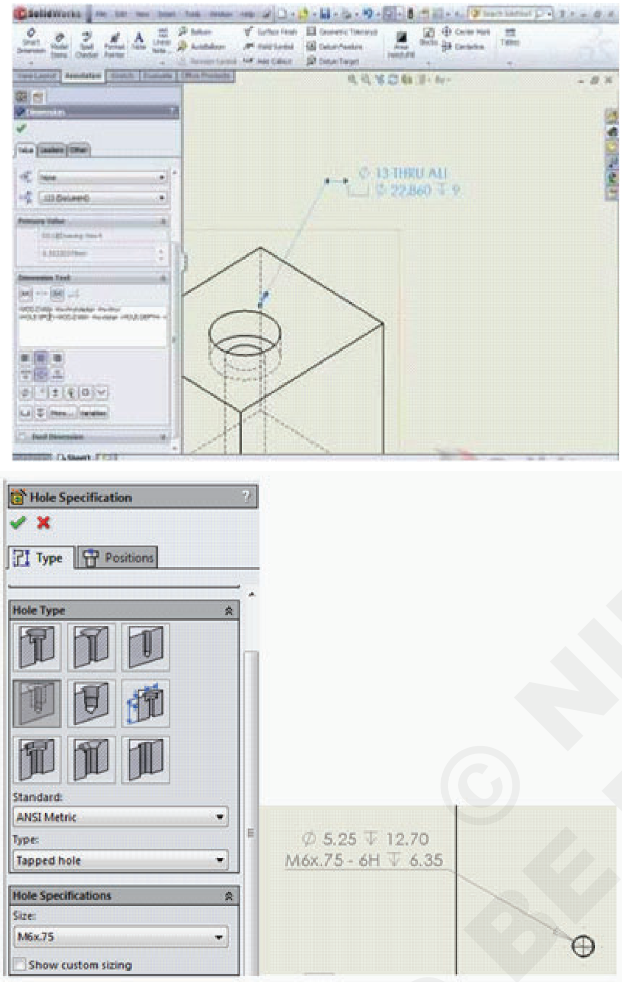
Annotating holes and threads (Fig 7)

- Click Hole Callout (Annotation toolbar), or click Insert> Annotations > Hole Callout.

The pointer changes to.

- Click the edge of a hole, then click in the graphics area to place the hole callout.

Fig 7



A Hole Callout is inserted and the Dimension Property Manager appears. The callout contains a diameter symbol and the dimension of the hole diameter. If the depth of the hole is known, the callout also contains a depth symbol and the dimension of the depth. If the hole is created in the Hole Wizard, the callout contains additional information (the dimensions of a countersink or number of hole instances, for example).

- Edit the callout in the Dimension Property Manager.

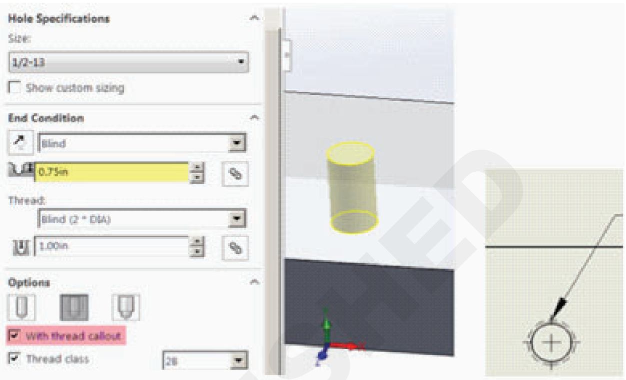
You can specify precision, select an arrow style, or add text. However, you should retain the dimensions and symbols for the size and type of hole.

If the hole has been created by the Hole Wizard, you can also click Variables in the Dimension Property Manager to access a list of Callout Variables to insert into the hole callout.

If you attach a hole callout to a tapped hole in ANSI inch standard and the current drawing units are millimeters, the drill diameter and hole depths are reported in mm but the thread description retains the ANSI inch size designation. You might want to replace the thread description with other variables from the Callout Variables dialog box.

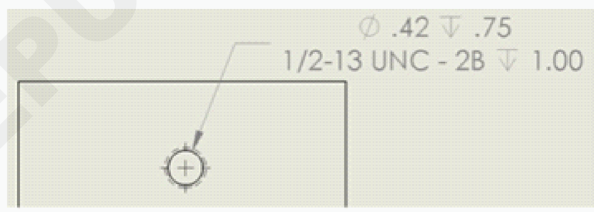
From Hole Wizard tapped holes, the option to include cosmetic threads with or without thread callouts. Using thread callouts results in a drawing note that doesn't conform to usual drafting standards. (Fig 8)

Fig 8



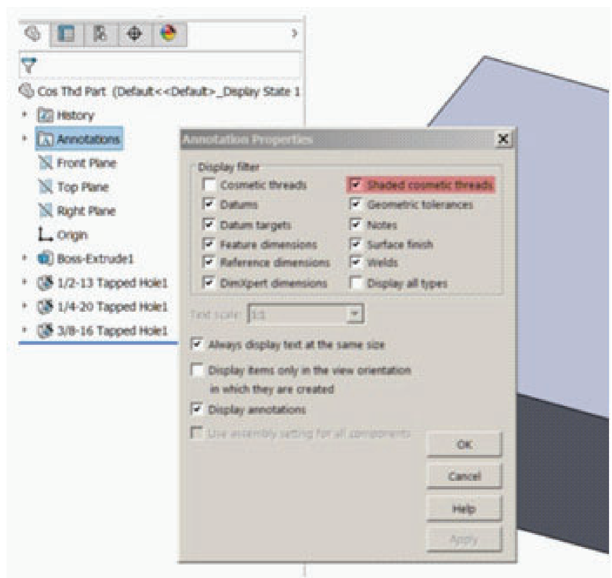
Unchecking 'With thread callout' removes the note and lets to use 'Insert > Annotations>Hole callout' in the drawing to get a note conforming to the drafting standard. (Fig 9)

Fig 9



Dashed line cosmetic threads are useful in drawing orthographic views. In this case, right click the annotations folder in the Feature Manager, then click Details, deselect Cosmetic threads and select Shaded cosmetic threads. Shaded threads give a realistic view in a model file. (Fig 10)

Fig 10



Cosmetic threads are not shown in assemblies by default. It can show cosmetic threads by making four settings: View menu > Hide/Show All annotations; Right click the Annotations folder > Details> Cosmetic threads> Apply; Right click the Annotations folder > Details> Check 'Use assembly settings for all components'> Apply; Right click the Annotations folder > Display Annotations.

Creating centerlines

To create centre lines the settings to be applied to all future part drawings, it is required to update the templates by adding these options and resaving those templates.

Navigating to these Auto Insert options

- Tools
- Options
- Document Properties
- Detailing
- Auto insert on view creation

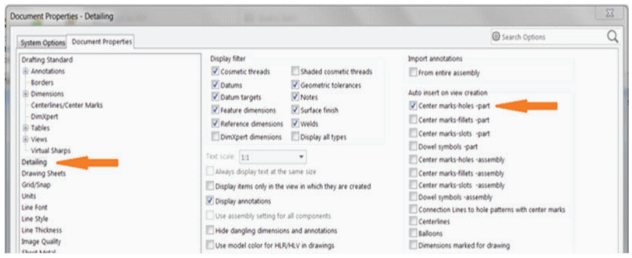
Below is an image which points using orange arrows, to the Detailing option and first option we talk about under the Auto Insert on view creation. (Fig 11)

The first auto insert option with regards to centerlines is the first in the list "Center marks-holes-part". This option will add centerlines to the holes visible when straight on a view like the drawing demonstrated below.

The second option for Auto Insert centerlines is "Centerlines", navigating to it is the same as listed above.

This second option will add centerlines through the part for any view orientation. Therefore displaying a through hole in this parts right side and isometric views. Image below shows this new type of centerline which can be automatically inserted on view creation.

