AE CAD Lab

CAD LABORATORY

MANUAL

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AE CAD LAB IN-CHARGE

LABORATORY MANUAL

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Course Name

CAD/CAM LABORATORY

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Assistant Professor	Professor	Professor & HoD

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Drafting is one of the first computer applications used by many users. It refers to the engineering model is communicated for manufacturing or any other application.

BASIC FACILITIES IN AUTOCAD:-

The release 2000 screen is shown in fig1. This has the familiar windows look and feel, in terms of the various buttons and an easier interface. It has set of dropdown windows for various menu options. From among them:

New: This allows for starting a new drawing.

Open: This allows opening an old drawing for editing.

Save: Allows saving the current drawing.

Save as: Allows saving the current drawing with new name.

Export: Allows for exporting the current drawing into other format. Suitable for other programs such as….3D studio.

Eg:-

BMP: Device-independent bit map.

DWG: AutoCAD drawing file.

DWF: AutoCAD drawing web format.

DXF: AutoCAD R14 drawing inter change.

SCREEN DISPLAY:-

From fig1.the status line is the bottom most line. On the right side a column is displayed for providing the possible menu selections. The column can be removed from the screen if necessary by changing the option in the AutoCAD set up. At the bottom a command area is provided which is generally designed for three lines. Rest screen is designed as the drawing area.

MENU:-

AutoCAD is a completely menu driven system. Also no. of menu commands available are many.

- Direct command entry.
- Through the side bar menu.
- Through the pop-up window from the menu bar.
- Through the button bars located in any portion of the screen.(fig2)

PLANING FOR A DRAWING:-

This is carried out by set up operations.

UNITS:-

This lets us set up the units in which the AutoCAD would have to work. It would be working in default co-ordinates called as drawing units. This is achieved by using “units” command. [fig3]

It offers following types of units.

- Scientific.
- Decimal.
- Engineering.
- Architectural.
- Fractional.

CO-ORDINATE SYSTEM:-

It generally uses the rectangular Cartesian co-ordinate system which follows right hand rule. It also uses rectangular co-ordinate system designed as x, y, & z axis. Co-ordinates can be imputed into the system in a no of ways by direct input of co-ordinate values in their respective order.

COMMAND: LINE<LR>

FROM POINT: 3.5, 12.0<LR>

CR: Carriage return.

LIMITS:

It is normally necessary to specify the limits of the drawing that one is about to use. The actual size of drawing would have to be specified using limit command.

Limits establishes the size of the drawing and the associated drawing guide such as grids, rullers etc……in proper format.

However, limits check option is kept on, and then AutoCAD would not allow you to specify any point beyond the limits.

GRID:-

Working on a plane drawing area s difficult since there is no means for the user to understand or correlate the relative position or straightness of the various objects or entities made in the drawing. The grid command controls the display of a grid of alignment to assist the placement of objects in the drawing.

SNAP:-

The resolution of the cursor can be effectively controlled by using SNAP command. When the cursor is moving in the drawing area, it moves in increments of the snap spacing value specified. This is useful for inputting data through the digester or mouse.

Functional key: F9

ORTHO:-

It allows to control "orthogonal" drawing mode. As a result all lines and traces drawn while this mode is on are constrained to be horizontal or vertical.

Functional key: F8

HELP:-

AutoCAD provides complete help at any point of working in the program.

OBJECT PROPERTIES:-

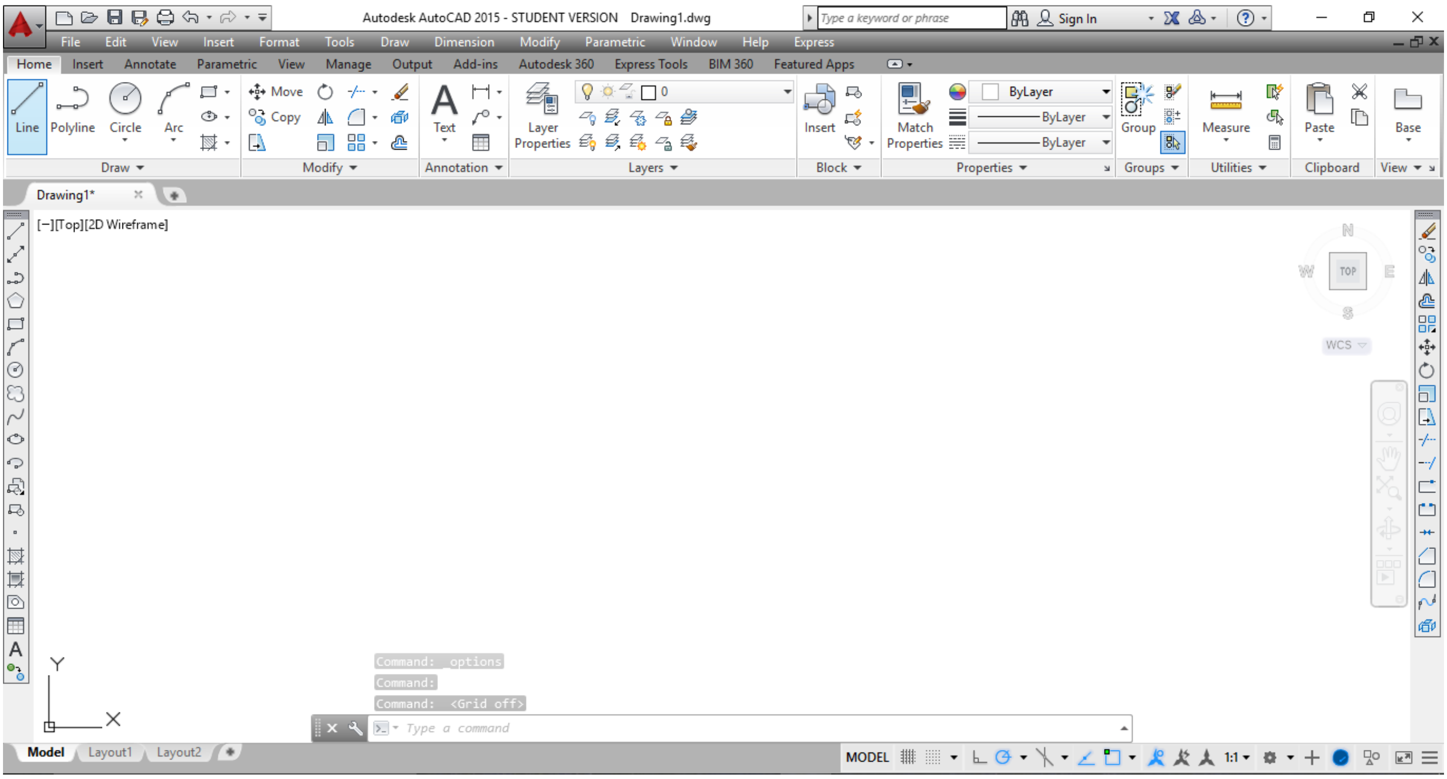
LINE TYPE:

AutoCAD allows the user to draw various types of lines in the drawing. To change the line type of existing object, use the "CHANGE "command. To control large line type use "LAYER" command. It can also load line type definitions from a library file.

<u>BASIC GEOMETRIC COMMANDS:-</u>

The various entities that can be used for making an AutoCAD drawing in 2D are:

- POINT
- LINE
- ARC
- CIRCLE
- ELLIPSE
- POLYGON
- POLYLINE
- DOUGH NUT
- SKETCH
- TEXT
- BLOCK



POINT:-

It is used to specify a point or a node in the drawing for any given purpose. It is also used as NODE in object snap option.

It is also possible to specify the co-ordinates in incremental format as the distance from the current cursor position in the drawing area. The distance is specified by using the "@" parameter before the actual value.

COMMAND: POINT<CR>

Co-ordinates of point: @34.5, 12.0<CR>

LINE:-

It allows you to draw straight line. You can specify the desired end points using either 2D or 3D co-ordinates. To erase the latest line segment without exiting the line command enters "U".

Lines may be constrained to horizontal or vertical by the "ORTHO" command. The close option uses the start point of the first line in the current line command.

CIRCLE:-

It is used to draw a full circle. We can specify a circle in many ways. For specifying the circle we need at least two values.

- Centre point and radius.
- Centre point and diameter.
- 2p\3p\ttr methods.

ARC:-

It enables to draw an arc as specified by following methods.

- Three points on the arc.
- Start point, centre and end point.
- Start, centre and included angle.
- Start, centre and length of chord.
- Start, end and radius.
- Start, end and included angle.
- Start, end and direction of start.

The arc is always drawn in counter clock wise direction. Depending on the data available it is necessary to plan carefully the sequence in which the data is specified.

Drawing a circle is easier than arc. The arc will be generated n which the points are specified.

LAYERS:-

A layer is basically one which contains some information which can be geometric or alpha-numeric. The reason of distributes all the information present in the drawing into various layers is that at any given time some of the layers can be deleted from the view(off) or can be made visible(on). This helps in organizing the information in a drawing. Thus each layer may be considered as a transparent sheet having some information.

- Each layer has a name which can be up to 31 characters.
- Default layer name given by AutoCAD is 0.
- A layer could be ON or OFF. When a layer is ON the information present in it would be visible on screen.
- A layer is either “current or inactive”.
- If the current layer is ON then the information being entered would be visible on screen.
- Each layer has a colour associated with it. The colour of individual information can be altered by using “CHANGE” command or by using “COLOR” command.

DISPLAY CONTROL COMMAND:-

ZOOM:-

Zoom is used to change the scale of display. This can be used to magnify a part of the drawing to any higher scale of or closely observing some file details in the drawing. There are no. of options available within zoom.

SCALE<X>: A numeric zoom factor. A value less than 1 zoom out and greater than 1 zoom in.

ALL : Zoom out to original drawing limits.

DYNAMIC: Graphically selects any portion of the drawing as your next screen view.

CENTRE : Pick a centre and picture top and bottom by selecting two end points of height.

EXTENTS: Shows everything in the file.

LEFT : Pick a lower left corner and a height of how much drawing information you want to

Display to fill up the screen.

PREVIOUS: Restores the last zoom setting.

Choosing the dynamic option displays all the drawing up to limits in a small window. So that the entire drawing is visible in the display screen. The current visible window would be shown in rectangular linked to the cursor.

PAN:-

It allows you to move the display window in any direction without changing the display magnification. This means the display being seen is through a window in an opaque sheet covering the drawing limits.

OBJECT SNAP:-

By selecting the OSNAP option the system would be able to automatically calculate the tangent point in the region selected. The various OSANP options are as follows…..

CENTRE: center or arc or circle

ENDPOINT: closest end point if line/arc etc….

INSERTION: insertion point of text/block etc…

INTERSECTION: intersection of lines/arcs/circles etc…

MIDPOINT: midpoint of lines/arcs/circles etc…

NEAREST: nearest point on line/arc/circle.

NODE: nearest point entity.

PERPENDICULAR: perpendicular to line/arc/circle.

QUADRANT: quadrant point of arc or circle.

TANGENT: tangent to arc or circle.

TEXT HANDLING:-

AutoCAD provides a large range of text entering capabilities including various fonts and other text handling features.

EDITING A DRAWING:-

Editing capabilities are the most useful part of AutoCAD to export the productivity potential, making use of the already existing objects in the drawing.

ARRAY: places multiple copies of objects with a single command.

BREAK: cuts existing objects and /or erase portions of objects.

CHANGE: Changes spatial properties of some objects.

COPY: makes copies of objects.

ERASE: Allows selecting objects in the drawing file and erasing them.

MIRROR: creates a mirror image.

MOVE: picks up existing objects and puts them in another location of drawing.

ROTATE: Turns existing object to any angular position.

SCALE: Scales object up or down to your specification.

MOVE:-

It is used to move one or more existing drawing entities from one location to another location. You can draw the object into position on the screen by giving base point and second point. The selected objects will follow the movements of the screen crosshair.

OBJECT: the default selects a set by picking individual objects.

WINDOW: objects are completely inside a window drawn by the cursor control device.

LAST: uses only the last object created.

CROSSING: works like a window, it also includes any object which is partially within the

Window.

REMOVE: it removes any objects that are accidentally selected by any of the object.

ADD: used o adding when the remove option is specified.

MULTIPLE: allows multiple objects in close proximity.

PREVIOUS: adds the entire previous selection list to the current selection list.

UNDO: undo the last selection operation.

SELECT ALL: selects all objects in drawing.

WINDOW POLYGON: Here, rectangular window is replaced by polygon of as many vertices as

Required.

CROSSING POLYGON: similar to the window polygon except that the polygon here is not

Would be selected.

COPY:-

This command is used to duplicate one or more existing drawing entities at another location without erasing original. You can drag the object into position on the screen. The selected object will follow the movements of the screen cross hairs.

To make multiple copies, respond to the base point prompt with „M‟. when you have made required number of copies give a null response to the second point prompt to come out of the copy command.

CHAMFER:-

It creates a bevel between two intersecting lines at a given distance from their intersection. It can also trim the lines from the bevel edge and connect the trimmed ends with a new line of TRIMMODE variable is set to 1. Chamfer can only be applied between line segments and not any other objects.

FILLET:-

It connects two lines, arcs, or circles with a smooth curve of specified radius. It adjusts the length of the original line or arcs so they end exactly on the fillet arc. The fillet valve specified remains in force until it is altered by another valve. If the fillet radius is „0‟ then two lines will meet exactly at a point which is normally used to make a sharp corner.

Filleting can also be done to two circles, a line and a circle, a line and an arc and a circle and an arc.

OFFSET:-

This command constructs an entity parallel to another entity at either a specified point. You can OFFSET a line, arc, circle or polygon. Offset lines are parallel, while the offset circles and arcs make concentric circles. Once object is selected it is highlighter on the screen.

Side to offset:

Through point:

The selected object will be de highlighted and the “select object to offset”.

ARRAY:-

It makes multiple copies of selected objects in a rectangular or polar pattern.

For a rectangular array you are asked for the no. of columns & rows and the spacing between them. The array is built along a base line defined by the current snap rotation angle set by the “SNAP ROTATE” command.

For polar array a centre point needs to be supplied. Following this, you must supply two of following.

- The number of items in the array.
- The number of degrees to fill
- The angle between items in the array.

DIMENSIONING:-

After creating the various views of the model or after preparing the drawing it is necessary to add dimensions at the appropriate places. AutoCAD provides semi automatic dimensions. As a result once dimensions is created. AutoCAD gives great control over the way dimensions may appear in the drawing. The dimension familiars are as follows…

- Linear
- Diameter
- Radial
- Angular
- Ordinate
- Leader
- Aligned

3D- MODELING

Creates 3D polygon mesh objects in common geometric shapes that can be hidden, shaded, or rendered.

Command entry: 3d

Enter an option

[Box/Cone/DIsh/DOme/Mesh/Pyramid/Sphere/Torus/Wedge]:

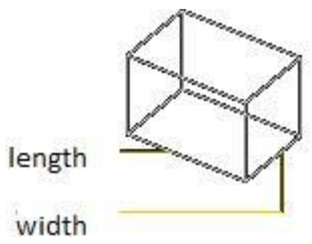
1.BOX

Creates a 3D box polygon mesh.

Specify corner point of box:

Specify length of box: *Specify a distance*

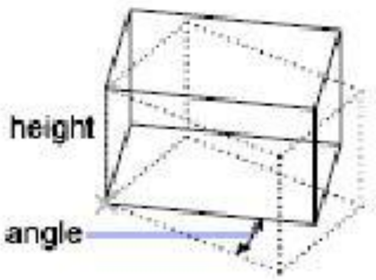
Specify width of box or [Cube]: *Specify a distance or enter* C



Width

Specifies the width of the box.

Enter a distance or specify a point relative to the corner point of the box



.

Specify height of box: *Specify a distance*

Specify rotation angle of box about the Z axis or [Reference]: *Specify an angle or enter* **r**

Rotation Angle Rotates the box about the first corner specified. If you enter 0, the box remains orthogonal to the current *X* and *Y* axes.

Reference Aligns the box with other objects in the drawing or relative to an angle you specify. The base point for the rotation is the first corner of the box.Specify the reference angle <0>: *Specify a point, enter an angle, or press Enter*

You can define a reference angle by specifying two points or an angle from the *X* axis on the *XY* plane. For example, you can rotate the box to align two specified points on the box with a point on another object. After defining a reference angle, specify a point for the reference angle to align with. The box then rotates around the first corner relative to the angle of rotation specified for the reference angle.

If you enter 0 as a reference angle, the new angle alone determines the rotation

of the box.

Specify the new angle: *Specify a point or enter an angle*

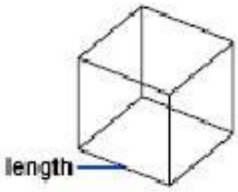
To specify the new angle of rotation, specify a point relative to the base point. The base point for the rotation is the first corner of the box. The box rotates by the angle between the reference angle and the new angle.

If you want to align the box with another object, specify two points on the target object to

define the new angle of rotation for the box. If the reference angle of rotation is 0, the box rotates the angular distance entered relative to the first corner of the box.

2.CUBE

Creates a cube using the length for the width and height of the box.



Specify rotation angle of box about the Z axis or [Reference]: *Specify an angle or enter* **r**

Rotation Angle Rotates the cube about the first corner of the box. If you enter 0, the box remains orthogonal to the current *X* and *Y* axes.

Reference Aligns the box with other objects in the drawing or relative to an angle you specify. The base point for the rotation is the first corner of the box.

Specify the reference angle <0>: *Specify a point, enter an angle, or press Enter*

You can define a reference angle by specifying two points or an angle from the *X* axis on the *XY* plane. For example, you can rotate the box to align two specified points on the box with a point on another object.

After defining a reference angle, specify a point for the reference angle to align with. The box then rotates around the first corner relative to the angle of rotation specified

for the reference angle. If you enter 0 as a reference angle, the new angle alone determines the rotation of the box.

Specify the new angle: *Specify a point or enter an angle*

To specify the new angle of rotation, specify a point relative to the base point. The base point for the rotation is the first corner of the box. The box rotates the angular distance between the reference angle and the new angle. If you want to align the box with another object, specify two points on the target object to define the new angle of rotation for the box. If the reference angle of rotation is 0, the box rotates the angular distance entered relative to the first corner point of the box.

3.CONE

Creates a cone-shaped polygon mesh.

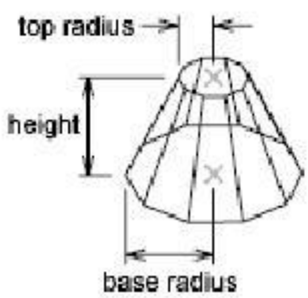
Specify center point for base of cone: *Specify a point (1)*

Specify radius for base of cone or [Diameter]: *Specify a distance or enter* d

Radius for Base

Defines the base of the cone by its radius.