Fig 11



Creating symbols

There is a new document option for the automatic creation of all dowel pin symbols on view creation. Go to Tools > Options. On the Document Properties tab, click Detailing. Under Auto insert on view creation, you can select either Dowel symbols -part or Dowel symbols -assembly. Then, click OK. (Fig 12, 13, 14)

Fig 12

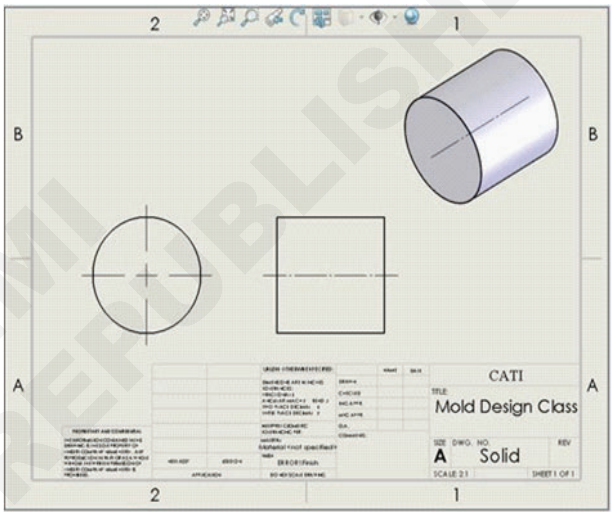


Fig 13

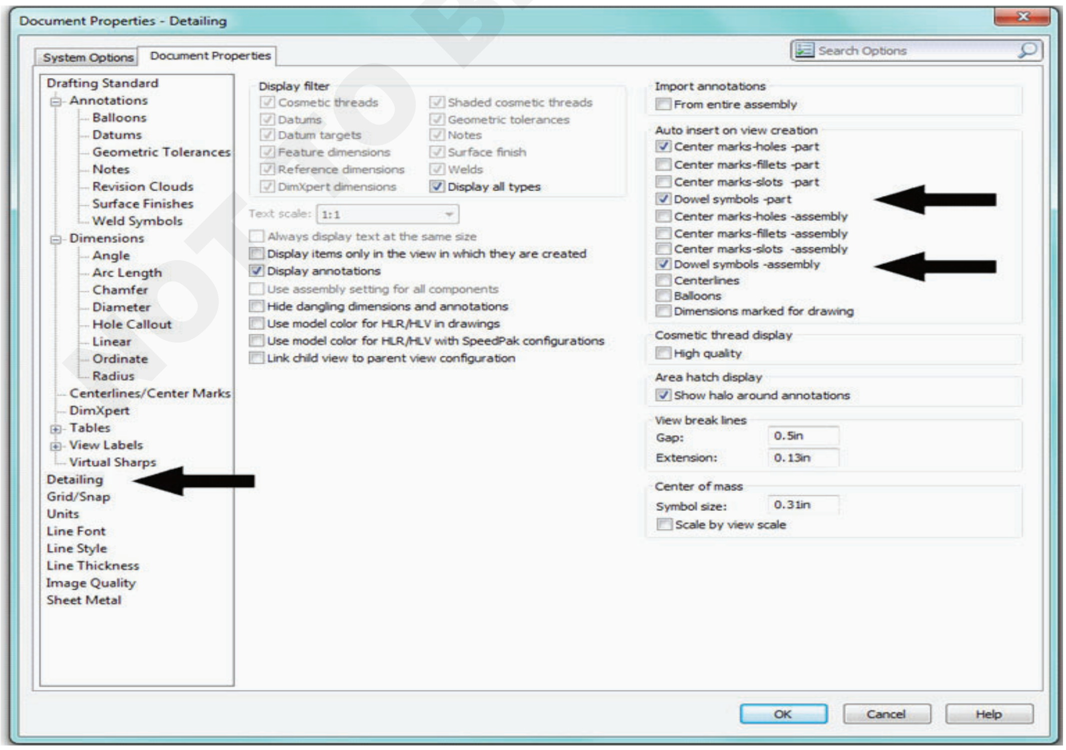
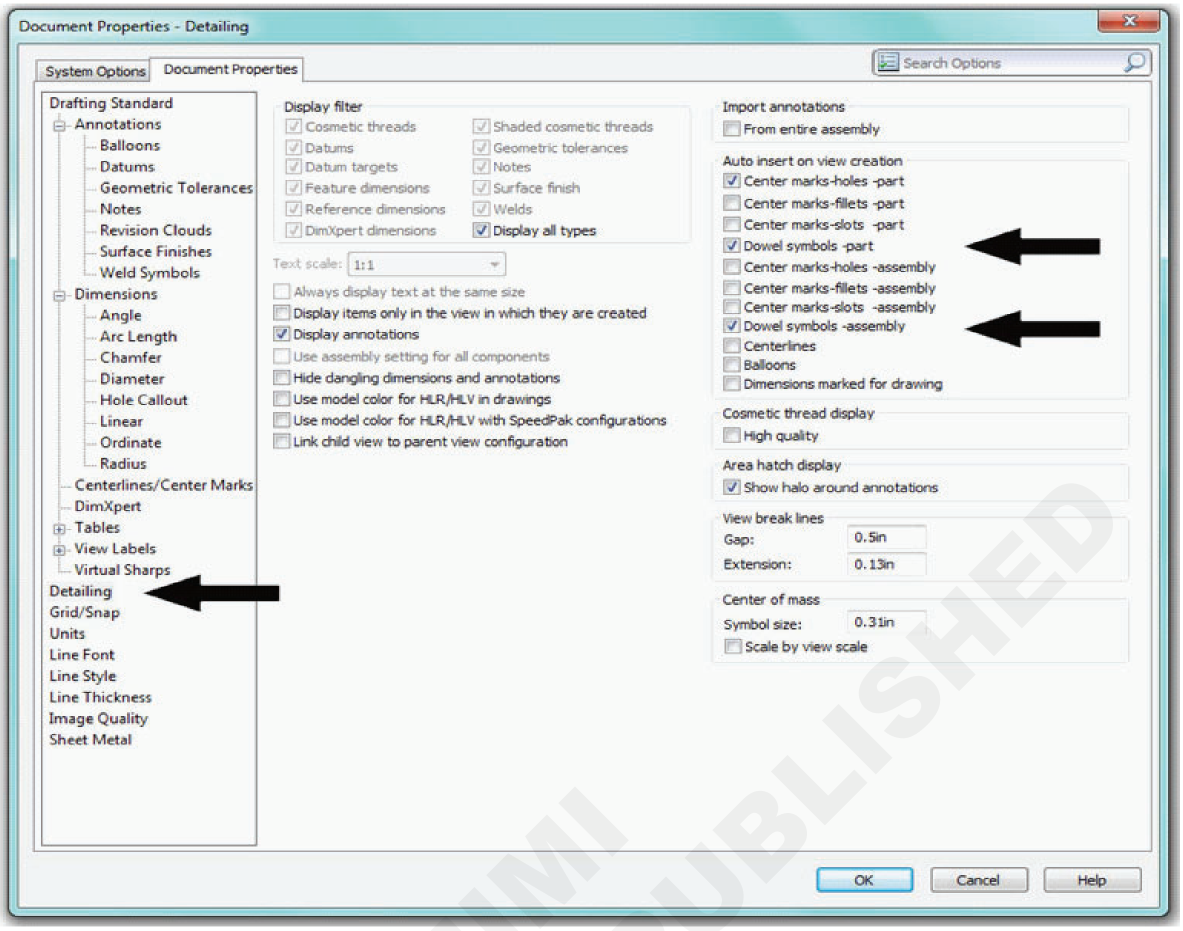


Fig 14



It can be automatically insert all dowel pin symbols in a Solid Works drawing view after view creation. Similarly, insertion of dowel pin symbols for dowel holes created with the Hole Wizard. To insert dowel pin symbols into a drawing, pull down the Insert menu and pick Annotations > Dowel Pin Symbol. Under Auto Insert, select For all dowel holes.

Selecting the drawing views, the dowel pin symbols are inserted in the view. The ability to flip a dowel pin symbol after it has been inserted (right-click the symbol and click Flip Symbol.)