Specify radius for top of cone or [Diameter] <0>: *Specify a distance, enter* d*, or press Enter*



Radius for Top Defines the top of the cone by its radius. A value of 0 produces

a cone. A value greater than 0 produces a truncated cone. Specify height of

cone: *Specify a distance*

Enter number of segments for surface of cone <16>: *Enter a value greater than 1 or press Enter*

Diameter for Top Defines the top of the cone by its diameter. A value of 0 produces a cone. A value greater than 0 produces a truncated cone.

Specify diameter for top of cone <0>: *Specify a distance or press* Enter

Specify height of cone: *Specify a distance*

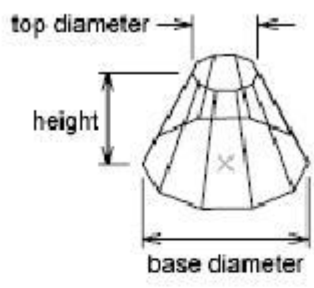
Enter number of segments for surface of cone <16>: *Enter a value greater than 1 or press* Enter

Diameter for Base

Defines the base of the cone by its diameter.

Specify diameter for base of cone: *Specify a distance*

Specify radius for top of cone or [Diameter] <0>: *Specify a distance, enter* d*, or press E*nter



Radius for Top Defines the top of the cone by its radius. A value of 0 produces

a cone. A value greater than 0 produces a truncated cone. Specify height of

cone: *Specify a distance*

Enter number of segments for surface of cone <16>: *Enter a value greater than 1 or press* Enter

Diameter for Top Defines the top of the cone by its diameter. A value of 0 produces a cone. A value greater than 0 produces a truncated cone.

Specify diameter for top of cone <0>: *Specify a distance*

Specify height of cone: *Specify a distance*

Enter number of segments for surface of cone <16>: *Enter a value greater than 1 or press* Enter

4. PYRAMID

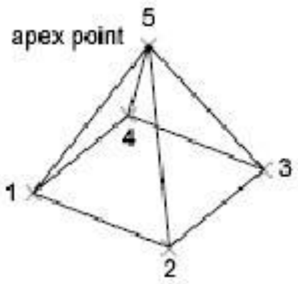
Creates a pyramid or a tetrahedron.

Specify first corner point for base of pyramid: *Specify a point (1)*

Specify second corner point for base of pyramid: *Specify a point (2)*

Specify third corner point for base of pyramid: *Specify a point (3)*

Specify fourth corner point for base of pyramid or [Tetrahedron]: *Specify a point (4) or enter* t



Fourth Corner Point

Defines the fourth corner point of the base of a pyramid.

Specify apex point of pyramid or [Ridge/Top]: *Specify a point (5) or enter an option.*

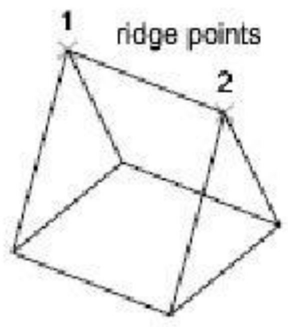
The *Z* value of the point specified determines the height for the pyramid's apex, top, or ridge line.

Apex Point Defines the top of the pyramid as a point (apex).

Ridge Defines the top of the pyramid as a ridge line. The two endpoints must lie in the same direction as the base points to prevent a self-intersecting wireframe.

Specify first ridge end point of pyramid: *Specify a point (1)*

Specify second ridge end point of pyramid: *Specify a point (2)*



Top Defines the top of the pyramid as a rectangle. If the top points cross, they create a self-intersecting polygon mesh.

Specify first corner point for top of pyramid: *Specify a point*

Specify second corner point for top of pyramid: *Specify a point*

Specify third corner point for top of pyramid: *Specify a point*

Specify fourth corner point for top of pyramid: *Specify a point*

Exp: No: 1

AIM: To develop the given model by using auto cad 2D commands and to specify its dimension.

SOFTWARE REQUIRED: AUTOCAD 2015 Database.

COMMANDS IN USE: LIMITS, ZOOM, LINE, DIMLINEAR.

PROCEDURE: In order to obtain given model the following procedure will be followed.

COMMAND:

Limits:

Specify lower left corner: (0,0)

Specify upper right corner : (150,100)

Command: ZOOM:[All/Center/Previous/Scale/Window/Object] : All

Command: LINE:

Specify first point: 0, 0

Specify next point or (undo): 100[0^0]

Specify next point or (close/undo): 20[90^0]

Specify next point or (close/undo): 40[180^0]

Specify next point or (close/undo): 120[90^0]

Specify next point or (close/undo):20[180^0]

Specify next point or (close/undo):120[270^0]

Specify next point or (close/undo): 40[180^0]

Specify next point or (close/undo): C

Specify next point or (close/undo): ESC

Command: DIMLINEAR

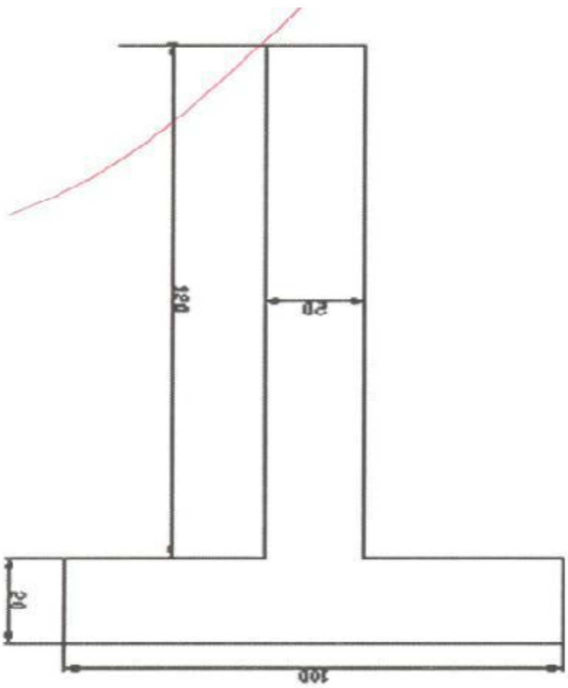
By using this command give dimensions linearly for drawn object to indicate it"s Linear dimensions.

PRECAUTIONS:-

1. Limits should be given before drawing the object.
2. Object should be drawn from a specific point of location only.
3. Ensure that proper sequence should be followed to draw an object.

RESULT:

Hence by using auto cad 2006 2D commands we have drawn the object model and Dimensions are specified.


120
50
20
100

EXP NO: 2

AIM: To develop the given model by using auto cad 2D commands and to specify it‟s Dimension.

SOFTWARE REQUIRED: - AUTOCAD 2015 Database.

COMMANDS IN USE: - LINE, CIRCLE, DIMLINEAR, DIMDIA.

PROCEDURE: - In order to obtain given model the following procedure will be followed…

COMMAND: - Limits:

Specify lower left corner : (0,0)

Specify upper right corner : (150,150)

Command: ZOOM:[All/Center/Previous/Scale/Window/Object] : All

Command: LINE:

Specify first point: 0, 0

Specify next point or (undo): 150[00]

Specify next point or (close/undo): 150[900]

Specify next point or (close/undo): 150[2700]

Specify next point or (close/undo): C

Specify next point or (close/undo): ESC

Command: CIRCLE

Specify centre point for circle (3p/2p/ttr): 30,30

Specify radius of circle or (diameter): d

Specify diameter of the circle: 10

Command: CIRCLE

Specify centre point for circle (3p/2p/ttr): 120,30

Specify radius of circle or (diameter): d

Specify diameter of the circle: 10

Command: CIRCLE

Specify centre point for circle (3p/2p/ttr): 120,120

Specify radius of circle or (diameter): d

Specify diameter of the circle: 10

Command: CIRCLE

Specify centre point for circle (3p/2p/ttr): 30,120

Specify radius of circle or (diameter): d

Specify diameter of the circle: 10

Command: DIMLINEAR

By using this command give dimensions linearly for drawn object to indicate it‟s Linear dimensions.

PRECAUTIONS:-

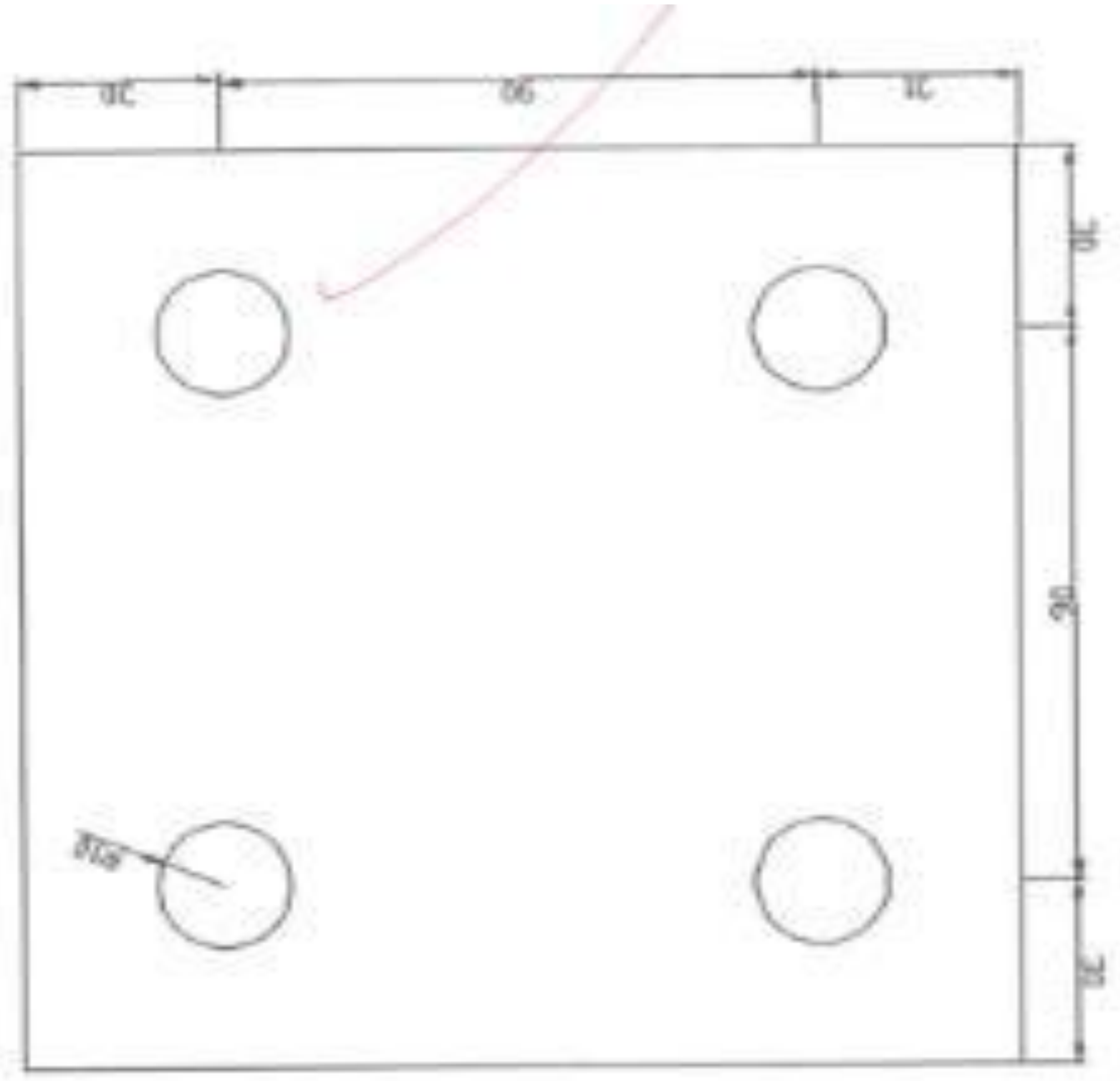
Limits should be given before drawing the object.

Object should be drawn from a specific point of location only.

Ensure that proper sequence should be followed to draw an object.

RESULT:

Hence by using auto cad 2006 2D commands we have drawn the object model and Dimensions are specified.



EXP NO: 3

AIM: To draw the isometric drawings by using AutoCAD 2015 2D commands and the Dimensions can be determined by counting the no of grids.

SOFTWARE REQUIRED: - AutoCAD 2015 Database.

COMMANDS USED: LIMITS, ZOOM,LINE, DIMLINEAR.

PROCEDURE: Highlight the grid option.

COMMAND: LIMITS

Specify lower left corner: 0, 0

Specify upper left corner: 300,300

ZOOM:[All/Center/Previous/Scale/Window/Object] : All

Command: LINE.

Polar: on setting 30 ^{c}

Specify the first point: 0,0

Specify the next point: 24[150^{0}]

Specify the next point: 16[90^{0}]

Specify the next point:24[30^{0}]

Specify the next point:16[90^{0}]

Specify the next point: 24[30^{0}]

Specify the next point:16[90^{0}]

Specify the next point:48[30^{0}]

Specify the next point:78[30^{0}]

Specify the next point: c

Specify the next point:104[150^{0}]

Specify the next point:72[90^{0}]

Specify the next point:24[30^{0}]

Specify the next point:48[30^{0}]

Specify the next point:80[150^0]

Specify the next point:104[150^0]

Specify the next point:48[30^0]

Specify the next point:c

Command: DIMLINEAR

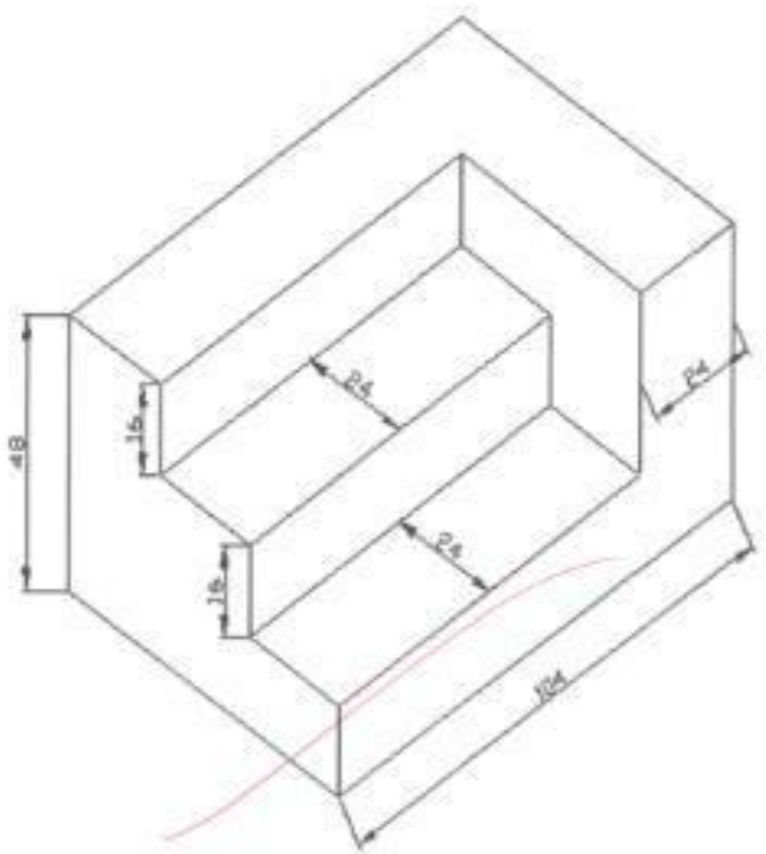
By using this command give dimensions linearly for drawn object to indicate it"s Linear dimensions.

PRECAUTIONS:-

1. Limits should be given before drawing the object.
2. Object should be drawn from a specific point of location only.
3. Ensure that proper sequence should be followed to draw an object.

RESULT:

Hence by using auto cad 2006 2D commands we have drawn the object model and Dimensions are specified .



EXP NO: 4

AIM: To draw the isometric drawing by using AutoCAD 2D drawing commands.

SOFTWARE REQUIRED: - AutoCAD 2015 Database.

COMMANDS: LINE, LIMITS

PROCEDURE: change the view to isometric view.

COMMAND: LIMIT

Specify the lower left corner: 0, 0

Specify the upper right corner: 200,200

ZOOM:[All/Center/Previous/Scale/Window/Object] : All

COMMAND: LINE

Polar: on setting 30^{c}

Specify the first point: 0,0

Specify the next point:50[90^{0}]

Specify the next point:25[30^{0}]

Specify the next point:25[30^{0}]

Specify the next point:20[30^{0}]

Specify the next point:25[90^{0}]

Specify the next point:12[90^{0}]

Specify the next point:25[30^{0}]

Specify the next point:12[90^{0}]

Specify the next point:25[90^{0}]

Specify the next point:12[30^{0}]

Specify the next point:20[150^{0}]

Specify the next point:25[90^{0}]

Specify next point or (close/undo): c

Command: DIMLINEAR

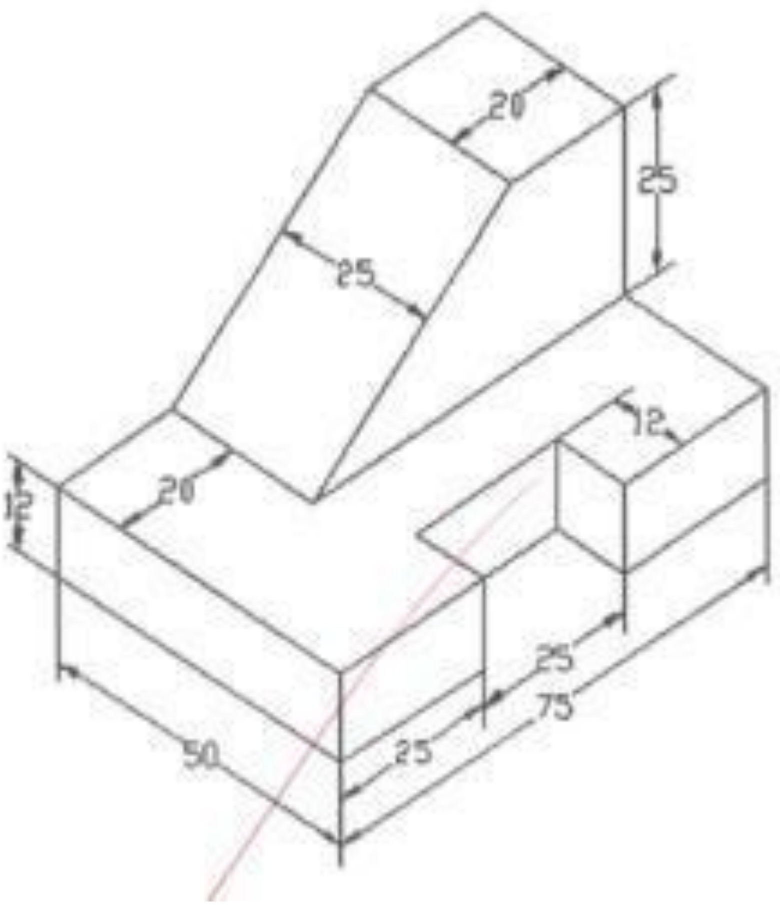
By using this command give dimensions linearly for drawn object to indicate it"s Linear dimensions.

PRECAUTIONS:-

1. Limits should be given before drawing the object.
2. Object should be drawn from a specific point of location only.
3. Ensure that proper sequence should be followed to draw an object.

RESULT:

Hence by using auto cad 2006 2D commands we have drawn the object model and Dimensions are specified.



EXP NO: 5

AIM: To develop the given model by using auto cad 2D commands and to specify its Dimension.

SOFTWARE REQUIRED: - AUTOCAD 2015 Database.

COMMANDS IN USE: - LINE, LIMITS, DIMLINEAR

PROCEDURE: - In order to obtain given model the following procedure will be followed…

COMMAND: LIMIT

Specify the lower left corner: 0, 0

Specify the upper right corner: 200,200

ZOOM:[All/Center/Previous/Scale/Window/Object] : All

COMMAND: LINE

Polar: on setting 30 ^{c}

Specify the first point: 0, 0

Specify the next point:8[90^{0}]

Specify the next point:32[30^{0}]

Specify the next point:20[30^{0}]

Specify the next point:8[90^{0}]

Specify the next point:16[30^{0}]

Specify the next point:12[90^{0}]

Specify the next point:16[30^{0}]

Specify the next point:12[90^{0}]

Specify the next point:56[30^{0}]

Specify the next point:20[90^{0}]

Specify the next point:16[30^{0}]

Specify the next point:12[150^{0}]

Specify the next point:8[90^{0}]

Specify the next point:12[30^0]

Specify the next point:5[150^0]

Specify the next point:16[30^0]

Specify the next point:8[90^0]

Specify next point or (close/undo): c

Command: DIMLINEAR

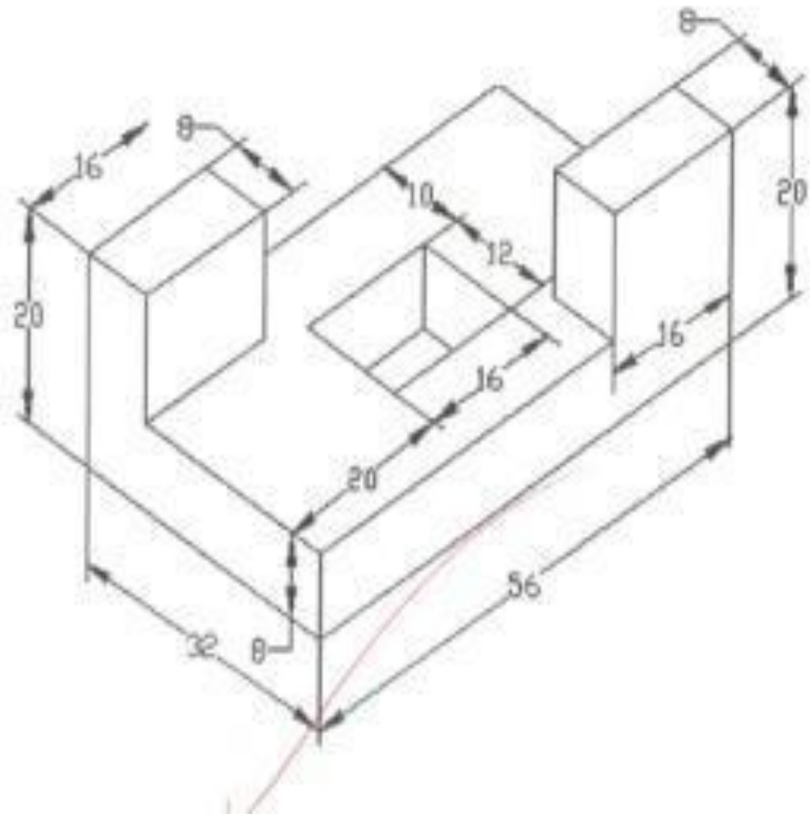
By using this command give dimensions linearly for drawn object to indicate it‟s Linear dimensions.

PRECAUTIONS:-

1. Limits should be given before drawing the object.
2. Object should be drawn from a specific point of location only.
3. Ensure that proper sequence should be followed to draw an object.

RESULT:

Hence by using auto cad 2006 2D commands we have drawn the object model and Dimensions are specified.



EXP NO: 6

AIM: To develop the given model by using auto cad 2D commands and to specify its Dimension.

SOFTWARE REQUIRED: - AUTOCAD 2015 Database.

COMMANDS IN USE: - LINE, LIMITS, DIMLINEAR

PROCEDURE: - In order to obtain given model the following procedure will be followed…

COMMAND: LIMIT

Specify the lower left corner: 0, 0

Specify the upper right corner: 200,200

ZOOM:[All/Center/Previous/Scale/Window/Object] : All

COMMAND: LINE

Polar: on setting 30^{c}

Specify the first point: 0, 0

Specify the next point:63[180^0]

Specify the next point:75[30^0]

Specify the next point:50[30^0]

Specify the next point:25[30^0]

Specify the next point:22[30^0]

Specify the next point:25[30^0]

Specify the next point:25[30^0]

Specify the next point:22[30^0]

Specify the next point:75[30^0]

Specify the next point:12[90^0]

Specify the next point:16[30^0]

Specify the next point:25[150^0]

Specify the next point:16[90^0]

Specify the next point:25[30^0]

Specify the next point: C

Command: DIMLINEAR

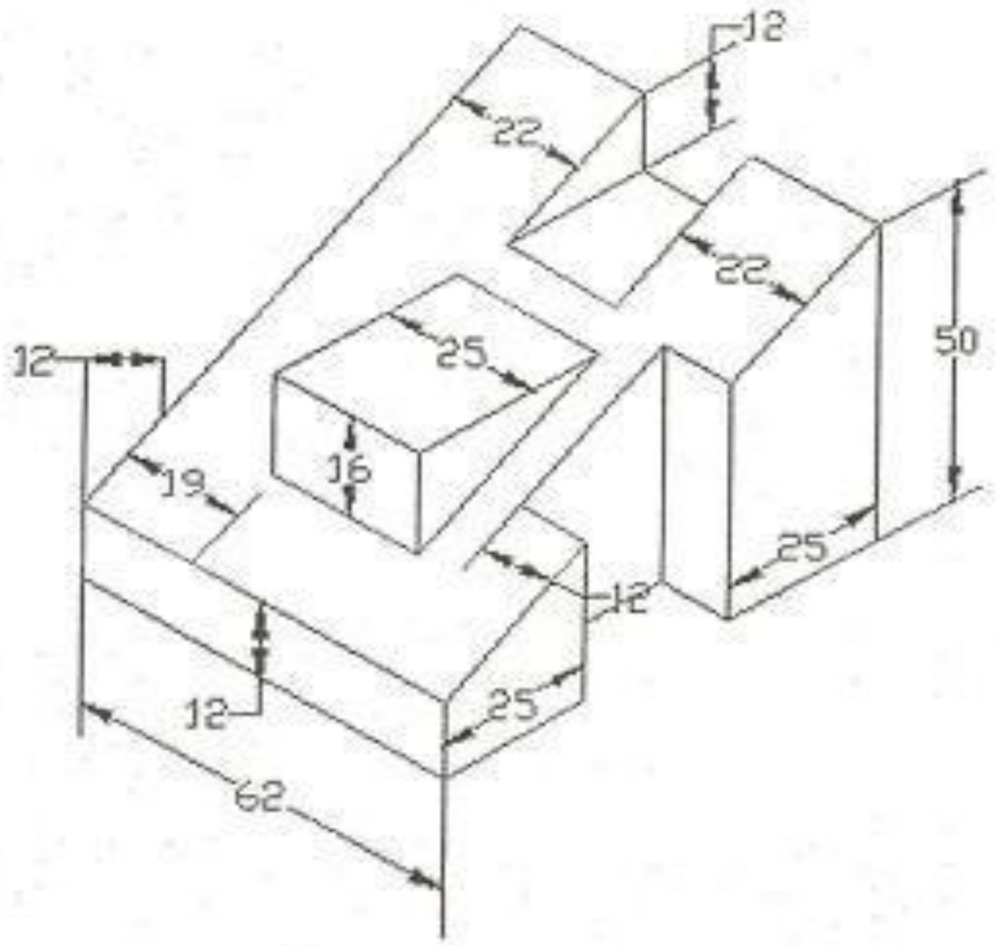
By using this command give dimensions linearly for drawn object to indicate it"s Linear dimensions.

PRECAUTIONS:-

1. Limits should be given before drawing the object.
2. Object should be drawn from a specific point of location only.
3. Ensure that proper sequence should be followed to draw an object.

RESULT:

Hence by using auto cad 2006 2D commands we have drawn the object model and Dimensions are specified.



Introduction to Creo Parametric 2.0

In short, it is a powerful, integrated family of product design software. It's used by thousands of leading manufacturers across the globe. It is a PTC product – the originators of parametric CAD technology. The way Creo works is that it is made up of individual apps, including:

- Creo Parametric
- Creo Simulate
- Creo Direct
- Creo Layout
- Creo Options Modeler

Each Creo application serves a different purpose in the product development process. This means that Creo takes you through every stage, including concept design work, design and analysis. Then it also enables you to communicate effectively with downstream partners, for instance manufacturing and technical publications.

Flexibility

For designers who are involved in several parts of product development, Creo offers them scalable access to the right capabilities. At the same time, for people involved in a specific aspect of the process, there are Creo apps tailored to their precise requirements. It doesn't matter what part you play in the product development process, Creo means you get to use the right tool for the job.

Interoperability

All of the Creo apps are able to communicate seamlessly with each other. This means your data can flow easily between the different apps that you are using.

So, no need to recreate work as you move through the design process and no more siloes between different stages of product development.

Combined benefits of parametric and direct modelling

Using Creo means you can access both 3D CAD modelling approaches when you are doing your work, all in one tool. This means you have the control provided by parametric modelling, alongside the speed and flexibility of direct modelling.

Ability to work with multi-CAD data

This benefit of Creo allows you to work with data from any CAD source. This means no recreating designs because of incompatible data, saving you time and money in the product development process.

Creo is a solution, enabling companies to overcome the typical product design challenges of designing, analysing and sharing information between your teams, your partners and your customers.

In this course, you will learn core modeling skills and quickly become proficient with Creo Parametric 2.0. Topics include sketching, part modeling, assemblies, drawings, and basic model management techniques.

EX.NO:

Date:

PART DRAWING OF SIMPLE COMPONENTS

AIM: 1. To draw the detail view of part drawing of the simple components as shown below by using pro-e software and obtain its respective views.

2. To find the mass properties of given drawings.

COMMANDS USED: Extrude, revolve, line, Circle, Round, Chamfer etc,

PROCEDURE:

Study the given drawing .completely and find out the front view of the given orthographic projection.

Draw the sectional view of the front view.

Extrude the drawn section using extrude command for the given dimension.

Next select the appropriate plane and draw the other sections in similar way.

Also remove the materials where ever needed.

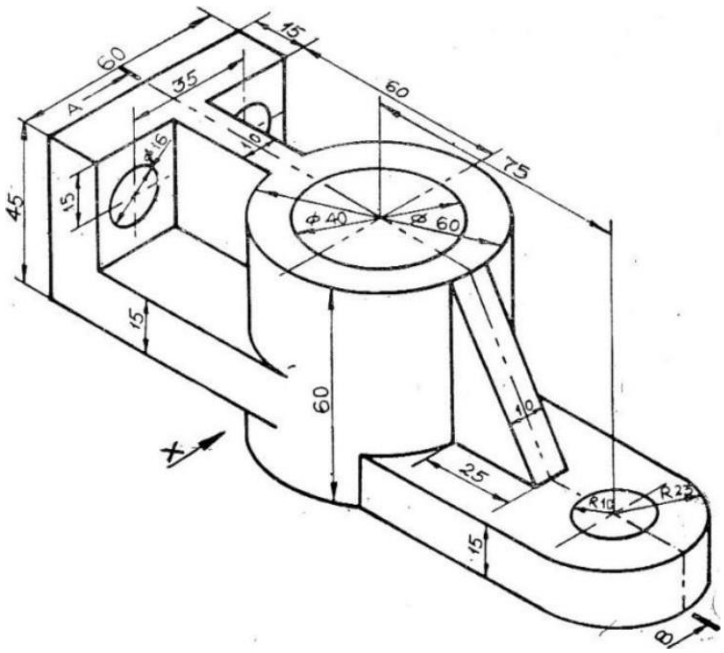
Using round tool we can round the edges.

Chamfering is done by the chamfer command.

Finally the part drawing is converted into the drawing format.

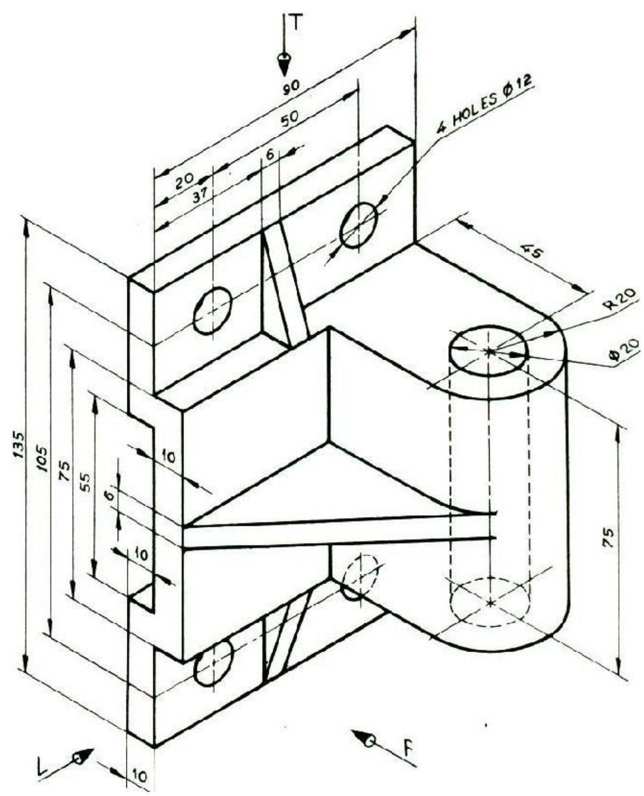
RESULT: Thus the detailed view of part drawing of the simple components as shown below was drawn by using the Pro-E software and mass properties were calculated.

1.



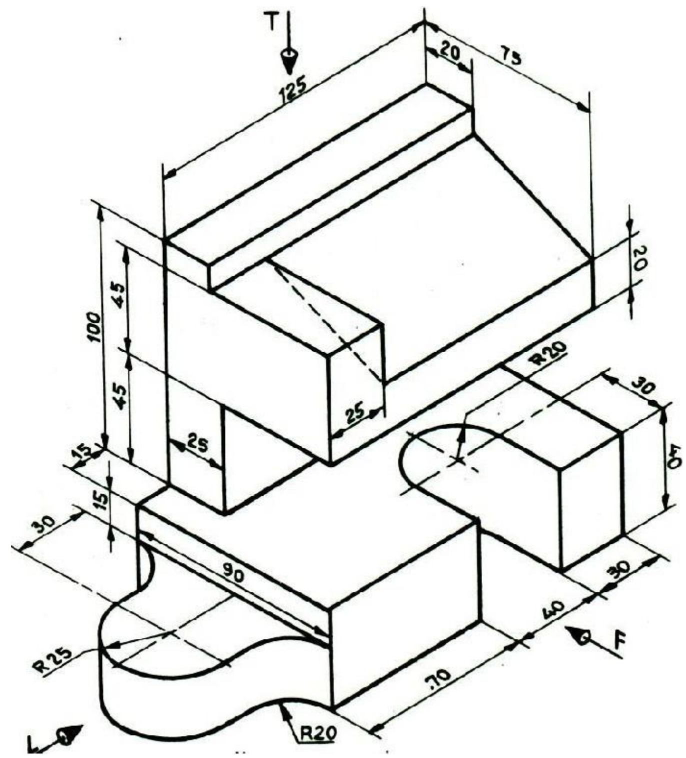
60
15
35
60
A
Ø16
16
75
45
15
Ø40
Ø60
15
60
10
X
25
R10
R22
15
B

2.

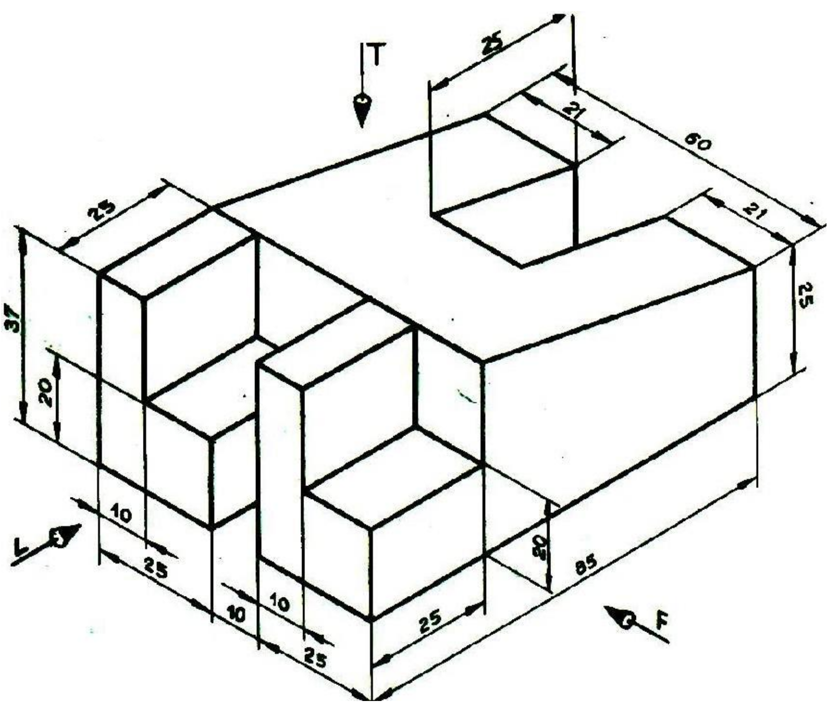


T
90
50
4 HOLES Ø12
6
20
37
45
R20
Ø20
135
105
75
55
10
6
10
75
L
10
F

3.


T
125
20
75
20
100
45
45
15
15
25
25
R20
30
40
30
30
90
R25
70
40
F
L
R20

4.


T
25
21
60
25
21
25
37
20
10
25
10
10
25
25
20
85
L
F

EX.NO:

Date:

FLANGE COUPLING

AIM:

1. To draw the detail view of the flange coupling and assemble the parts by using the Pro-E software and obtain its respective views.
2. To find the mass properties of the final assembly.

COMMANDS USED: Sketch, Extrusion, Revolve, Pattern, Mate, Align, Helical Sweep, Round, Chamfer etc,.

PROCEDURE:

PART DRAWING:

FLANGE:

Draw the sectional view of the flange in the sketcher mode.