Lastly, to manually insert dowel pin symbols into a Solid Works drawing, pull down the Insert menu and pick Annotations > Dowel Pin Symbol. Select a circular edge, a sketched circle, or an arc. Note that pre-select circular edges, sketched circles, or arcs and then click Insert > Annotations > Dowel Pin Symbol. Dowel pin symbols appear in the selected holes. (Fig 15)

Creating Leaders

To assign multiple leaders from a single annotation. There are several different ways of creating multiple leaders depending on what type of annotation are using. (Fig 16)

Fig 15

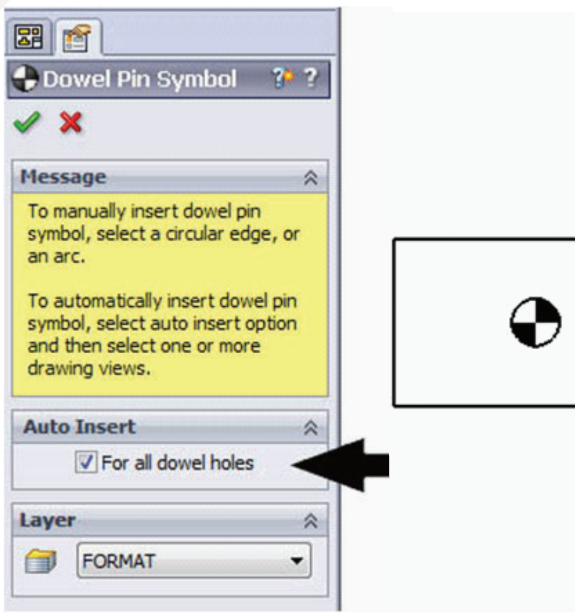
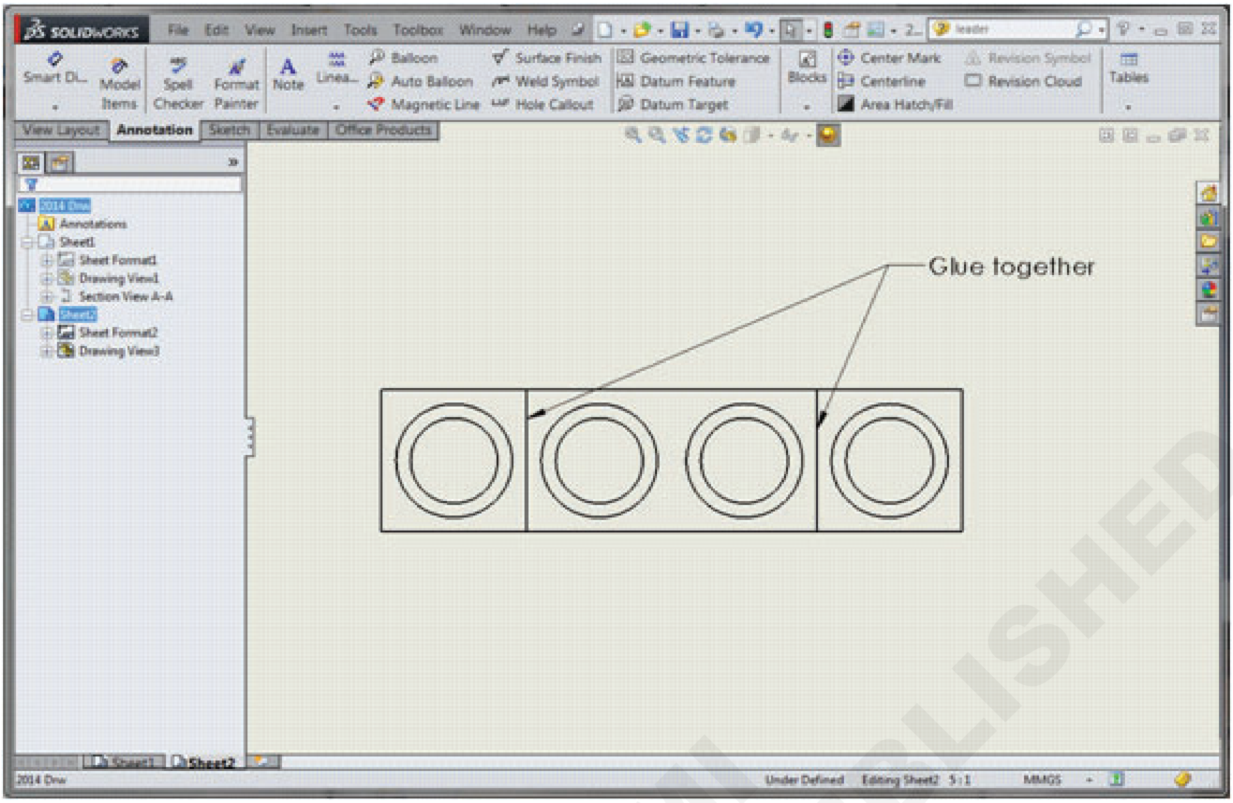


Fig 16



1 Pre-select when adding note

- for adding Notes that need to point to multiple locations, pre-select the vertices, edges or faces and then use the Note tool

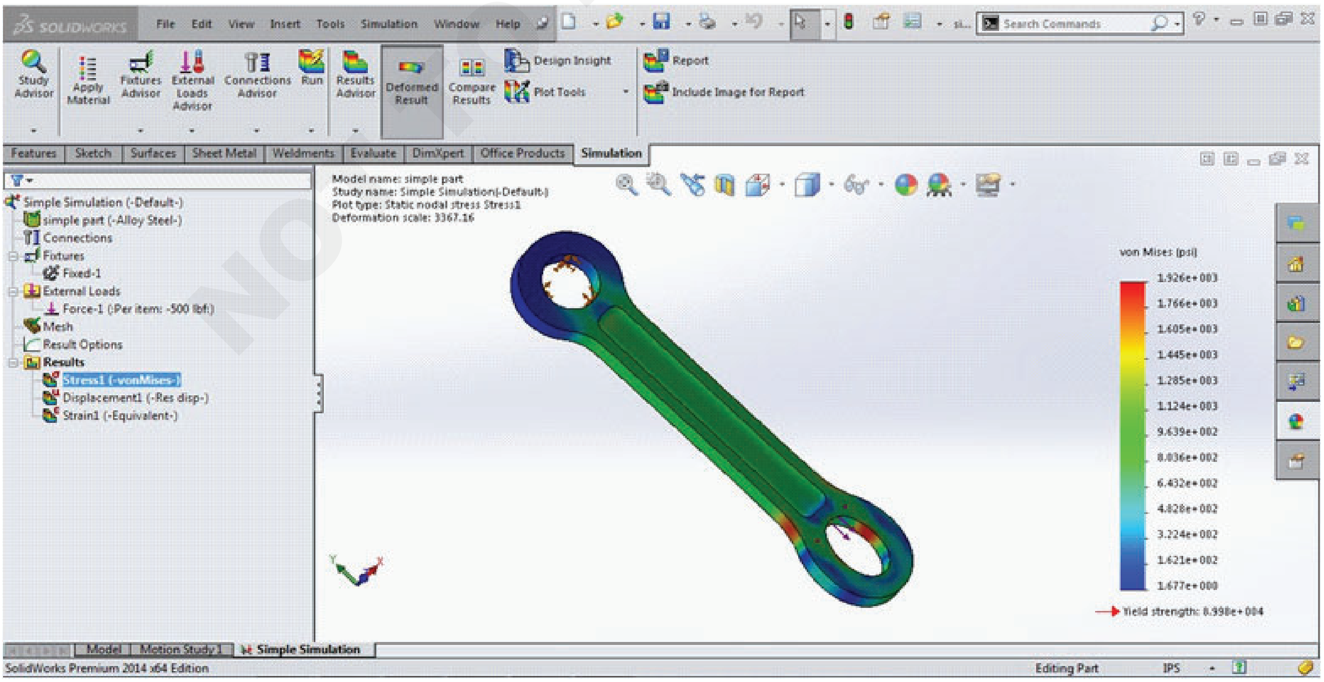
2 Ctrl-select before placing the annotation

- When using an annotation tool like Balloon, select the location for the first leader, then hold Ctrl and select as many additional leader locations
- Then click to place the annotation

3 Ctrl-drag existing leader attachment points to other locations

- If an annotation has already been placed on the drawing with a leader, Ctrl-drag the leader attachment point and drop it on another location

Fig 17



Create Simulation

Solidworks simulation professional enables to optimize you design, determine product, mechanical resistance, product durably, to apology, natural frequencies, and test heat transfer and buckling instabilities it Can also perform sequential multi-physics Simulations."pant of solid works simulation's ease of use are the simple six steps that every Simulation study shares. (Fig 17, 18)

Step 1: Define your study. Static, Thermal, frequency, etc

Step 2: Assign your materials

Step3: Apply the Boundary Conditions (free body diagram)