Draw the middle axis line for the purpose of using revolves command and make the flange.

Make the keyway and holes by using extrude material remove command.

Round the sharp edges of the flange by using round tool command.

SHAFT AND KEY:

Use extrude command to make the shaft and the keyway.

Use extrude command to make the key.

BOLT AND NUT:

Use the extrude command makes the bolt head and shank of the bolt.

Use the helical sweep command makes the thread in bolt shank.

Use the extrude and helical sweep command make the nut with thread.

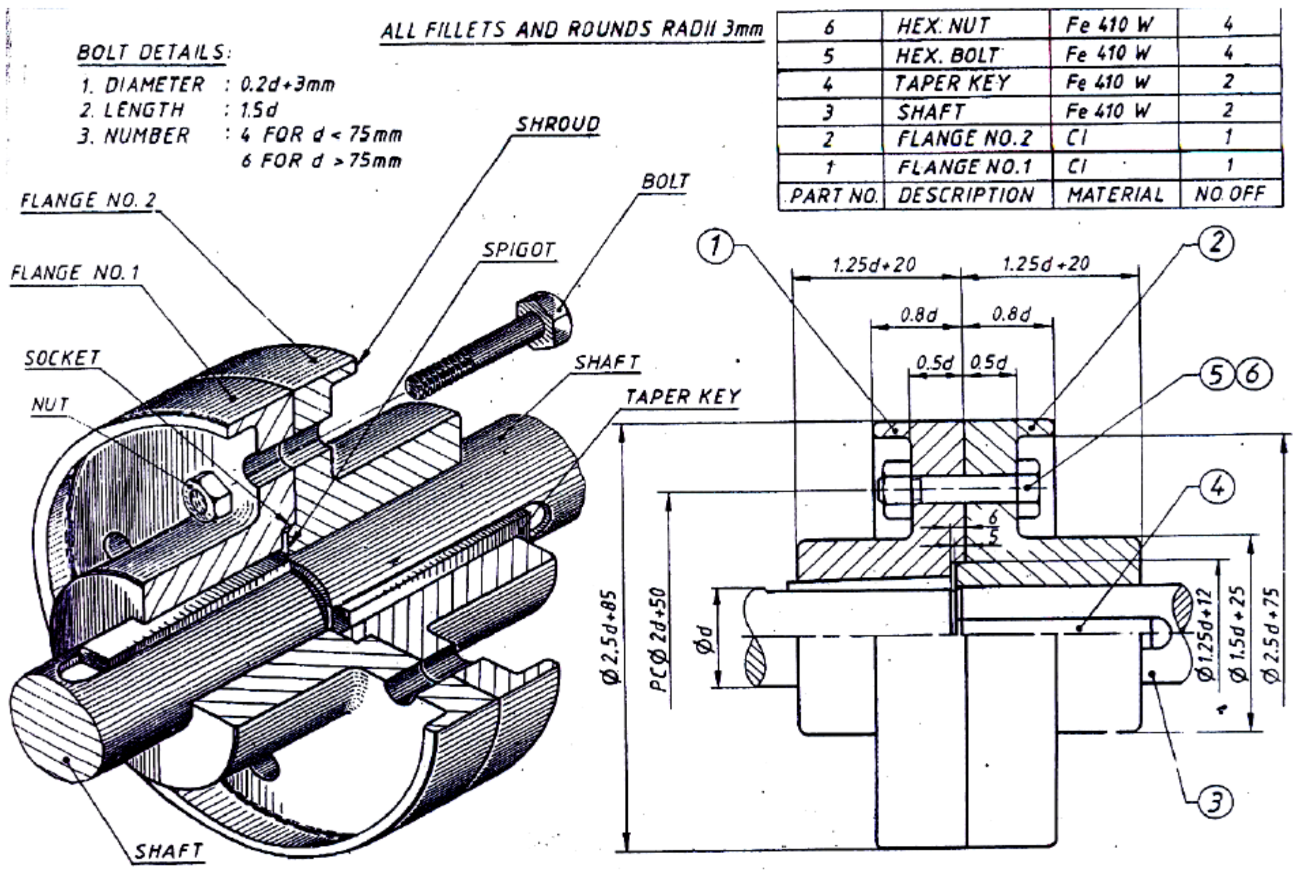
ASSEMBLY:

Use the mate, align, insert and pattern commands to assemble the flange coupling.

DETAILED DRAWING:

Use the drawing mode makes the respective views and bill of materials.

RESULT: Thus the Detail View of the Flange Coupling along with it’s respective views and mass properties have been found.

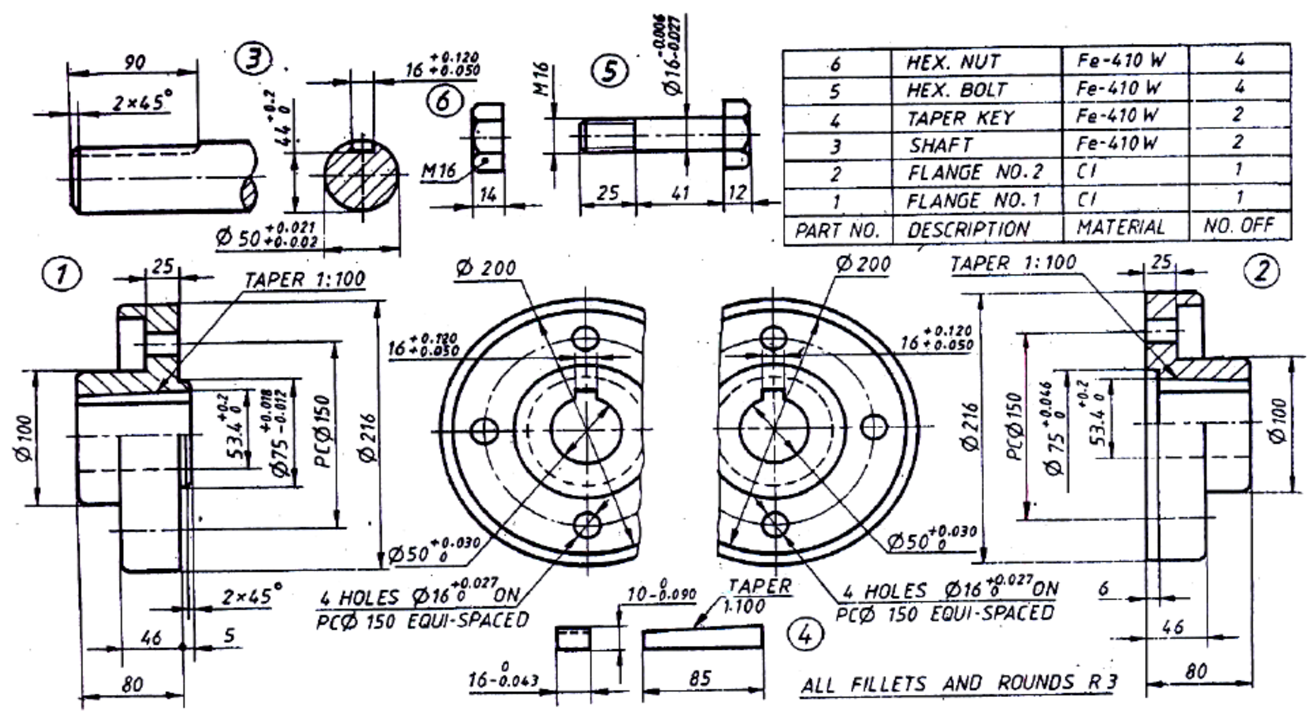


PART NO.	DESCRIPTION	MATERIAL	NO OFF
6	HEX. NUT	Fe 410 W	4
5	HEX. BOLT	Fe 410 W	4
4	TAPER KEY	Fe 410 W	2
3	SHAFT	Fe 410 W	2
2	FLANGE NO. 2	CI	1
1	FLANGE NO. 1	CI	1

All Dimensions in mm

Flanged Coupling — Protected Type

Fig. 16.9



PART NO.	DESCRIPTION	MATERIAL	NO. OFF
6	HEX. NUT	Fe-410 W	4
5	HEX. BOLT	Fe-410 W	4
4	TAPER KEY	Fe-410 W	2
3	SHAFT	Fe-410 W	2
2	FLANGE NO. 2	CI	1
1	FLANGE NO. 1	CI	1

EX.NO:

Date: **NON RETURN VALVE**

AIM: To draw the detail view of the Universal Coupling and assemble the parts by using the Pro-E software and obtain its respective views.

COMMANDS USED:

Sketch, Extrusion, Revolve, Mate, Align, Round, Chamfer etc,.

PROCEDURE: PART DRAWING:

BODY:

Draw the cross section of the body and revolve it.

Draw the concentric circles of the fork and remove materials.

Draw the flange part of the body and extrude it.

Valve Seat:

Use the revolve command make the Valve Seatof the Non Return Valve.

Valve:

Use the revolve command make the Valve Seatof the Non Return Valve.

ASSEMBLY:

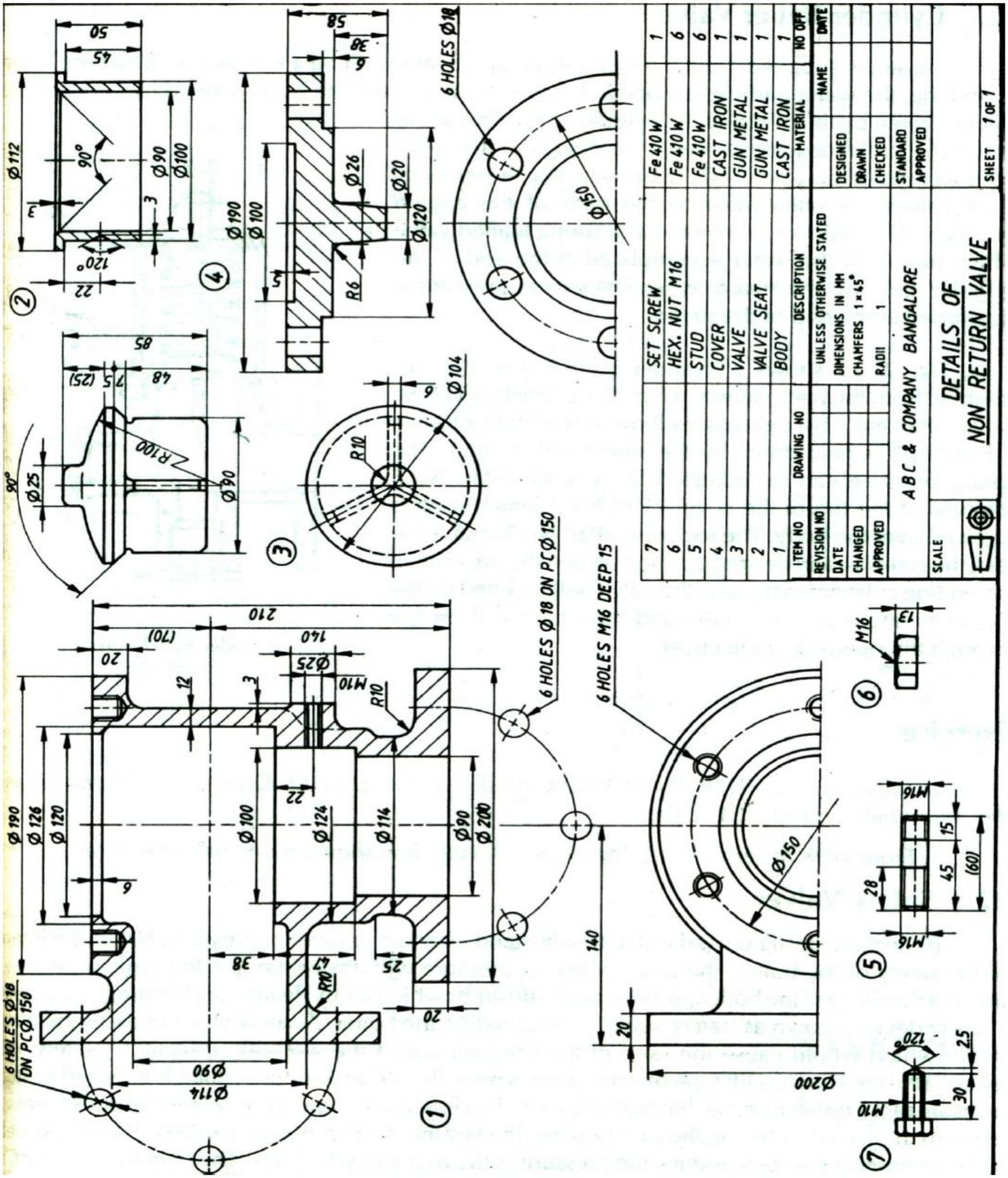
Use the mate, align, insert and pattern commands to assemble the Non Return Valve.

DETAILED DRAWING:

Use the drawing mode makes the respective views and bill of materials.

RESULT:

Thus the Detail View of the Non Return Valveand the it's respective views has been drawn.


DETAILS OF
NON RETURN VALVE
ABC & COMPANY BANGALORE
SET SCREW
HEX. NUT M16
STUD
COVER
VALVE
VALVE SEAT
BODY
Fe 410 W
CAST IRON
GUN METAL
UNLESS OTHERWISE STATED
DIMENSIONS IN MM
CHAMFERS 1×45°
6 HOLES Ø18 ON PCØ150
6 HOLES M16 DEEP 15
SHEET 1 OF 1

EX.NO:

Date: **PIPE VICE**

AIM: To draw the detail view of the Pipe Vice and assemble the parts by using the pro-e software and obtain its respective views.

COMMANDS USED:

Sketch, Extrusion, Revolve, Pattern, Mate, Align, Helical Sweep, Round, Chamfer etc,

PROCEDUR
E: PART
DRAWING:

PIPE BASE:

Using Extrude command the Pipe Base of the Pipe Vice has been drawn.

MOVABLE JAW:

Using Extrude command the Movable Jaw of the Pipe Vice has been drawn.

SET SCREW:

Using Revolve and Extrude Set Screw of the Pipe Vice has been drawn.

HANDLE BAR:

Using Revolve command the Handle Bar has been drawn.

HANDLE BAR CAP:

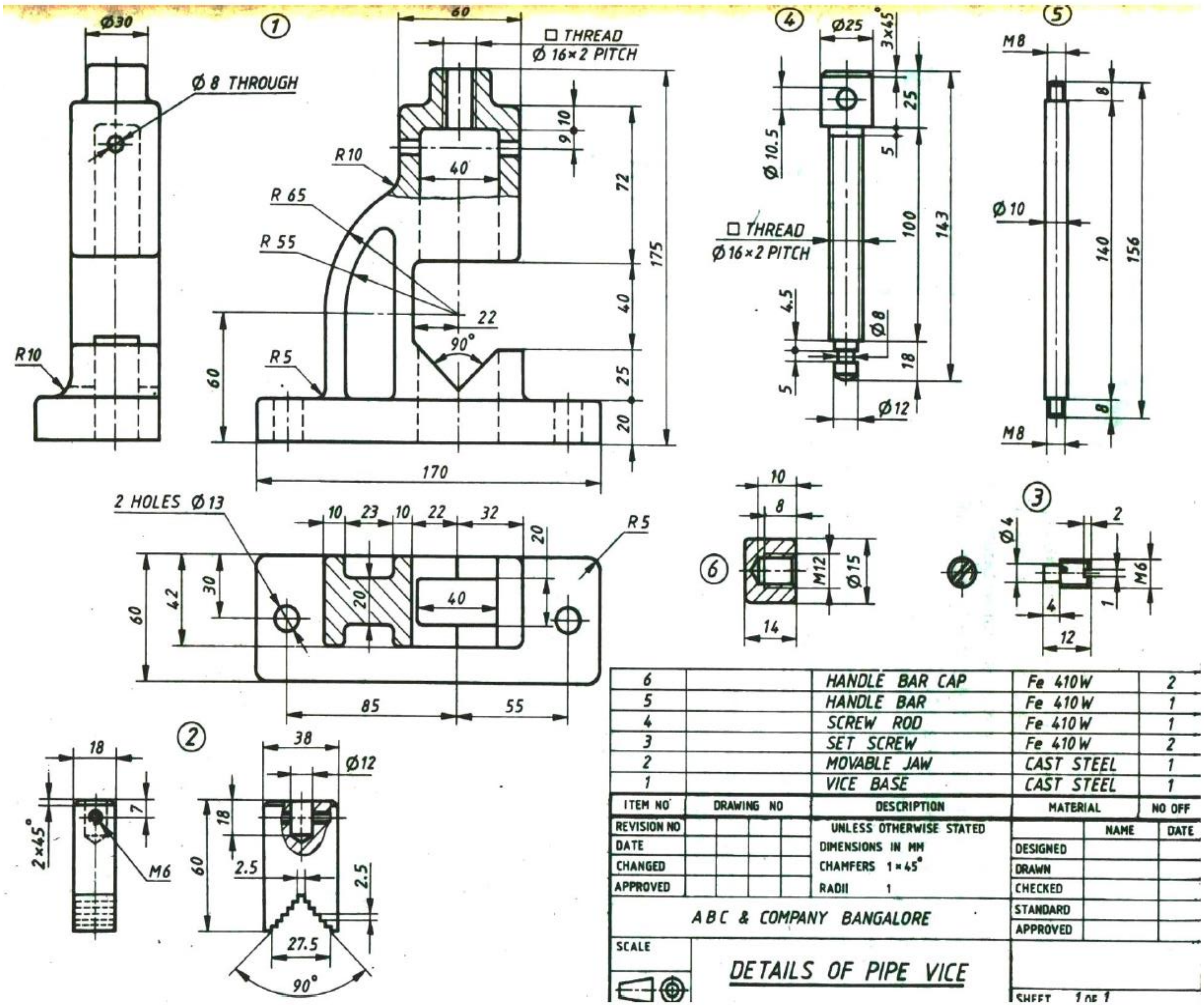
Using Revolve command the Handle Bar Cap has been drawn.

ASSEMBLY AND DETAILED DRAWING:

Using the Assembly and Drawing mode to make the respective views and bill of mate
rials.

RESULT:

Thus the Detail View of the Pipe Vice and it's respective views has been drawn.



ITEM NO	DRAWING NO	DESCRIPTION	MATERIAL	NO OFF
6		HANDLE BAR CAP	Fe 410W	2
5		HANDLE BAR	Fe 410W	1
4		SCREW ROD	Fe 410W	1
3		SET SCREW	Fe 410W	2
2		MOVABLE JAW	CAST STEEL	1
1		VICE BASE	CAST STEEL	1

REVISION NO					UNLESS OTHERWISE STATED		NAME	DATE
DATE					DIMENSIONS IN MM	DESIGNED		
CHANGED					CHAMFERS 1×45°	DRAWN		
APPROVED					RADII 1	CHECKED		
						STANDARD		
						APPROVED		

ABC & COMPANY BANGALORE

SCALE

DETAILS OF PIPE VICE

SHEET 1 OF 1

EX.NO:

DATE: **STUFFING BOX**

AIM: To draw the detail view of the Stuffing Box and assemble the parts by using the pro-e software and obtain its respective views.