Step 4: Mesh the model

Step 5: Run the analysis (Step 6: View the results)

Step 6: View the results

Creating a Simulation Temp directory

1 Create a temporary directory named Simulation Temp in the Examples folder of the SolidWorks Simulation installation directory. (Fig 19)

2 Copy the Solid Works Simulation Education Examples directory into the Simulation Temp directory. (Fig 20, 21)

Fig 18

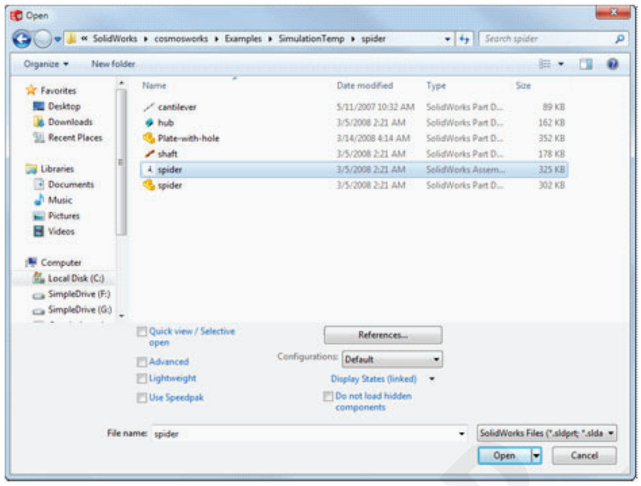


Fig 19

Fig 20

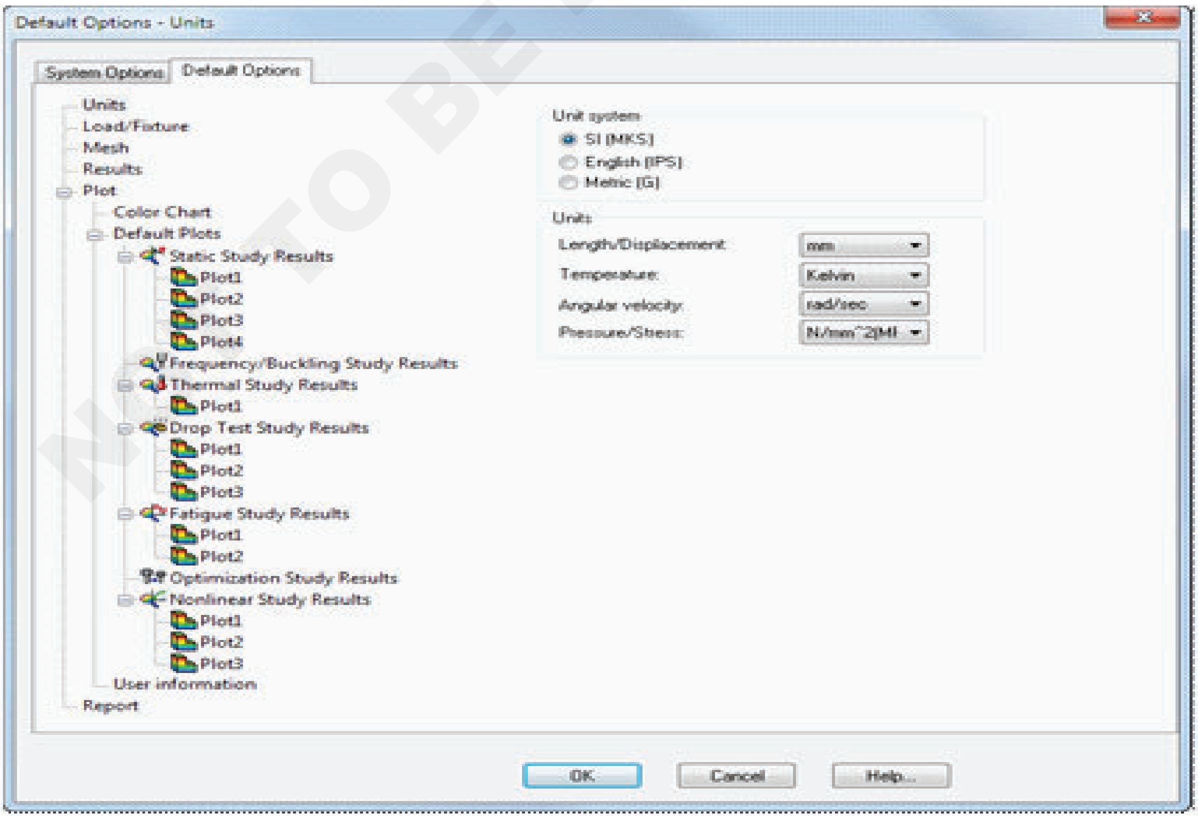
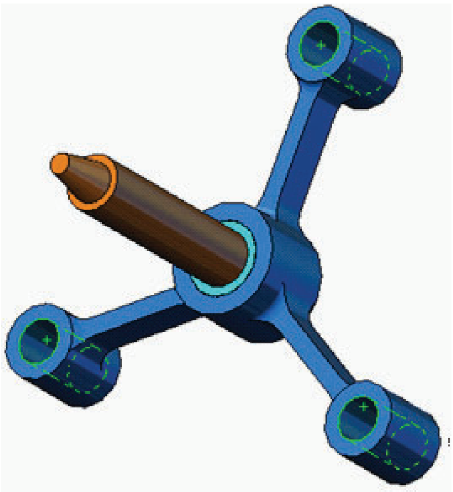


Fig 21



Setting the Analysis Units

Before start this lesson, set the analysis units.

1 On the SolidWorks menu bar click Simulation, Options.

2 Click the Default Options tab.

3 Select SI (MKS) under Unit system.

4 Select mm and N/mm2(MPa) from the Length/Displacement and Pressure/Stress fields, respectively.

5 Click OK.

Detailed information of production drawing

Objectives: At the end of this lesson you shall be able to
- **study production drawing**
- **state the elements of production drawing**
- **state the other features and classification of drawing.**

Production Drawing

- Production drawings (sometimes called as working drawing are complete sets of drawings that the manufacturing and assembly of products. They are widely used as orthographic views of machine parts and their assembly.
- Production drawings are drawn (graphic) information prepared by the design team for use by the construction or production team, the main purpose of which is to define the size, shape, location and production of the building or component.
- The drawings many also outline the most convenient order in which to assemble components.

Main sets of production drawings

The three main sets of production drawings include the following:

- Detail of each non - standard part on a drawing sheet, usually one part per sheet
- Assembly drawing showing all parts on one sheet
- A bill of materials (BOM), essentially of each part

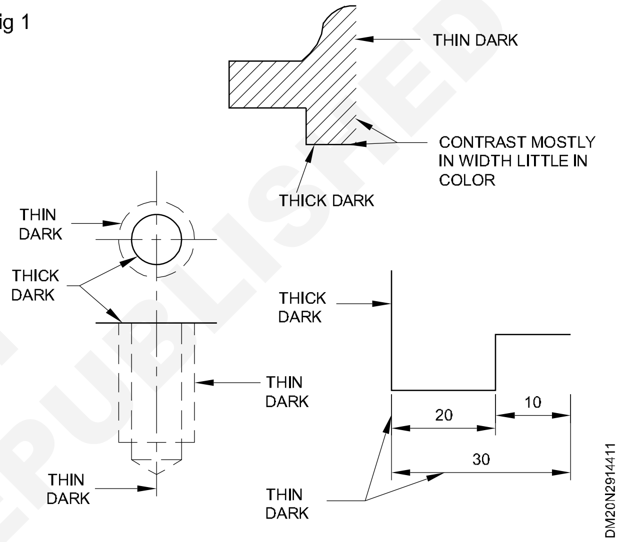
Elements of production drawings

- Size and shape of component
- Format of drawing sheet
- Process sheet
- Projection method
- Limits, fits, and tolerances, of size, form, and position
- Production method
- Indication of surface roughness and other heat treatments
- Conventions used to represent certain machine components
- Inspection and testing methods

Basic principles of dimensioning in production drawings (Fig 1)

- The drawing module should dimension each feature only once.
- The drawing should show no more dimensions than necessary.
- Place dimensions outside the drawing view as far as possible.
- Represent dimensions by visible outlines rather than by hidden lines.
- Avoid dimensioning the center line, except when it passes through the centre hole

Fig 1



Bill of materials (Fig 2)

- The parts list is a listing of all of the component parts of the assembly. The parts list includes part number, part name, number required, material of part, and sometimes other descriptive text. The parts list is clouded on all detail drawings and assembly drawings or can be on a separate sheet. Generally the parts list is shown with the assembly drawings and includes only those parts shown on the assembly drawing sheet.

Fig 2

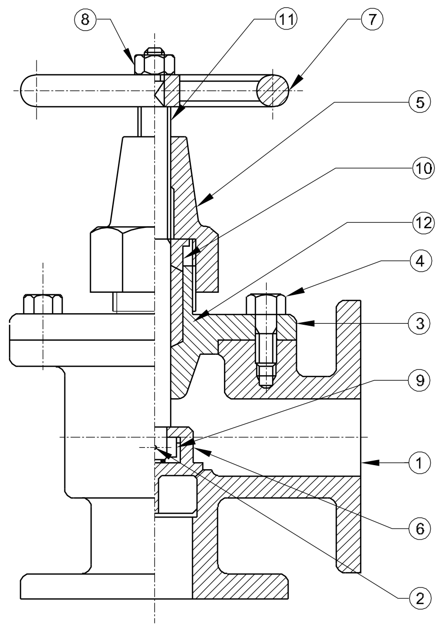
4	BLOCK	1	SAE 1020
3	RING	1	SAE 1020
2	WEDGE	1	SAE 1020
1	SCREW	1	SAE 1112
No	Part name	Qnty.	Material

DM20N2914412

Assembly Drawings (Fig 3)

- An assembly drawing shows the assembled machine or structure with all detail parts in their functional positions.
- Assembly drawings show how the parts fit together in the assembly and to suggest function.

Fig 3



ITEM LIST

ITEM	DESCRIPTION	QTY	MATERIAL
1	BODY	1	C.I.
2	PIN	1	G.M.
3	COVER	1	C.I.
4	BOLT	4	M.S.
5	GLAND NUT	1	G.M.
6	VALVE	1	G.M.
7	HAND WHEEL	1	C.I.
8	NUT	1	M.S.
9	COLLAR	1	G.M.
10	GLAND	1	G.M.
11	SPINDLE	1	G.M.
12	PACKING	-	ASBESTOS

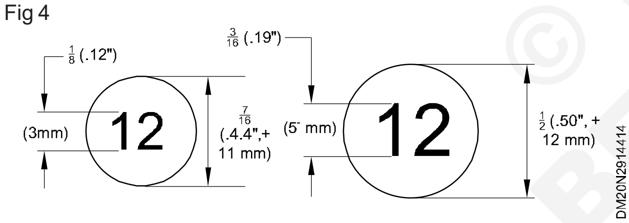
STEAM STOP VALVE (ASSEMBLY)

DM20N2914413

Part identification (Fig 4)

- Circles containing part numbers are used to identify parts on detail and assembly drawings.
- Identification circles on assembly drawings are placed adjacent to the parts with leaders terminated by arrowheads touching the parts.
- Identification circles used to identify a detail drawing of a part are placed below the detail.

Fig 4



DM20N2914414

Table of contents

Scope

This procedure defines the requirements for releasing and editing approved / issued drawings, individual responsibilities and vendor contracts. Critical components (research programs) that are being fabricated or modified in a strict configuration- control process are included.

Procedure for Releasing and Revising Drawings

As any given design matures from concept through to completion, it is important to follow a semi - formal review process prior to initial release to fabrication. This should be true even in our research and development environment. Important aspects of the design to be considered Should include, but are not limited to :

- Manufacturability in a machine shop
- Value engineering
- Vacuum properties
- Synchrotron radiation power parameters
- All other power and heat loads
- Physical stresses and strains
- Aperture checkout
- Installation procedure
- Welding (including EBW) and /or braze joint design
- Utilities integration

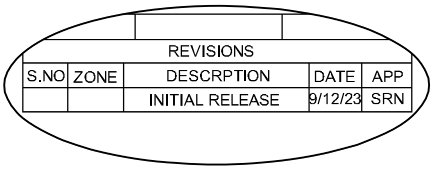
The author or originator of the design is responsible for consultation and review of the afore mentioned properties and obtain explicit approvals where applicable.

Once a drawing has been released and issued into the design office it is very important to understand and follow a best practice for changing those drawings, writing revisions (rev letter increments), and releasing / issuing those revised drawings. Design - Drafting Office must not be sent for fabrication, especially to outside vendors,

A design develops to a point where the initial drawings have been completed. The author (defined as originator of the design or originator or subsequent design changes) communicates to the Design-Drafting Office when they have been approved and are ready to be released and issued for fabrication,

The Design - Drafting Office plots the drawings and enters the initial release data, from the drawing title block, into the drawing database. This release data includes the release /plot date, the author's name (Drawn For), the drawing titles and sheet quantities. At this time, the plot date on every sheet's title block reflects the date that any sheet of the drawing was last revised or released. There is no revision letter used at the initial release, either in the title block or the revision history in the upper right hand corner of every drawing sheet. However, the date and approval fields for the initial Release should be filled out by the drafting office to show that the sheet has been released and is OK to send to the shop or outside vendors. (Fig 5 & 6).

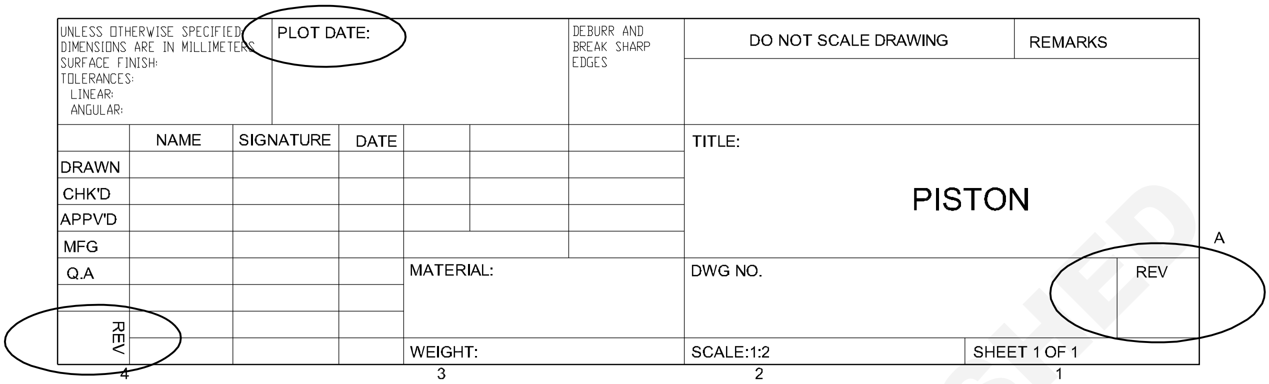
Fig 5



REVISIN HISTORY (UPPER RIGHT CORNER OF SHEET)

DM20N2914415

Fig 6

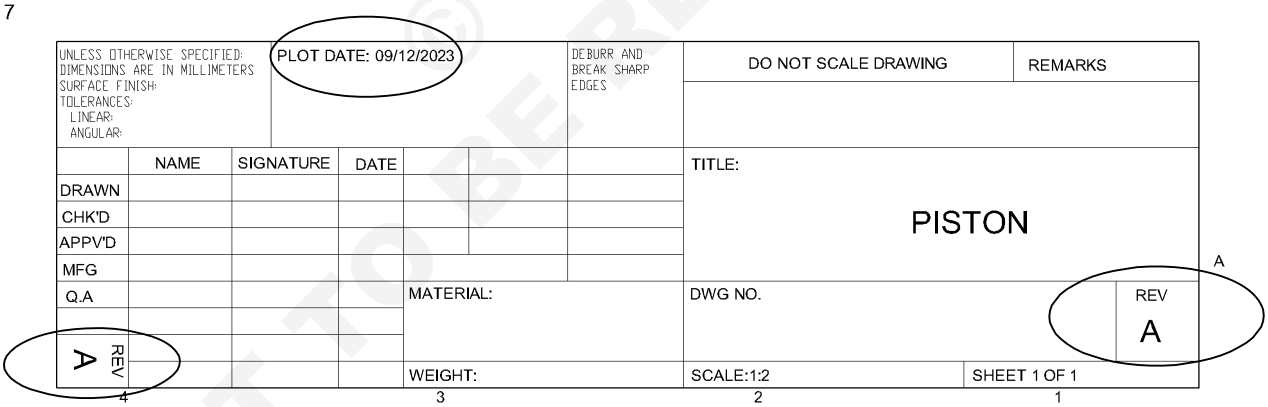


TITLE BLOCK

DM20N2914416

Changing any drawing after it has been released necessitates writing a revision to the affected sheet(s). This revision could be as minor as adding a missing dimension or as major as total part re - designs. The same approval process for releasing drawings initially is also followed for approving the revised drawings. The author communicates to the design - drafting office when the revisions have been approved and are ready to be released and issued. At this time, the title block and revision history sections of the drawing have been edited to show an incremental revision letter distinguishing the revised sheet from the initial release. The plot date is also changed to reflect this revision release date, further distinguishing it from the initial release. (Fig 7,8)