COMMANDS USED:

Sketch, Extrusion, Revolve, Pattern, Mate, Align, Helical Sweep, Round, Chamfer etc,

PROCEDUE:

PART DRAWING:

CYLINDER:

Using Extrude, Cut and Round Commands the cylinder has been drawn.

NUT:

Using Extrude, Cut and Round Commands the nut has been drawn.

GLAND BUSH:

Using Extrude and Cut Commands the gland bush has been drawn.

PISTON ROD:

Using Extrude and Cut Commands the piston rod has been drawn.

PACKING:

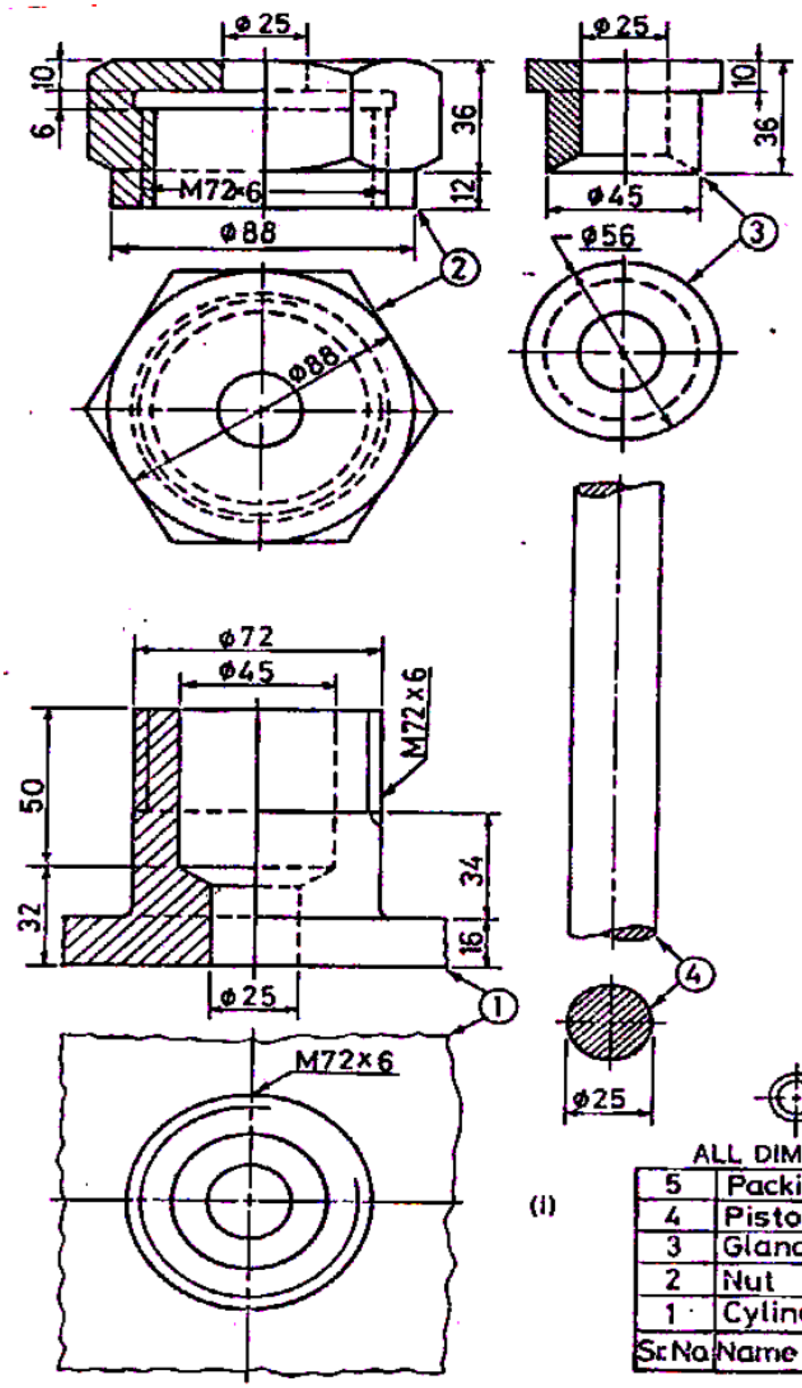
Using Revolve command the packing has been drawn.

ASSEMBLY AND DETAILED DRAWING:

Using the Assembly and Drawing mode to make the respective views and bill of materials.

RESULT:

Thus the Detail View of the Stuffing Box and the it's respective views has been drawn.



SCALE: 1:0.8

ALL DIMENSIONS IN MM

Sr.No	Name of part	No. off	Material	Remark
5	Packing		Asbestos	
4	Piston rod	1	C-30	
3	Gland bush	1	Brass	
2	Nut	1	C.I.	
1	Cylinder	1	C.I.	

CAD/CAM LABORATORY

CNC MILLING PROGRAM

Ex.No.1

Study of G Codes and M Codes to Write Manual Part Programming for Fanuc Control Systems

PREPARATORY FUNCTION (G CODES)

The preparatory functions are the commands, which prepare the machine for different modes of movement like contouring, thread cutting, positioning, peck drilling etc. These functions are also called as G codes. G codes are used as machining commands.

MISCELLANEOUS FUNCTION (M CODES)

The miscellaneous functions are the commands describing miscellaneous functions like subprogram call or exit., spindle clockwise or counter clockwise, coolant ON/ OFF, program end etc. these functions are also called as M codes. M codes are used as machine control commands.

SUBROUTINES

Subroutines or subprograms are mini programs similar to macros but are used in manual part programming. It can be defined as a set of instructions that can be activated and used for repetitive applications in the main program. In Fanuc control systems, subprograms are written as separate programs with specific subprogram names. When a subprogram name is called in the main program, the set of instructions in the subprogram is executed. After execution of the program flow returns to the main program at a point immediately after the original call point.

CANNED CYCLE

Canned cycles are built-in- functions that are available to perform specific tasks like thread cutting, grooving, pattern repeating, pocketing etc. A canned cycle simplifies the program using one or two blocks with specific G codes to specify the machining operations, instead of using several blocks.

Examples are

G71	-	Multiple turning cycle
G73	-	Pattern turning cycle
G75	-	Grooving cycle
G76	-	Multiple thread cutting cycle
G170, G171	-	Rectangular pocketing
G172, G173	-	Circular pocketing

The list of G codes and M codes that can be used in milling machines are given below.

M CODES	FUNCTION
M00	PROGRAM STOP
M01	OPTIONAL STOP
M02	PROGRAM STOP
M03	SPINDLE CLOCKWISE ROTATION
M04	SPINDLE ANTI-CLOCKWISE ROTATION
M05	*SPINDLE STOP*
M06	TOOL CHANGE
M08	COOLANT ON
M09	COOLANT OFF
M10	VICE ON
M11	*VICE OFF*
M13	COOLANT, SPINDLE CW
M14	COOLANT, SPINDLE CCW
M30	PROGRAM STOP AND REWIND
M70	X MIRROR ON
M71	Y MIRROR ON
M80	*X MIRROR OFF*
M81	Y MIRROR OFF
M98	SUBPROGRAM CALL
M99	SUBPROGRAM OFF/EXIT

G CODE	FUNCTION
G00	RAPID POSITIONING
G01	LINEAR INTERPOLATION
G02	CIRCULAR INTERPOLATION CW
G03	CIRCULAR INTERPOLATION CCW
G04	DWELL
G20	INPUT IN INCH
G21	INPUT IN MM
G28	RETURN TO REFERENCE POINT
G40	CUTTER COMPENSATION CANCEL
G41	CUTTER COMPENSATION LEFT
G42	CUTTER COMPENSATION RIGHT
G43	TOOL LENGTH COMPENSATION (+)
G44	TOOL LENGTH COMPENSATION (-)
G49	TOOL LENGTH COMPENSATION CANCEL
G73	PECK DRILLING CYCLE
G74	COUNTER TAPPING CYCLE
G76	FINE BORING CYCLE
G80	CANNED CYCLE CANCEL
G81	DRILLING CYCLE, SPOT BORING
G82	DRILLING CYCLE, COUNTER BORING
G83	PECK DRILLING CYCLE
G84	TAPPING CYCLE
G85	BORING CYCLE
G90	ABSOLUTE COMMAND
G91	INCREMENTAL COMMAND
G92	PROGRAMMING OF ABSOLUTE ZERO POINT
G94	FEED PER MINUTE
G95	FEED PER REVOLUTION

A list of G codes and M codes that can be used in lathes are given below.

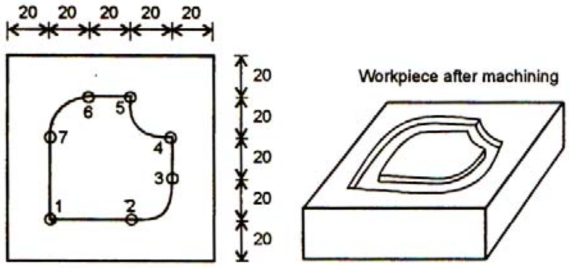
M CODES	FUNCTION
M00	PROGRAM STOP
M01	OPTIONAL STOP
M02	PROGRAM END
M03	SPINDLE CLOCKWISE
M04	SPINDLE COUNTER CLOCKWISE
M05	SPINDLE STOP
M06	TOOL CHANGE
M08	COOLANT ON
M09	COOLANT OFF
M10	VICE OPEN
M11	VICE CLOSE
M30	PROGRAM END AND REWIND
M98	SUBPROGRAM CALL
M99	SUBPROGRAM EXIT

G CODES	FUNCTION
G00	RAPID POSITIONING
G01	LINEAR INTERPOLATION
G02	CIRCULR INTERPOLATION CW
G03	CIRCULAR INTERPOLATION CCW
G04	DWELL
G20	INPUT IN inch
G21	INPUT IN mm
G28	REFERENCE POINT RETURN
G32	THREAD CUTTING
G40	TOOL NOSE RADIUS COMPENSATION CANCEL
G41	TOOL NOSE RADIUS COMPENSATION LEFT
G42	TOOL NOSE RADIUS COMPENSATION RIGHT
G50	SPINDLE SPEED CLAMPING
G70	FINISHING CYCLE
G71	MULTIPLE TURNING CYCLE
G72	MULTIPLE REPEATING CYCLE
G73	PATTERN REPEATING CYCLE
G74	PECK DRILLING CYCLE
G75	GROOVING CYCLE
G76	THREAD CUTTING CYCLE
G90	BOX TURNING CYCLE
G94	BOX FACING CYCLE
G98	FEED PER MINUTE
G99	FEED PER REVOLUTION

LINEAR INTERPOLATION AND CIRCULAR INTERPOLATION

Ex.No.2

Write a manual part program for the given diagram using Linear interpolation and circular interpolation



O2000

[BILLET X100 Y100 Z10;

[TOOLDEF T1 D5;

[EDGEMOVE X0 Y0;

N10 G21 G40 G94;

N20 G50 S2000;

N30 G91 G28 Z0;

N40 G28 X0 Y0;

N50 M06 T0101;

N60 M03 S1000;

N70 G90;

N80 G00 X20 Y20 Z1;

N90 G01 X20 Y20 Z-1 F35;

N100 G01 X60 Y20 Z-1 F35;

N110 G03 X80 Y40 Z-1 R20 F35;

N120 G01 X80 Y60 Z-1 F35;

N130 G02 X60 Y80 Z-1 R20 F35;

N140 G01 X40 Y80 Z-1 F35;

N150 G03 X20 Y60 Z-1 R20 F35;

N160 G01 X20 Y20 Z-1 F35;

N170 G00 Z1;

N180 G91 G28 Z0;

N190 G28 X0 Y0;

N200 M05;

N210 M30;

The same program can also be written as given below.

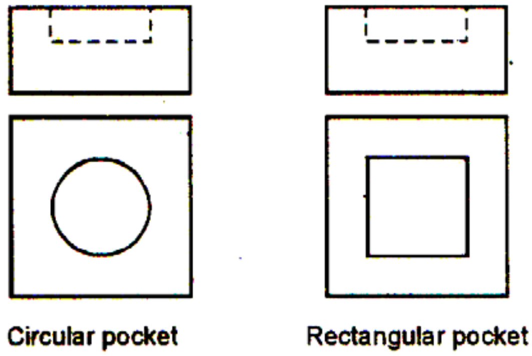
EXAMPLE PROGRAM – 2 FOR MILLING OPERATION

```
O2001
[BILLET X100 Y100 Z10;
[TOOLDEF T1 D5;
[EDGEMOVE X0 Y0;
N10 G21 G40 G94;
N20 G50 S2000;
N30 G91 G28 Z0;
N40 G28 X0 Y0;
N50 M06 T0101;
N60 M03 S1000;
N70 G90;
N80 G00 X20 Y20 Z1;
N90 G01 Z-1 F35;
N100 X60 ;
N110 G03 X80 Y40 R20;
N120 G01 Y60;
N130 G02 X60 Y80 R20;
N140 G01 X40;
N150 G03 X20 Y60 R20;
N160 G01 Y20;
N170 G91 G28 Z2;
N180 G28 X0 Y0;
N190 M05;
N200 M30;
```

CIRCULAR POCKETING AND RECTANGULAR POCKETING

Ex.No.3

Write a CNC program for milling machine for the profile given using circular pocketing and rectangular pocketing.



The syntax for **circular pocketing** is given below.

G170 R0 P0 Q3 X10 Y10 Z - 5 I0 J0 K24

G171 P75 S1000 R50 F45 B1500 J15

R	-	Position of tool to start cycle
P	-	Roughing (0) / finishing (1)
Q	-	Peck increment for each cut
X,Y & Z	-	Coordinates of bottom center of the circular pocket.
I & J	-	Finishing allowance for side and pocket base
K	-	Radius of circular pocket
P	-	Cutter movement percentage for next step
S	-	Roughing spindle speed
R	-	Roughing feed in Z direction
F	-	Roughing feed in XY directions
B	-	Finishing spindle speed
J	-	Finishing feed

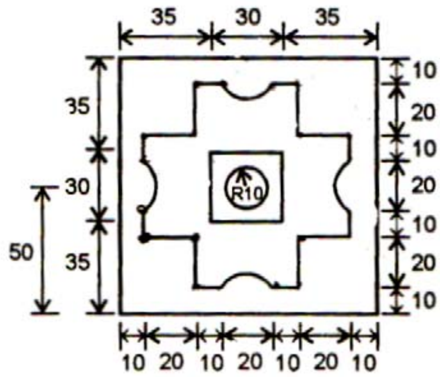
The syntax for **rectangular pocketing** is given below:

G172 I30 J50 K0 P0 Q.5 R0 X10 Y10 Z-5

G173 I0 K0 P75 T1 S1000 R35 F45 B1500 J15 Z5

Where

I,J	-	Length of pocket in X, Y directions
K	-	Corner radius
P	-	Roughing (0) / Finishing (1)
Q	-	Depth of cut for each pass
R	-	Absolute depth from the surface
X & Y	-	Pocket corner coordinates
Z	-	Base of pocket
I,K	-	Pocket side and base finish allowance
P	-	Cutter width percentage
T	-	Tool number
S	-	Roughing spindle speed
R	-	Roughing feed in Z direction
F	-	Roughing feed in XY directions
B	-	Finishing spindle speed
J	-	Finishing feed



O2002;

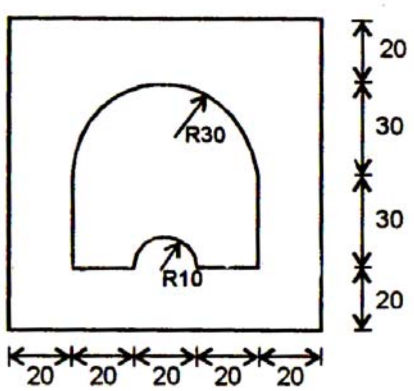
```
[BILLET X100 Y100 Z10;
[TOOLDEF T1 D5;
[EDGEMOVE X0 Y0;
N10 G21 G40 G94;
N20 G91 G28 Z0;
N30 G28 X0 Y0;
N40 M06 T0101;
N50 M03 S2000;
N60 G90 G00 X30 Y10 Z5;
N70 G01 Z-1 F35;
N80 X30 Y30;
N90 X10 Y30;
N100 X10 Y40;
N110 G03 X10 Y60 R10;
N120 G01 X10 Y70;
N130 X30 Y70;
N140 X30 Y90;
N150 X40 Y90;
N160 G03 X60 Y90 R10;
N170 G01 X70 Y90;
N180 X70 Y70;
N190 X90 Y70;
N200 X90 Y60;
N210 G03 X90 Y40 R10;
N220 G01 X90 Y30;
N230 X70 Y30;
```

```
N240 X70 Y10;
N250 X60 Y10;
N260 G03 X40 Y10 R10;
N270 G02 X30 Y10;
N280 G00 Z5;
N290 G172 I30 J30 K0 P0 Q0.5 R0 X35 Y35 Z-1.5;
N300 G173 I0 K0 P75 T1 S2000 R75 F275 B2500 J200 Z6;
N310 G170 P0 Q0.5 R1 X50 Y50 Z-3 I0 J0 K10;
N320 G171 P75 S2000 R50 F150 B1500 J150;
N330 G91 G28 X0 Y0 Z0;
N340 M05;
N350 M30;
```

CNC PROGRAM USING SUBPROGRAM

Ex.No.4

Write a CNC program for milling machine for the profile given using sub program.



Profile depth = 5 mm

SUBPROGRAM

O9000;

N10 G91 G01 Z-1 F35;

N20 G90;

N30 G01 X40 Y20;

N40 G02 X60 Y20 R10;

N50 G01 X80 Y20;

N60 X80 Y50;

N70 G03 X20 Y50 R30;

N80 G01 X20 Y20;

N90 M99;

** save the subprogram as 4 digit number 9000.

Main Program

```
O2003
[BILLET X100 Y100 Z20;
[EDGEMOVE X0 Y0;
[TOOLDEF T1 D5;
N10 G21 G94 G40;
N20 G91 G28 Z0;
N30 G28 X0 Y0;
N40 M06 T0101;
N50 M03 S1000;
N60 G90 G00 X20 Y20 Z1;
N70 G01 Z0 F35;
N80 M98 P0059000;
N90 G01 Z1;
N100 G91 G28 Z0;
N110 G28 X0 Y0;
N120 M05;
N130 M30;
```

The statement M98 P0059000 can be explained as follows:

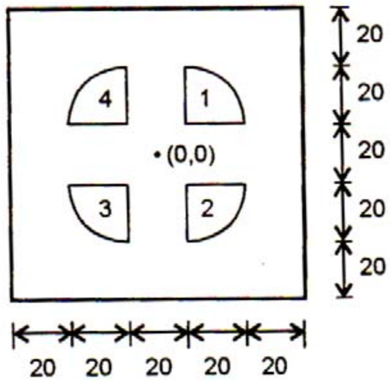
M 98 – For subprogram call.

P0059000 – 005 is the number of times the subprogram 9000 has to be called. (i.e. the subprogram 9000 has to be executed for 5 times.)

MIRRORING USING SUBPROGRAM

Ex.No.5

Write a CNC program for milling machine for the profile given using sub program and mirror command.



Subprogram

O8000;

N10 G90 G00 X10 Y10 Z1;

N20 G01 Z-1 F35;

N30 G01 X30 Y10;

N40 G03 X10 Y30;

N50 G01 X10 Y10;

N60 G00 Z1;

N70 G00 X0 Y0;

N80 M99;

**** save the file as 4 digit number 8000.**

Main Program

O2004

[BILLET X100 Y100 Z10;

[EDGEMOVE X-50 Y-50;

[TOOLDEF T1 D5;

N10 G21 G94 G40;

N20 G91 G28 Z0;

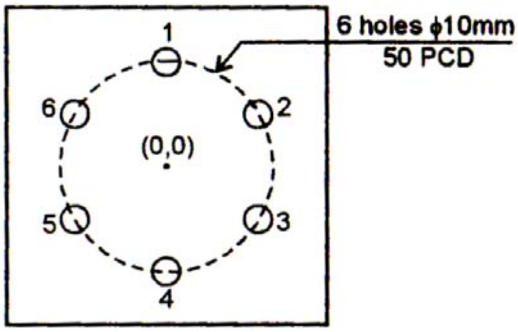
N30 G28 X0 Y0;

```
N40 M06 T0101;
N50 M03 S1000;
N60 G90 G00 X0 Y0 Z5;
N70 M98 P0018000;        ——————————  PROFILE 1
N80 M70;                 ——————————  X – Mirror On
N90 M98 P0018000;        ——————————  PROFILE 4
N100 M71;                ——————————  Y – Mirror On
N110 M98 P0018000;       ——————————  PROFILE 3
N120 M80;                ——————————  X – Mirror Off
N130 M98 P0018000;       ——————————  PROFILE 2
N140 M81;                ——————————  Y – Mirror Off
N150 G91 G28 Z0;
N160 G28 X0 Y0;
N170 M05;
N180 M30;
```

CNC PROGRAM USING DRILLING CYCLE

Ex.No.6

Write a CNC program for milling machine as shown in diagram using drilling cycle.

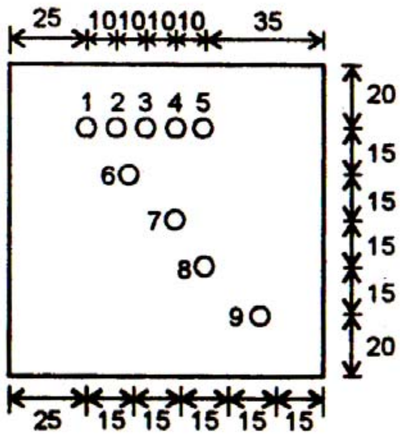



```
O2005;
[BILLET X100 Y100 Z20;
[TOOLDEF T1 D10;
[EDGEMOVE X-50 Y-50;
N10 G21 G94 G41;
N20 G91 G28 Z0;
N30 G28 X0 Y0;
N40 M06 T0101;
N50 M03 S1000;
N60 G90 G00 X0 Y0 Z5;
N70 G83 X0 Y25 Z-10 Q0.5 R1 F35;      ————————      DRILL 1
N80  X21.65 Y12.5;                    ————————      DRILL 2
N90  X21.65 Y-12.5      ;             ————————      DRILL 3
N100 X0 Y-25;                         ————————      DRILL 4
N110 X-21.65 Y - 12.5;                ————————      DRILL 5
N120 X-21.65 Y 12.5;                  ————————      DRILL 6
N130 G80;
N140 G91 G28 Z0;
N150 G28 X0 Y0;
N160 M05;
N170 M30;
```

CNC PROGRAM USING FAST DRILLING CYCLE

Ex.No.7

Write a CNC program for milling machine as shown in diagram using fast peck drilling cycle.




```
O2006
[BILLET X100 Y100 Z20;
[TOOLDEF T1 D10;
[EDGEMOVE XO YO;
N10 G21 G94 G41;
N20 G91 G28 Z0;
N30 G28 X0 Y0;
N40 M06 T0101;
N50 M03 S1000;
N60 G90 G00 X15 Y80 Z5;
N70 G01 Z0;
N80 G91 G73 X10 Y0 Z-5 Q0.5 R0.0 K5 F35;
N90 G90;
N100 G00 X25 Y80 Z0;
N110 G91 G73 X15 Y-15 Z-5 Q0.5 R0.0 K4 F35;
N120 G91 G28 Z0;
N130 G28 X0 Y0;
N140 M05;
N150 M30;
```

Explanation

Statement N20:-

G73- Peck drilling

X10, Y10 denotes the incremental distance from its present position (Present position is defined in N10)

Z-5 denotes the depth of the drill

Q0.5 denotes the depth of cut for each peck

K5 denotes that drilling has to be done five times at the given increment X & Y distances

R - denotes the position of tool to start in Z direction

The block N20 drills five holes. Initially the tool is positioned at X15 and Y80 in block N10. From this position the tool takes a move of 10mm in X direction, which is point 1 and starts drilling. Then it moves to point 2 and starts drilling. So on, five drills at points 1,2,3,4 & 5 are drilled. After that, the tool is positioned at point 1. Then as per instructions in the block N30, the tool moves 15mm in X direction and 15mm in Y direction, which is point 6 and starts drilling. It moves to points 7,8 & 9 and performs drilling operation at each point as explained above.

FACING

AIM: To write the part programming and simulation them to the given lathe job.

TOOLS AND EQUIPMENTS

1. CNC simulation software FANUC
2. CNC trainer software
3. Software Pentium IV

PROCEDURE

1. To write the program for given job.
2. To type G and M CODES.
3. To give the tool size and stock dimensions.
4. Finally to run the machine to the operation.

PROGRAM

```
[BILLET X32 Z65]
G21 G98;
G28 V0 W0;
M06 T01;
M03 S1200;
G00 X34 Z2;
G94 X0 Z-1 F60;
X0 Z-2;
X0 Z-3;
X0 Z-4;
G00 X34 Z2;
G28 V0 W0;
M05;
M30;
```

RESULT: Thus the part program was written and simulated for given job.

TAPER TURNING

AIM: To write the part programming and simulation them to the given lathe job.

TOOLS AND EQUIPMENTS

1. CNC simulation software FANUC
2. CNC trainer software
3. Software Pentium IV

PROCEDURE

1. To write the program for given job.
2. To type G and M CODES.
3. To give the tool size and stock dimensions.
4. Finally to run the machine to the operation.

PROGRAM

```
[BILLET X32 Z65]
G21 G98;
G28 V0 W0;
M06 T01;
M03 S1200;
G00 X34 Z2;
G00 X30;
G90 X32 Z-50 F45;
G00 X32;
G00 X2;
G00 X28;
G01 X30 Z-50;
G01 X32;
G00 Z2;
G00 X27;
G01 X30 Z-50;
G01 X32;
G28 V0 W0;
M05;
```

M30;

RESULT: Thus the part program was written and simulated for given job.

TURNING OPERATION

AIM: To write the part programming and simulation them to the given lathe job.

TOOLS AND EQUIPMENTS

1. CNC simulation software FANUC
2. CNC trainer software
3. Software Pentium IV

PROCEDURE

1. To write the program for given job.
2. To type G and M CODES.
3. To give the tool size and stock dimensions.
4. Finally to run the machine to the operation.

PROGRAM

```
[BILLET X32 Z65]
G21 G98;
G28 V0 W0;
M06 T01;
M03 S1200;
G00 X34 Z2;
G90 X32 Z-50 F60;
X31 Z-50;
X30 Z-50;
X29 Z-50;
X28 Z-50;
X27 Z-50;
X26 Z-50;
X25 Z-50;
G00 X34 Z2;
G28 V0 W0;
M05;
M30;
```

RESULT: Thus the part program was written and simulated for given job.

THREAD CUTTING

AIM: To write the part programming and simulation them to the given lathe job.

TOOLS AND EQUIPMENTS

1. CNC simulation software FANUC
2. CNC trainer software
3. Software Pentium IV

PROCEDURE

1. To write the program for given job.
2. To type G and M CODES.
3. To give the tool size and stock dimensions.
4. Finally to run the machine to the operation.

PROGRAM

```
[BILLET /20, 100]
[STOCK/170,100,0,-170]
[TOOL/ THREAD,60,50,15,90,0,0]
G50 X200 Z220;
G00 X120 Z182 S2000;
G76 P011260 Q100 R200;
G76 X87 Z50 P5000 Q2500 F8;
G00 X200 Z220;
M02;
```

RESULT: Thus the part program was written and simulated for given job.

STEP TURNING

AIM: To write the part programming and simulation them to the given lathe job.

TOOLS AND EQUIPMENTS

1. CNC simulation software FANUC
2. CNC trainer software
3. Software Pentium IV

PROCEDURE

1. To write the program for given job.
2. To type G and M CODES.
3. To give the tool size and stock dimensions.
4. Finally to run the machine to the operation.

PROGRAM

[BILLET X32 Z65]

G21 G98;

G28 V0 W0;

M06 T01;

M03 S1200;

G00 X32 Z2;

G90 X32 Z-50 F60;

X31 Z-54;

X30 Z-54;

X29 Z-54;

X28 Z-54;

X27 Z-54;

X26 Z-54;

X25 Z-36;

X24 Z-36;

X23 Z-36;

X22 Z-36;

X21 Z-36;

X20 Z-36;

X19 Z-18;

X18 Z-18;

X17 Z-18;

X16 Z-18;

X15 Z-18;

X14 Z-18;

G00 X34 Z2;

G28 V0 W0;

M05;

M30;

RESULT

Thus the part program was written and simulated for given job.

LINEAR INTERPOLATION

AIM: To write the part programming and simulation them to the given milling job.

TOOLS AND EQUIPMENTS

1. CNC simulation software
2. CNC milling software
3. Software Pentium IV

PROCEDURE

1. To write the program for given job.
2. To type G and M CODES.
3. To give the tool size and stock dimensions.
4. Finally to run the machine to the operation.

PROGRAM

G21 G41;

(STOCK/BLOCK 125,135,20,8,-8)

G28 V0 W0;

M06 T01;

(TOOL/MILL 8,8,16,8)

M03 S1000;

G00 X0 Y0 Z5;

X50 Y25;

G01 Z-10 F45 M08;

X75 Y25;

X100 Y50;

X100 Y85;

X75 Y110;

X50 Y110;

X25 Y85;

X25 Y50;

G00 Z5 M09;

G28;

M05;

M30;

RESULT: Thus the part program was written and simulated for given job.

CIRCULAR INTERPOLATION-I

AIM: To write the part programming and simulation them to the given milling job.

TOOLS AND EQUIPMENTS

1. CNC simulation software
2. CNC milling software
3. Software Pentium IV

PROCEDURE

1. To write the program for given job.
2. To type G and M CODES.
3. To give the tool size and stock dimensions.
4. Finally to run the machine to the operation.

PROGRAM

```
G21 G41;
(STOCK/BLOCK 160, 120, 20, 5,-5, 10)
(TOOL/MILL 8, 2, 60, 2)
COLOR 255,255,255;
M06 T01;
M03 S1000;
G00 X0 Y0 Z5;
G00 X50 Y20;
G01 Z-10 F45 M08;
G01 X110 Y20;
G02 X140 Y50 R30;
G01 X140 Y130;
G02 X110 Y160 R30;
G01 X50 Y160;
G02 X20 Y130 R30;
G01 X20 Y50;
G02 X50 Y20 R30;
G00 Z5 M09 ;
```

```
G00 Z5 M09;
G28;
M05;
M30;
```

RESULT: Thus the part program was written and simulated for given job.

CIRCULAR INTERPOLATION-II

AIM: To write the part programming and simulation them to the given milling job.

TOOLS AND EQUIPMENTS

1. CNC simulation software
2. CNC milling software
3. Software Pentium IV

PROCEDURE

1. To write the program for given job.
2. To type G and M CODES.
3. To give the tool size and stock dimensions.
4. Finally to run the machine to the operation.

PROGRAM

```
G21 G41;
(STOCK/BLOCK 160, 120, 20, 5,-5, 10)
(TOOL/MILL 8, 2, 60, 2)
COLOR 255,255,255;
M06 T01;
M03 S1000;
G00 X0 Y0 Z5;
G00 X50 Y20;
G01 Z-10 F45 M08;
G01 X110 Y20;
G03 X140 Y50 R30;
G01 X140 Y130;
G03 X110 Y160 R30;
G01 X50 Y160;
G03 X20 Y130 R30;
G01 X20 Y50 ;
G03 X50 Y20 R30 ;
G00 Z5 M09 ;
G00 Z5 M09;
G28;
```

M05;

M30;

RESULT: Thus the part program was written and simulated for given job.

DRILLING CYCLE

AIM: To write the part programming and simulation them to the given milling job.

TOOLS AND EQUIPMENTS

1. CNC simulation software
2. CNC milling software
3. Software Pentium IV

PROCEDURE

1. To write the program for given job.
2. To type G and M CODES.
3. To give the tool size and stock dimensions.
4. Finally to run the machine to the operation.

PROGRAM

```
G21 G41;
(STOCK/BLOCK 160, 120, 20, 5,-5, 21)
(TOOL/DRILL 10, 120,50)
(COLOR 255,255,255)
M06 T01;
M03 S1000;
G00 X0 Y0 Z5;
G83 X40 Y40 Z-15 R0.5 Q3 M08 ;
X80 Y90 ;
X120 Y135 ;
G00 Z2 M09;
G28;
M05;
M30;
```

RESULT: Thus the part program was written and simulated for given job.

PREPARATORY FUNCTION

(G -CODES)

G00- Fast transverse

G01- Linear interpolation

G02- Circular interpolation(c.w)

G03- Circular interpolation(c.c.w)

G04-Dwell

G20-Imporial (input in inches)

G21- Metric (input in mm)

G28- Go to reference

G40- Cutter compensation cancel

G41- Cutter compensation right

G42-Cutter compensation left

G50- Co-ordinate setting

G70-Finishing cycle

G71- Stock removal in turning

G72- Multiple facing

G73-Pattern repeating

G74- drilling

G76- Multiple thread

G81- Drilling cycle

G90-Turning cycle

G94- Facing cycle

G96- Constant surface

G97- Variable surface

G98- Feed per minute

G99- Feed per revolution

MISCELLANEOUS FUNCTION

(M - CODES)

M00- Program stop

M02- Optional stop

M03- Program end

M04- Spindle forward

M05- Spindle stop

M06- Tool change

M08- Coolant on

M09- Coolant off

M10- Vice open

M11- Vice close

M62- Output 1ON

M63- Output 2ON

M64- Output1OFF

M65- Output 2OFF

M60- Wait input 1ON

M67- Wait input 10FF

M76- Wait input 2OFF

M77-Sub program call

M98-Sub program exit

M99- Sub program exit

M30- Program and rewind

Tutorial 1:

Introduction to ANSYS

Introduction:

This Tutorial will use a readymade file to speed up the learning process for the student. This file is provided in Parasolid format. The intention of this tutorial is to get the student to run a straight forward simulation. By the end of this tutorial a check list for the required procedure can be formulated by the student. ANSYS as a software is made to be user-friendly and simplified as much as possible with lots of interface options to keep the user as much as possible from the hectic side of programming and debugging process.

Why is it that such a simple model is used?

During this tutorial a simple geometry is used, the objective of that is that the student masters the steps to get to run a simple simulation, once that's done the student can model any kind of geometry he sees necessary for his studied case.

Step1: Launch ANSYS ,by going to the start-up menu and double clicking on workbench file in the ANSYS 13.0 folder.

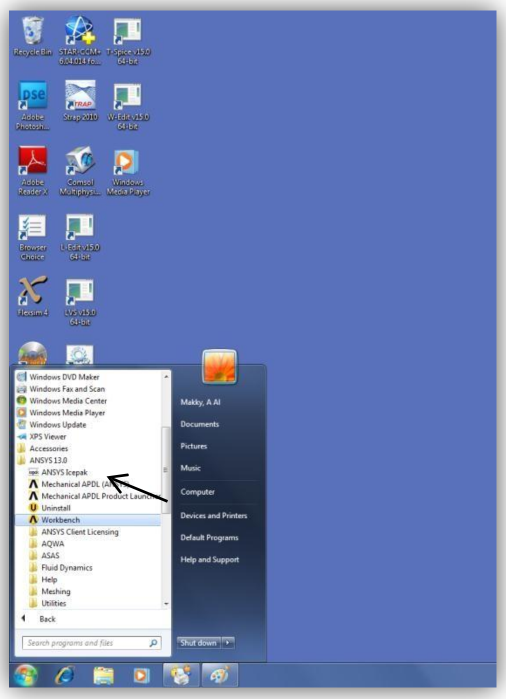


Figure1: A reminder that not all lab machines have the ANSYS software installed on them.

Step2: Once the program is launched it should look like as shown below. Go to Analysis Systems Fluid Flow (CFX) and double click.

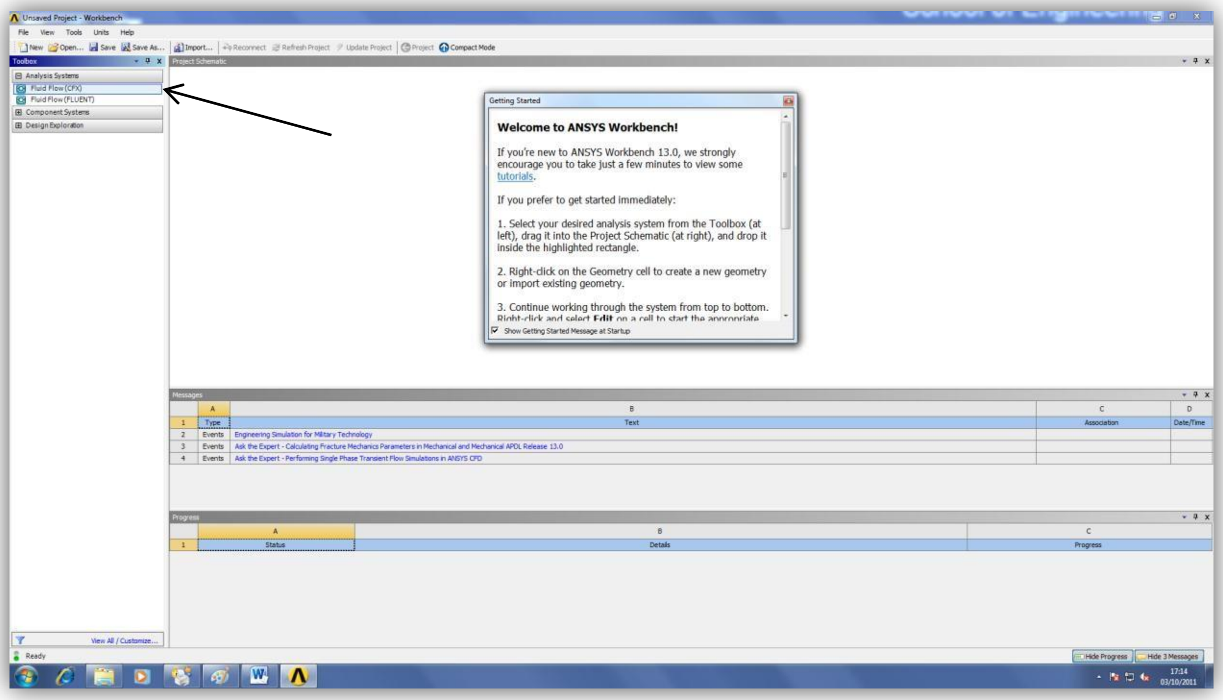


Figure2: You might have to wait a bit till ANSYS gets running, the student is encouraged to use the provided help with the software, it has lots of useful hints here and there.