Fig 7



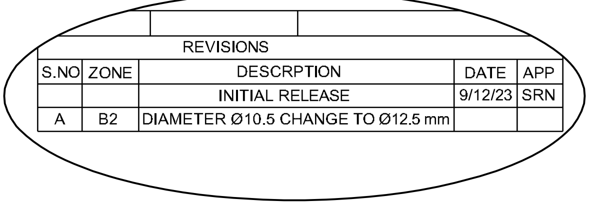
REVISED TITLE BLOCK

DM20N2914417

It is the author's responsibility to secure approval for the revisions from the original drawing approver (if available) and to secure any relevant system approvals for SR power, Aperture Checkout, HOM heating, Vacuum properties and Installation procedure if/when applicable. It is then the responsibility of the author to make sure a hard copy of the revised drawing goes to the Machine shop purchasing office for relay to the outside vendor. If requested by the designated contact person for the order, the Design - drafting office will forward these drawings electronically to the vendor. The purchasing Office will be copied on this electronic transfer and , if needed, a change order will be negotiated and issued.

This process is repeated each time released drawing needs to be revised.

Fig 8



REVISIN HISTORY UPDATED

DM20N2914418

Numbering of drawings and standard parts(Familiarization with SP:46-2003)

Objectives: At the end of this lesson you shall be able to
- **explain scope and item references.**

Scope

This section gives guidance and recommendations on establishment of item reference and item list for use with technical drawings.

Item References

The item references should be assigned in sequential order to each component part shown in an assembly and /or each detailed item on the drawing. Further identical parts shown in the same assembly should have the same item reference. All item references shall be shown in an item list (Fig 1 and Table 1)

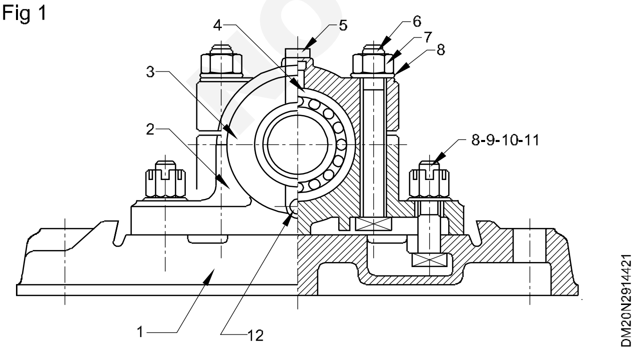
Table 1

Item	Quantity	Description	Reference Material
1	1	Base	
2.	1	Bottom housing	
3	1	Top housing	
4	1	Bearing	
5	1	Filling plug	
6	2	T-bolt	
7	2	Hex nut	
8	4	Washer	
9	2	T-bolt	
10	2	Castle nut	
11	2	Split pin	
12	1	Drain plug	

Presentation

Item references should generally be composed of Arabic Item reference shall be placed outside the general outlines of the items concerned.

Fig 1

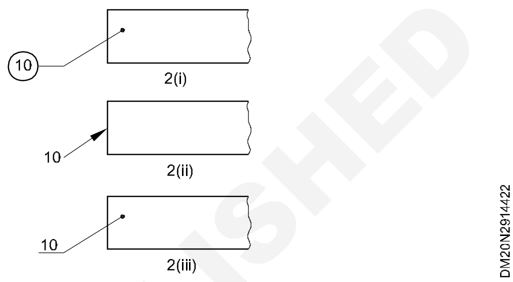


All item references on the same drawing shall be of the same type and height of lettering. They shall be clearly distinguishable from all other indications. This can be achieved, for example by:

a using characters of a larger height for example, twice the height as used for dimensioning and similar indications;

b encircling the characters of each item reference, in that case all such circles shall have the same diameter and to be drawn with continuous narrow line (Fig 2)

Fig 2



c combining methods (a) and (b)

Item reference shall be placed outside the general outlines of the items concerned.

Each item reference should be connected to its associated item by a leader line (Fig 2(i), 2(ii) and 2(iii))

Leader lines shall not intersect. They should be kept as short as practicable and generally should be drawn at an angle to the item reference. In case of encircled item references, the leader line shall be directed towards the centre of the circle.

Item references of related items may be shown against the same leader line (Fig 2, Items 8,9, 10 and 11). These item reference may be separated from each other by a short--when written horizontally.

Item references of identical items need only by shown once, provided there is no risk of ambiguity.

Item List

Item lists are complete lists of the items constituting an assembly (or a sub-assembly), or of detailed parts, presented on a technical drawing. It is not necessary for all these items to be detailed on an end-product drawing. The association between the items on an item -list and their representation on the relevant drawing (or on other drawings) is given by the item references.

The item lists may be included on the drawing itself or be a separate document.

When the item list is included in the drawing, the sequence shall be form bottom to top, with headings of the column immediately underneath with separate item lists, the sequence shall be from top to bottom with headings at the top.

When included on the drawing, the position of the item list should be such as to be read in the viewing direction of the drawing. The list may be in conjunction with the title block. Its outlines may be drawn with continuous wide lines.

Where the item list is shown on a separate document, this shall be identified by the same number as that of the parent drawing.

However, to distinguish this identification from that of the parent drawing, it is recommended that the item list number be preceded by the prefix item list (or a similar term in the language used on the documents)

Layout

It is recommended that the item list be arranged in columns by means of continuous wide or narrow lines to allow information to be entered under the following headings (the sequence of these is optional):

a item

b description,

c quantity,

d reference, and

e material.

If necessary, more columns can be added to cover specific requirements.

Classification of drawings

Objectives: At the end of this lesson you shall be able to
- **explain production drawing and machine drawing**
- **describe classification of drawings.**

Machine drawing

It is pertaining to machine parts or components. it is presented through a number of orthographic views, so that the size and shape of the component is fully understood. Part drawings and assembly drawings belong to this classification. An example of a machine drawing is given in Fig 1.

Production drawing

A production drawing, also referred to as working drawing, should furnish all the dimensions, limits and special finishing processes such as heat treatment, honing, lapping, surface finish, etc., to guide the craftsman on the shop floor in producing the component. The title should also mention the material used for the product, number of parts required for the assembled unit, etc.

Since a craftsman will ordinarily make one component at a time, it is advisable to prepare the production drawing of each component on a separate sheet. However, i some cases the drawings of related components may be given on the same sheet. Fig 2 represents an example of a production drawing.

Part drawing

Component or part drawing is a detailed drawing of a component to facilitate its manufacture. All the principles of orthographic projection and the technique of graphic representation must be followed to communicate the details in a part drawing. A part drawing with production details is rightly called as a production drawing or working drawing.

Fig 1

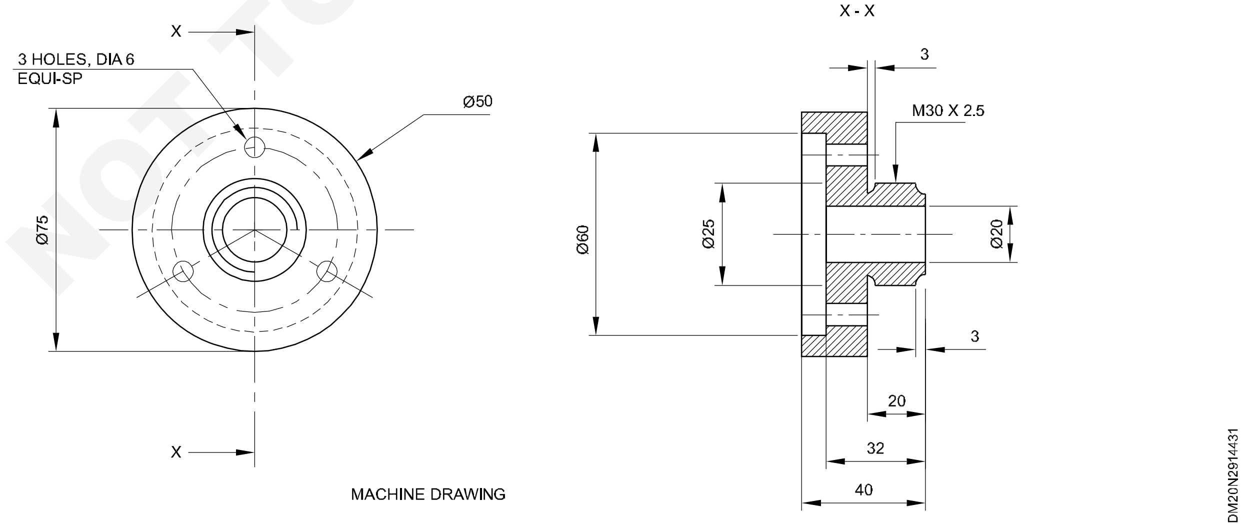
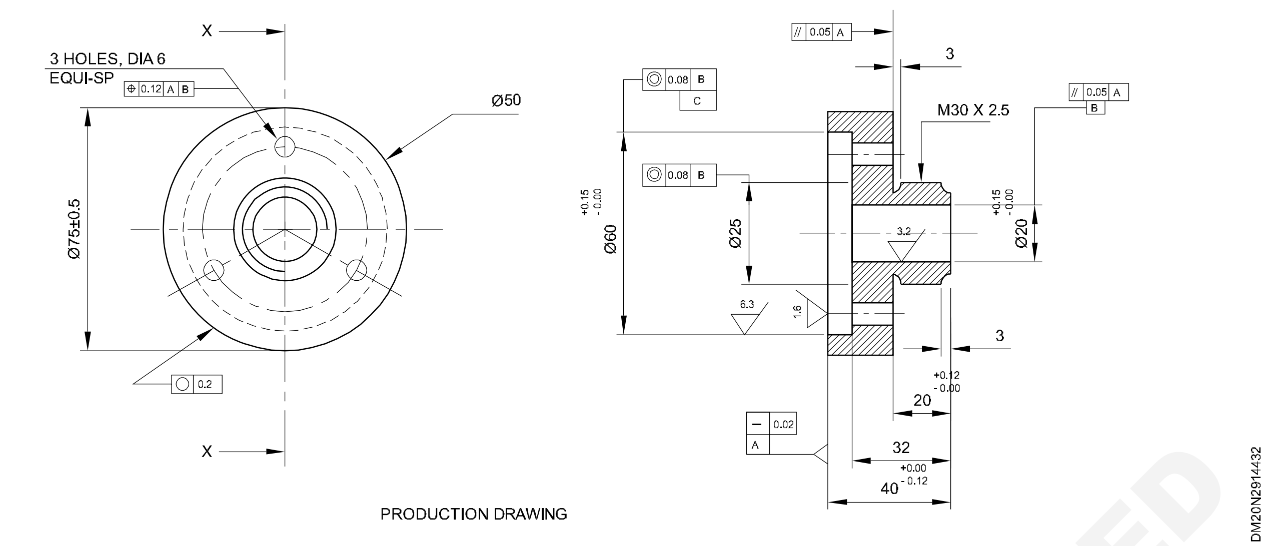


Fig 2



Assembly drawing

A drawing that shows the various parts of a machine in their correct working locations is an assembly drawing (Fig 3). There are several types of such drawings.

Design assembly drawing

When a machine is designed, an assembly drawing or a design layout is first drawn to clearly visualise the performance, shape and clearances of various parts comprising the machine.

Detailed assembly drawing

It is usually made for simple machines, comprising of a relatively smaller number of simple parts. All the dimensions and information necessary for the construction of such parts and for the assembly of the parts are given directly on the assembly drawing. Separate views of specific parts in enlargements, showing the fitting of parts together, may also be drawn in addition to the regular assembly drawing.

Sub-assembly drawing

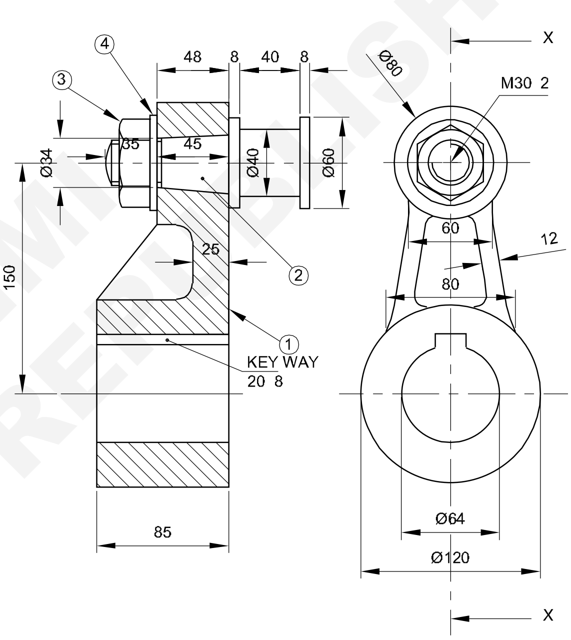
Many assemblies such as an automobile, lathe, etc., are assembled with many pre-assembled components as well as individual parts. These pre-assembled units are known as sub-assemblies.

A sub assembly drawing is an assembly drawing of a group of related parts, that form a part in a more complicated machine. Examples of such drawings are: lathe tail-stock, diesel engine fuel pump, carburettor, etc.

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 3



Part list

PART NO	NAME	MATERIAL	QTY.
1	CRANK	FORGED STEEL	1
2	CRANK PIN	45C	1
3	NUT	MS	1
4	WASHER	MS	1

ASSEMBLY DRAWING

DM20N2914433

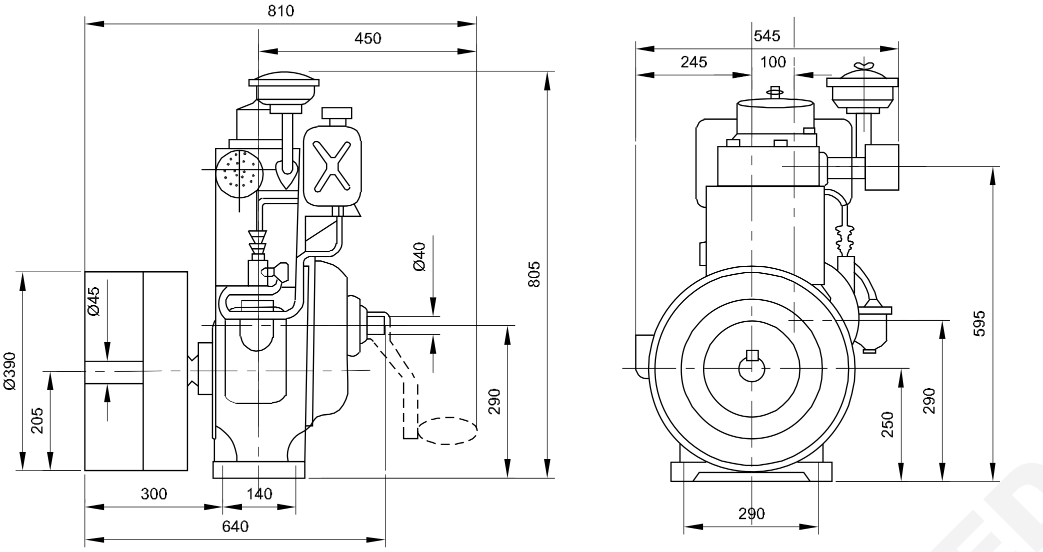
Installation assembly drawing

On this drawing, the location and dimensions of few important parts and overall dimensions of the assembled unit are indicated. This drawing provides useful information for assembling the machine, as this drawing reveals all parts of a machine in their correct working position.

Assembly drawings for catalogues

Special assembly drawings are prepared for company cataloguers. These drawings show only the pertinent details and dimensions that would interest the potential buyer. Fig 4 shows a typical catalogue drawing, showing the overall and principal dimensions.