Step3: Next Double click on the Geometry. This stage is for getting the required geometry read into the software, note that there is a blue question mark icon beside the geometry text. Looking at the bottom of the window you will see two windows one having the title of **Messages**, this title confirms that the imported geometry has no problems with it, the next window has the title **Progress** and that is necessary to prove that state of the progress and if there is a problem it will state the problem.

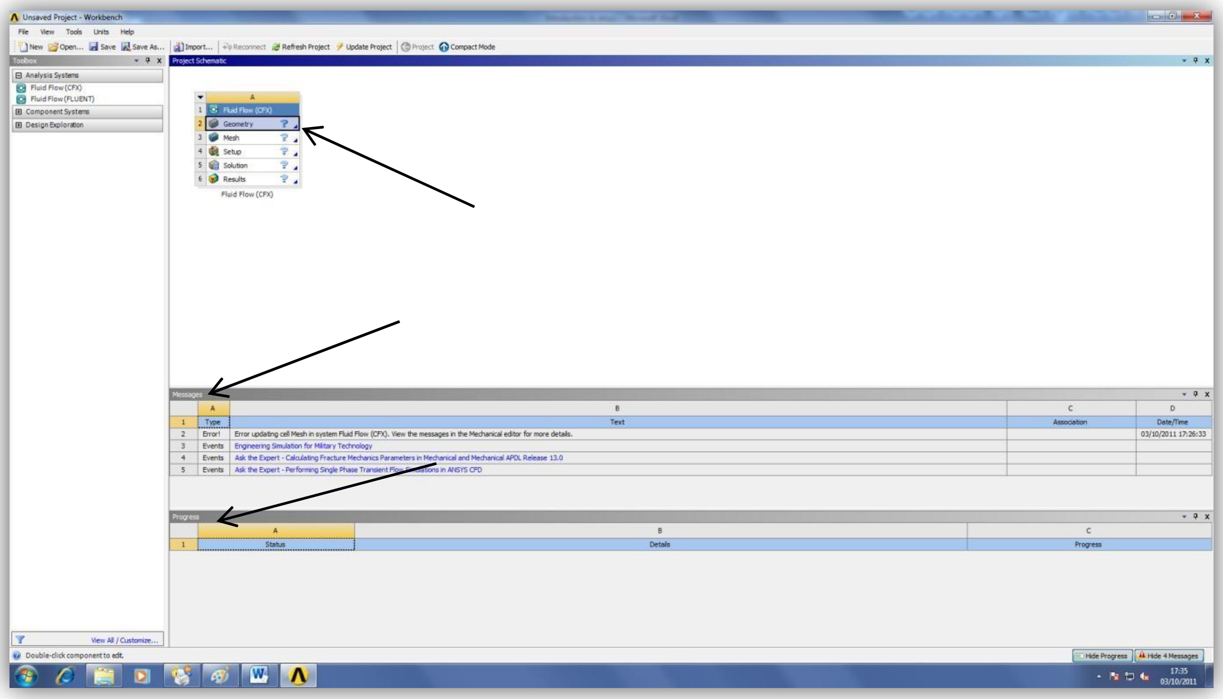


Figure3: At the moment the illustration are a bit simplified for the user and will get complex with time.

Step4: Once ANSYS Workbench window is active you will get a window asking to specify working units for the model dimension chose meters and press ok. For the user this step might seem secondary in importance but as a matter of fact it's of great importance, because at later stages you will have to specify the box size (discrete element dimension). Box size dimension leads to finer mesh, the finer the used mesh is the more accurate is the captured data. The captured data term refers to the fluid flow structures.

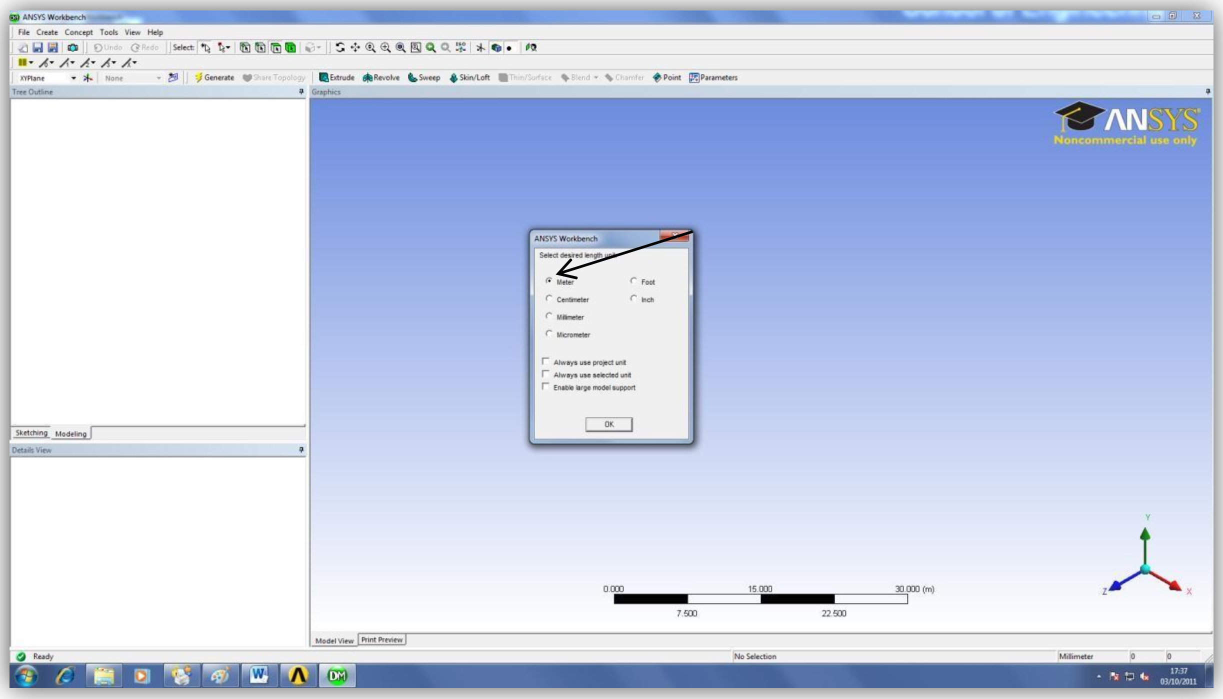


Figure4: Depending on your studied case the selection of serial or parallel is taken, also depending on the hardware provided in the computer lab dual core or quad core etc.

Step5: Go to file and choose Import External Geometry File…. .

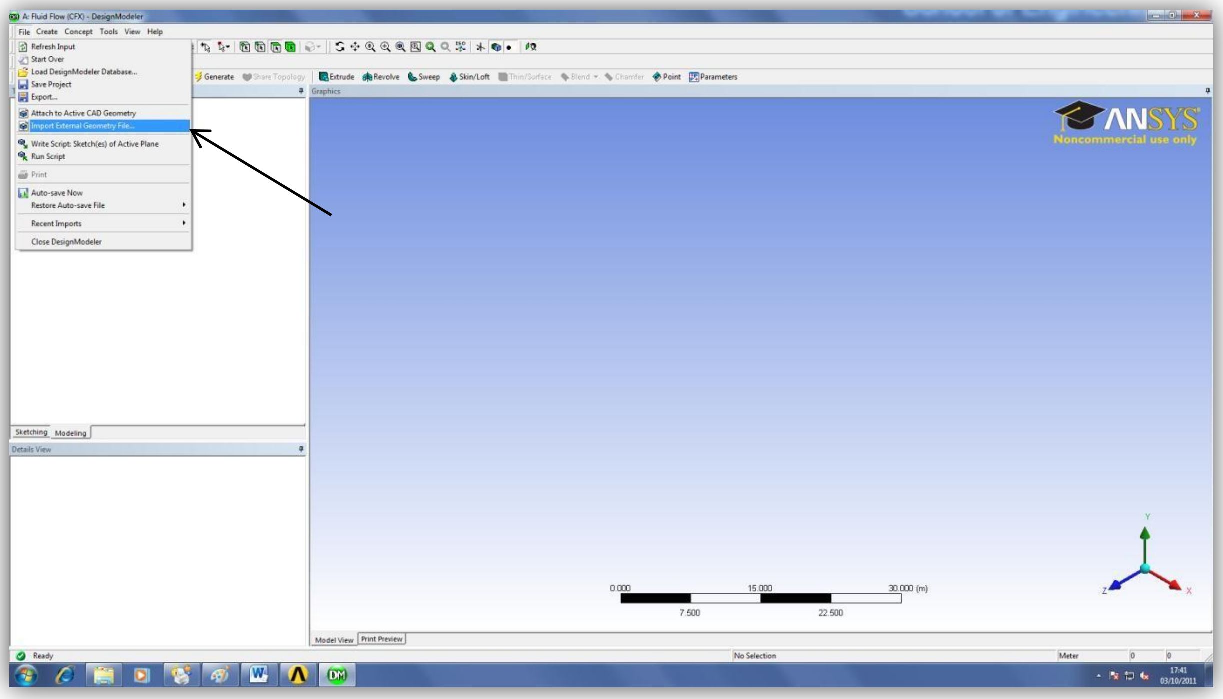


Figure 5: You can model your geometry using the sketching tools provided with DesignModeler.

Step 6: A window having a title open will be visible to the user, choose File type Parasolid(*x_t;*xmt_txt;*x_b;*xmt_bin) then go to the folder that has the required file .

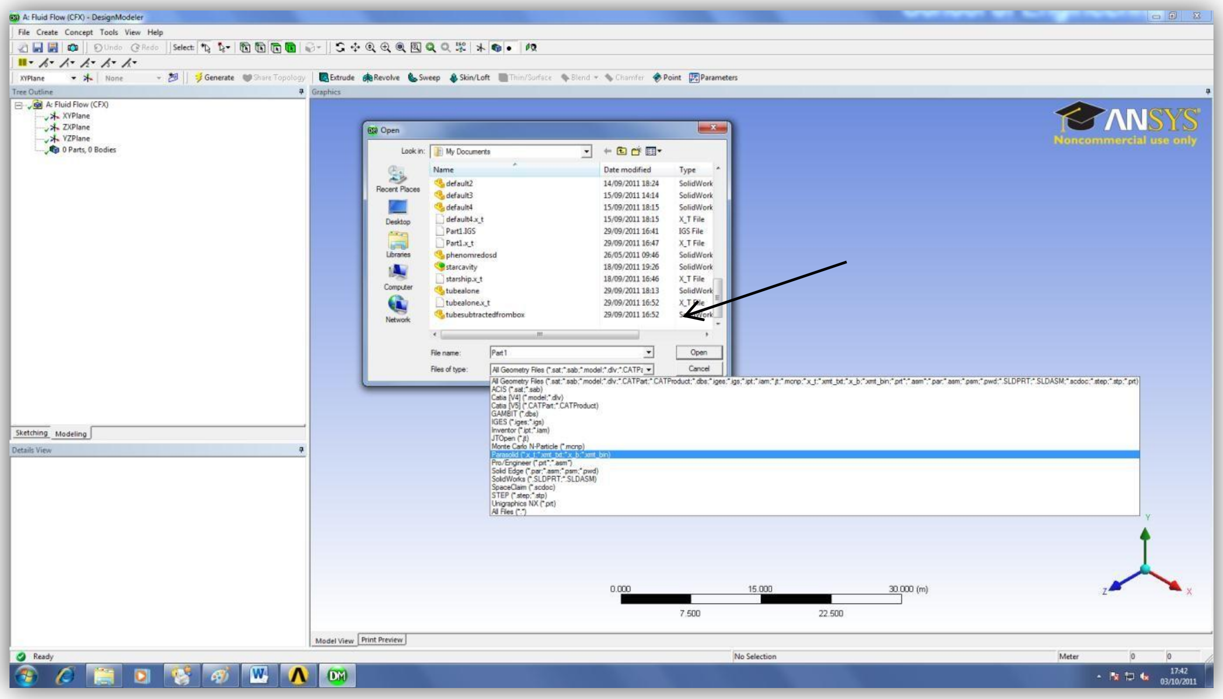


Figure 6: There are lots of software that are used to generate meshes, depending on the software used the file extension text would be, in our case we are using SolidWorks to generate the mesh and then exporting it in Parasolid format. A question comes to the mind of the student why do I have to specify the file extension. The answer is that each mesh generation software has its own structure in its generated data sets. A simple example:

Software 1:

N	x	y	z
1	1*dx	1*dy	1*dz
2	2*dx	2*dy	2*dz
3	3*dx	3*dy	3*dz

Software 2:

N	1	2	3
x	1*dx	2*dx	3*dx
y	3*dy	3*dy	3*dy
z	3*dz	3*dz	3*dz

Step7: Looking at the DesigModeler window, we can't see the imported geometry yet, what is required next is to press on the generate icon that is represented by a yellow thunder icon.

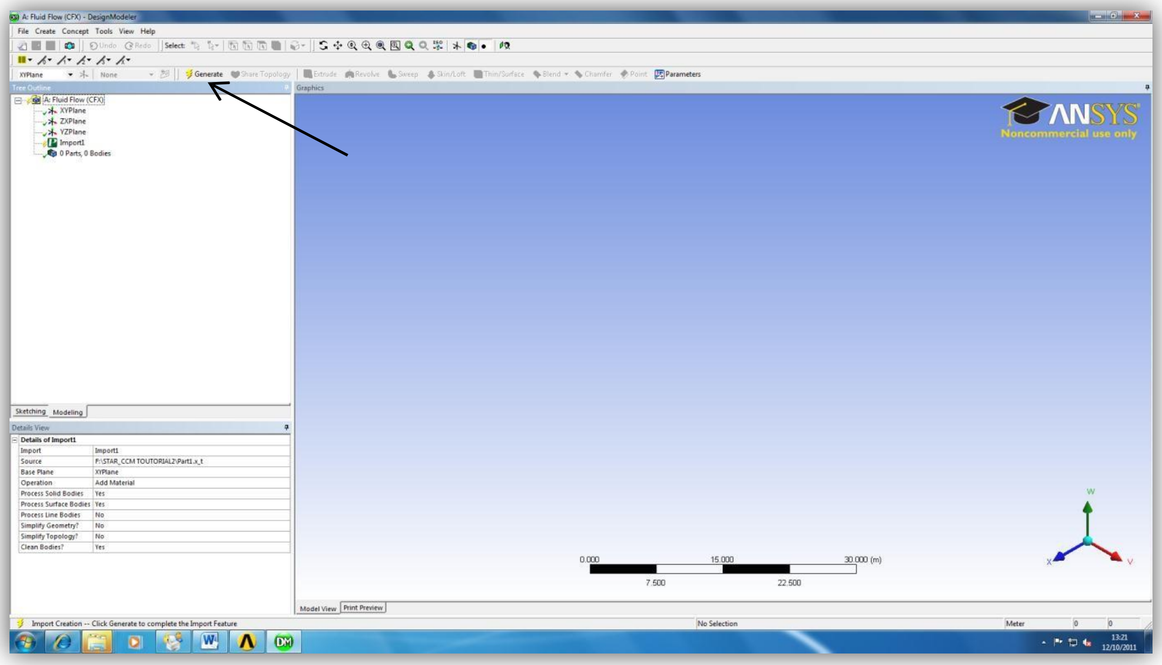


Figure6: The DesignModeler will read in the imported data file, and will construct the required mesh.**Step7:** The imported Geometry Domain should look something like this, still that doesn't give any hints to the user, relating to the inner structure of the domain.

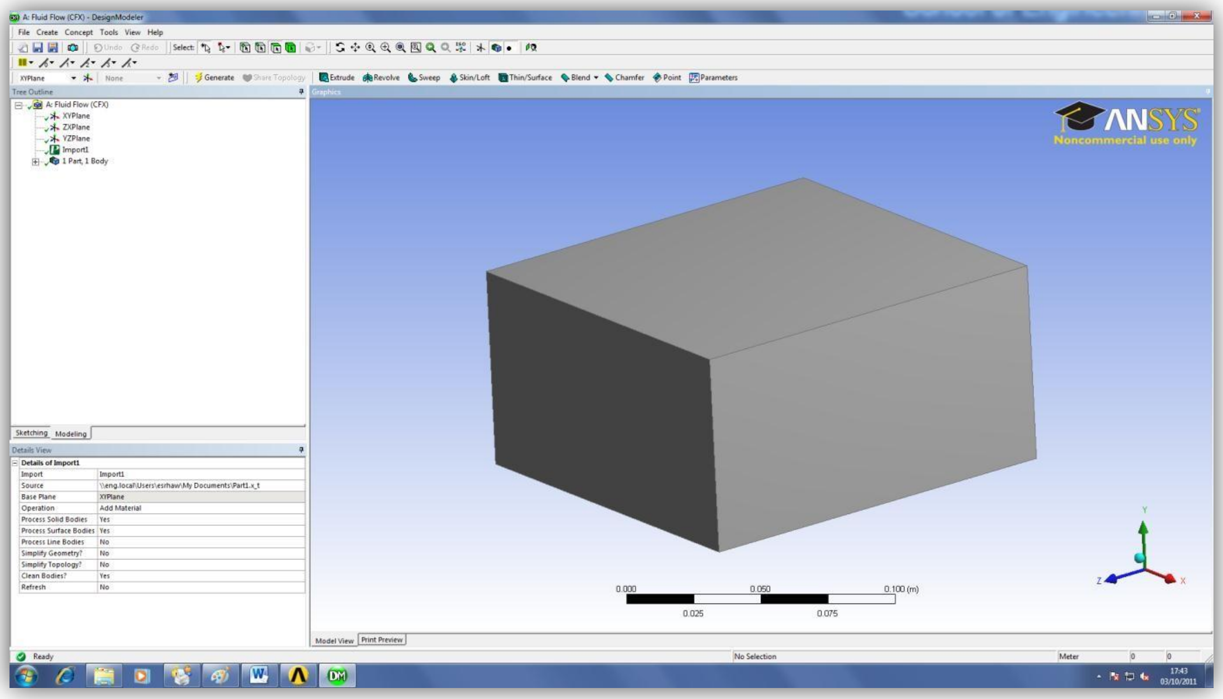


Figure7: The geometry domain is viewed in the shaded exterior style.