Fig 4



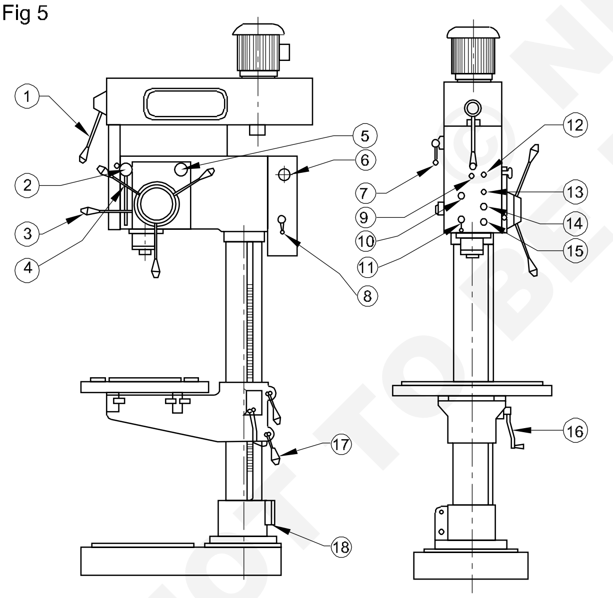
CATALOGUE DRAWING

DM20N2914434

Assembly drawings for instruction manuals

These drawings in the form of assembly drawings, are to be used when a machine, shipped away in assembled condition, is knocked down in order to check all the parts before reassembly and installation. These drawings have each component numbered on the job. Fig 5 shows a typical example of such a drawing.

Fig 5



Speed change lever (1)	Selector switch (10)
Depth adjusting knob (2)	Forward/reverse switch (11)
Mech. feed engagement lever (3)	Pilot lamp (12)
Hand feed lever (4)	Feed disengagement push button (13)
Feed change knob (5)	Start push button (14)
Switch for tapping (6)	Emergency stop (15)
Gear shifting lever (7)	Elevating Handle (16)
Main switch (8)	Clamping Handle (17)
Lamp switch (9)	Supply inlet (18)

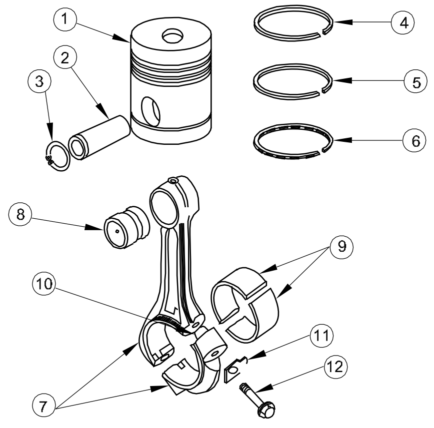
ASSEMBLY DRAWING FOR INSTRUCTION MANUALS

DM20N2914435

Exploded views

In some cases, exploded pictorial views are supplied to meet instruction manual requirements. These drawings generally find a place in the parts list section of a company instruction manual. Fig 6 shows drawings of this type which may be easily understood even by those with less experience in the reading of drawings; because in these exploded views, the parts are positioned in the sequence of assembly, but separated from each other.

Fig 6



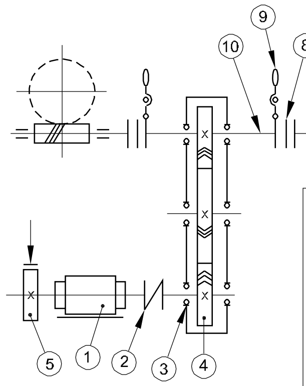
EXPLODED ASSEMBLY DRAWING

DM20N2914436

Schematic assembly drawing

It is very difficult to understand the operating principles of complicated machinery, merely from the assembly drawings. Schematic representation of the unit facilitates easy understanding of its operating principle. It is a simplified illustration of the machine or of a system, replacing all the elements, by thier respective conventional representations. Fig 7 shows the schematic representation of a gearing diagram.

Fig 7



No	NAME	Qty
10	Shaft	1
9	Change-over length	2
8	Disk clutch	2
7	Worm wheel	2
6	Worm	2
5	Shoe brake	2
4	Herringbone gear	3
3	Bearing	6
2	Elastic coupling	2
1	Electric motor	2

DM20N2914437

SCHEMATIC ASSEMBLY DRAWING

Machine shop drawing

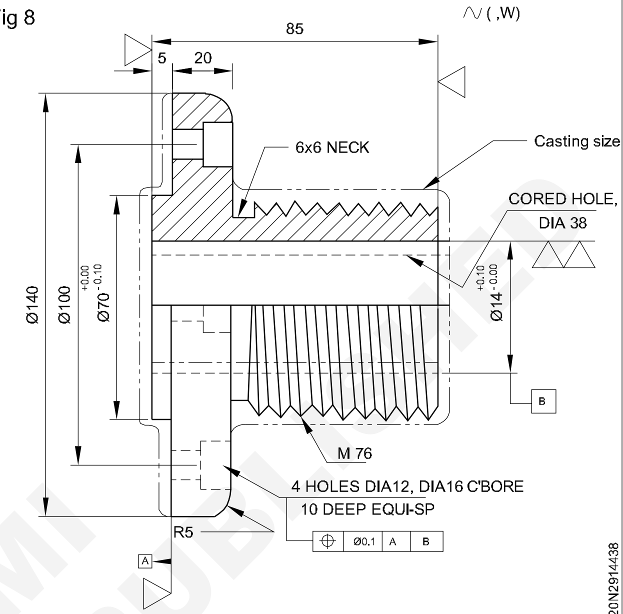
Rough castings and forgings are sent to the machine shop for finishing operation (Fig 8). Since the machinist is not interested in the dimensions and information of the previous stages, a machine shop drawing frequently gives only the information necessary for machining. Based on the same principle, one may have forge shop drawing, pattern shop drawing, sheet metal drawing, etc.

Drawing revision process

The term "Drawing Revision" refers to modifications that are made to a drawing after it has been signed and issued. The first revision to a drawing takes place after the initial issue of the drawing is signed and released forbid or construction.

The details of revision marks or details should be mentioned in the table as shown in fig 9 & 10.

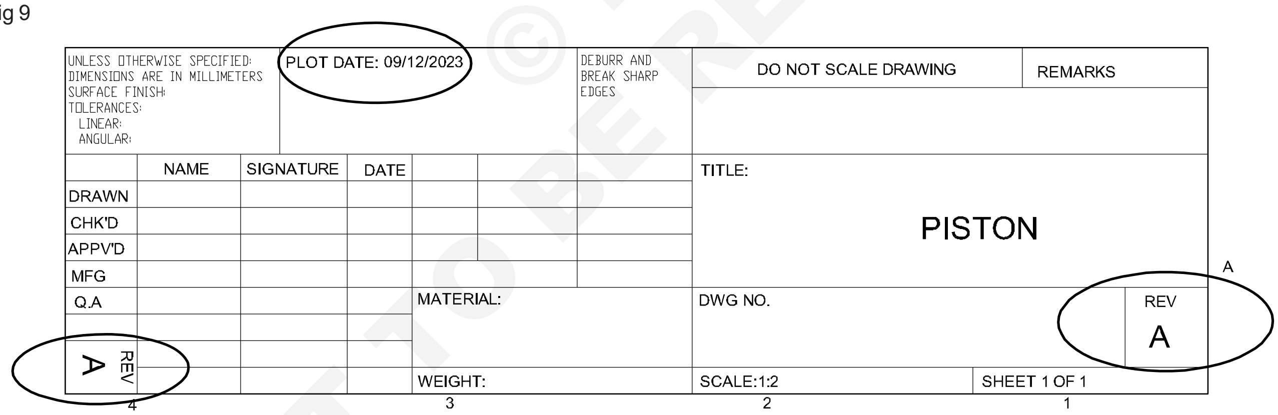
Fig 8



DM20N2914438

MACHINE SHOP DRAWING

Fig 9



DM20N29146H1

REVISED TITLE BLOCK

Fig 10

REVISIONS				
S.NO	ZONE	DESCRPTION	DATE	APP
		INITIAL RELEASE	9/12/23	SRN
A	B2	DIAMETER Ø10.5 CHANGE TO Ø12.5 mm		

DM20N29146H2

REVISIN HISTORY UPDATED