Step8: go to view and chose wireframe.

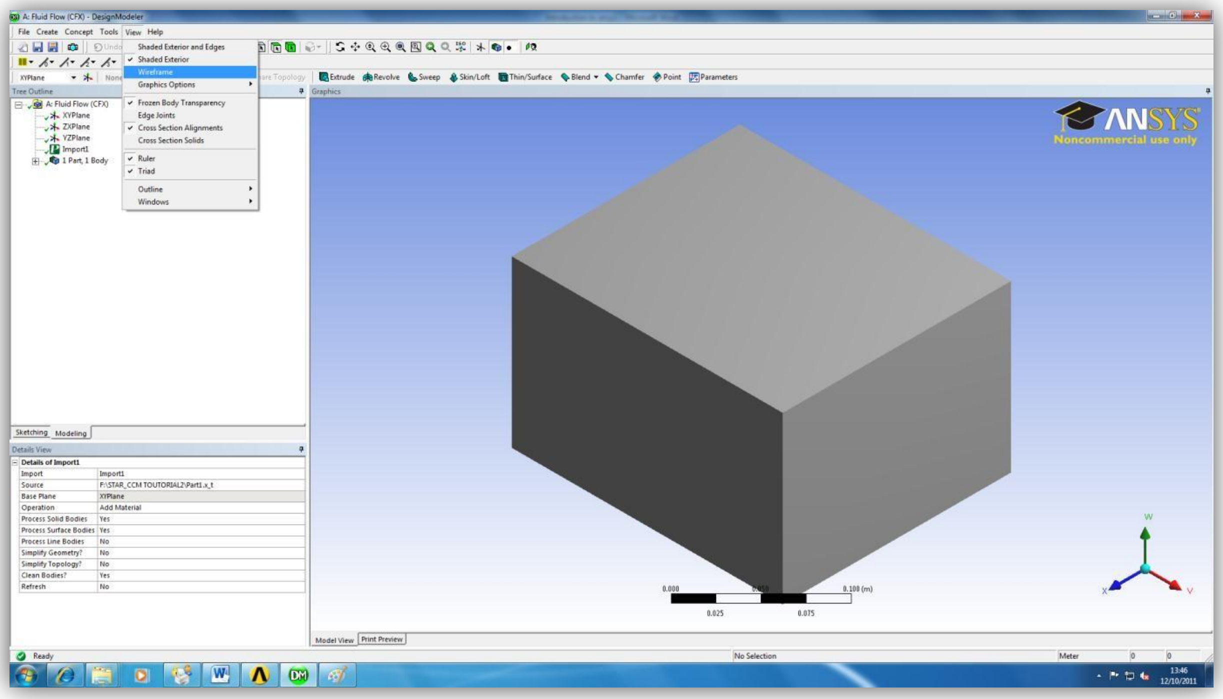
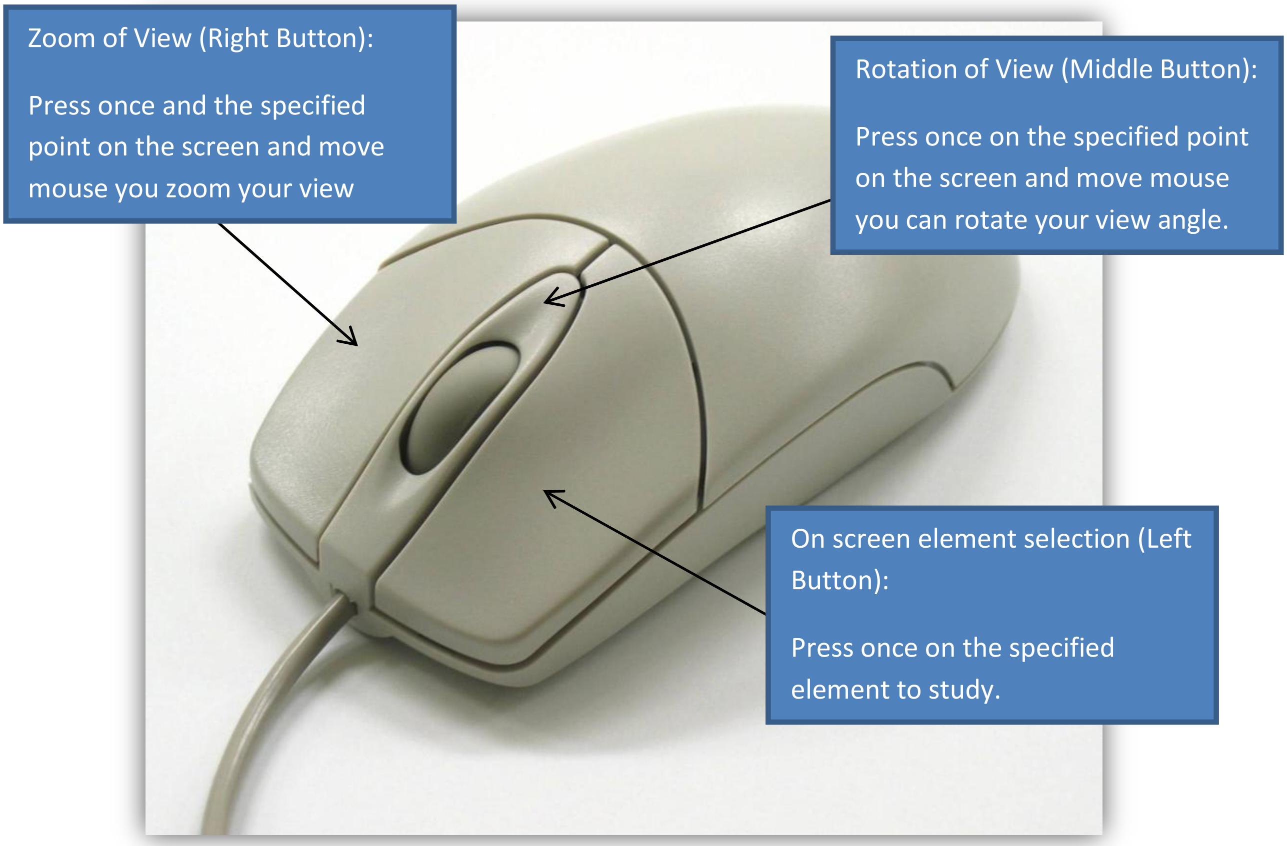


Figure 8: This step is necessary to view the inner structure of the domain**.**


Zoom of View (Right Button):
Press once and the specified point on the screen and move mouse you zoom your view
Rotation of View (Middle Button):
Press once on the specified point on the screen and move mouse you can rotate your view angle.
On screen element selection (Left Button):
Press once on the specified element to study.

Step 9a: Once the student gets to this stage, that means he has finished from the DesignModeler and has to proceed to the Meshing part.

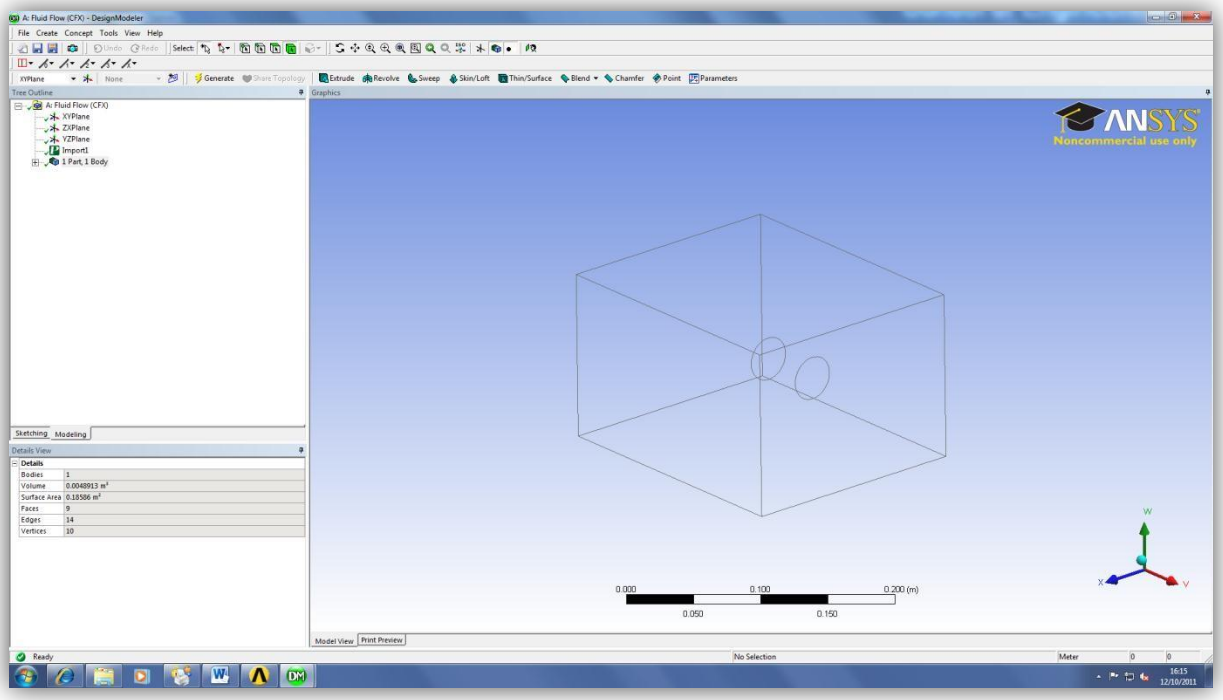


Figure 9a: Rotate the view and check that the Geometry satisfies the design requirements.

Step 9b: Go to the workbench and check that there is a green tick sign beside the Geometry and then double click on the Mesh Icon.

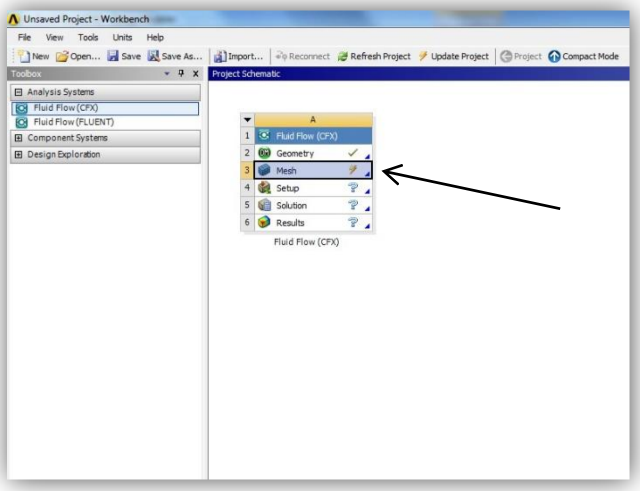


Figure 9b: Congratulations you have finished from DesignModeler and now have started with the Meshing part.

Step 10a: The Meshing part of the project has started, notice that beside the Mesh there is a yellow thunder icon.

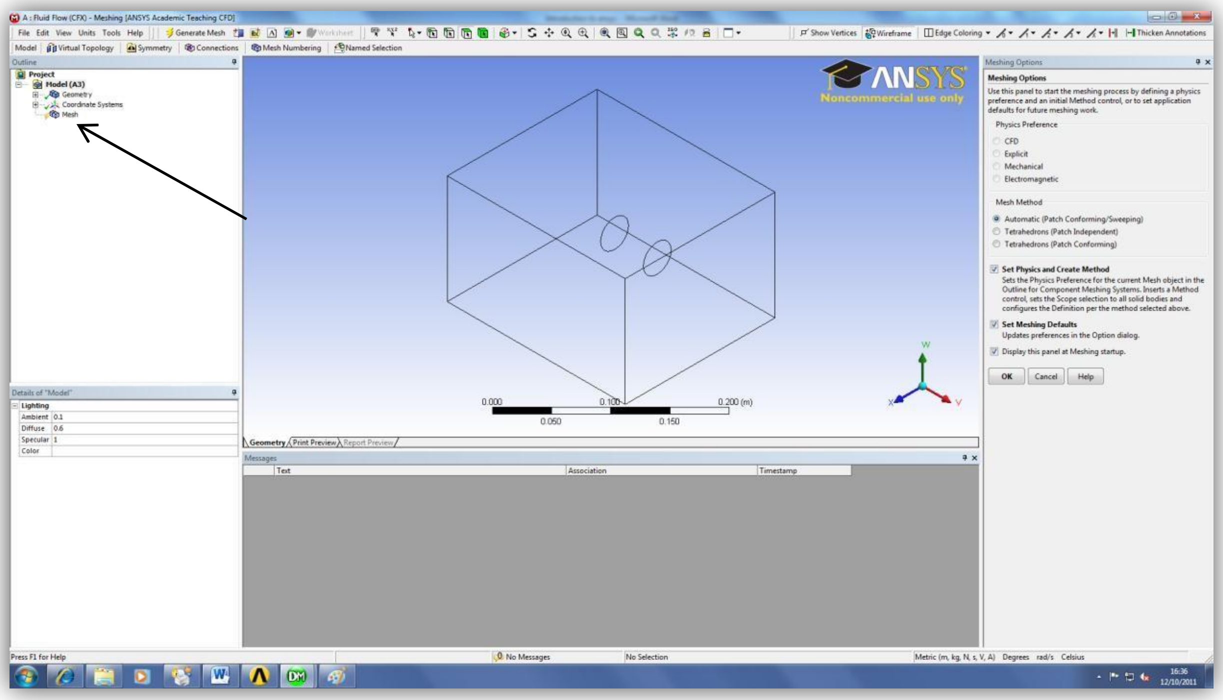


Figure 10a: The scale shown at the bottom helps you make the right decision on the box sizing, sothat we can see that the largest value on the scale is 0.200(m) which means we have to choose a value less than 0.050(m).

Step 10b: right click on Mesh and chose Insert and then chose Method.

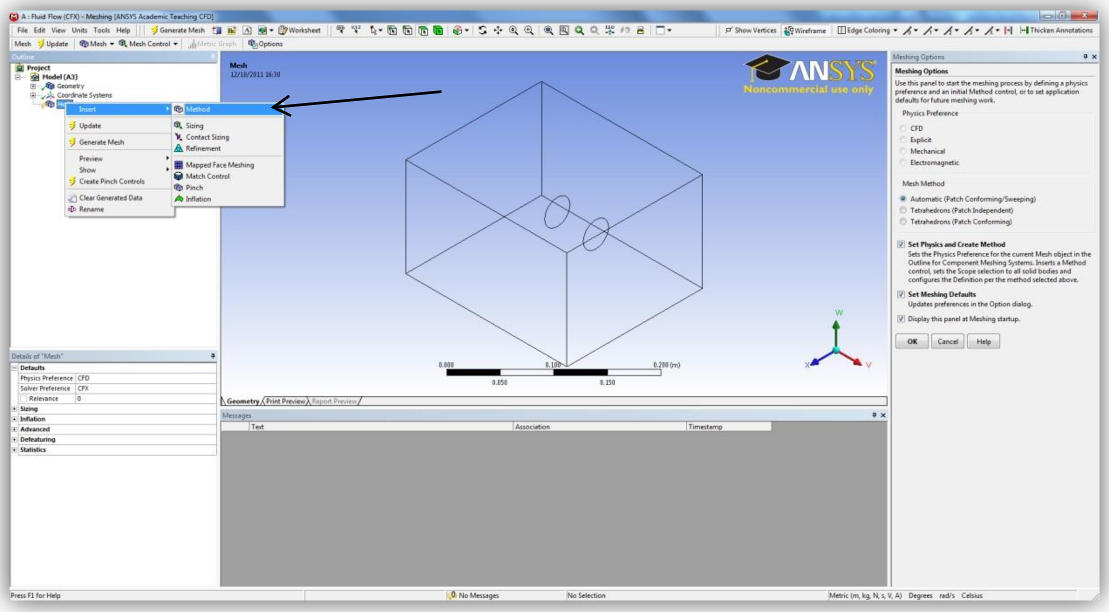


Figure 10b: at this stage we come to the point where we have to choose what kind of mesh are we going to use wither regular or irregular or etc.

Step 10c: click on the positive sign beside the Mesh you should get a tree sub branch have automatic Method using the left button click on the grey box domain, as a result it should by highlighted in green, then you see that the geometry text is highlighted in blue press the apply.

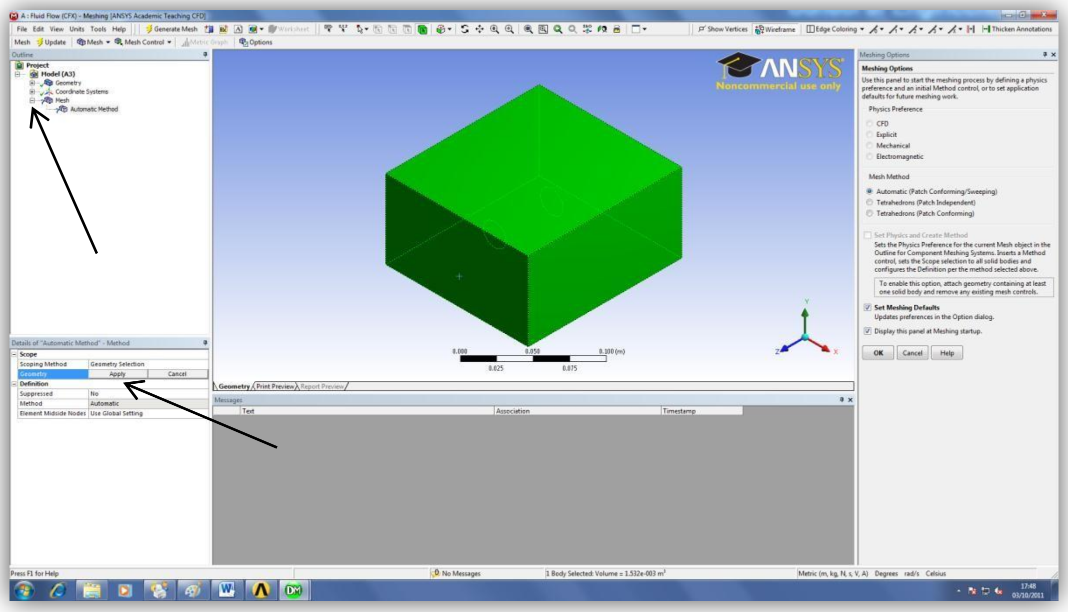


Figure 10c: choose the parallel option in the projection mode, which will come handy later on, when you want to use the measure command or choosing the appropriate slice plane for your study.

Step 11: go to method and choose Tetrahedrons.

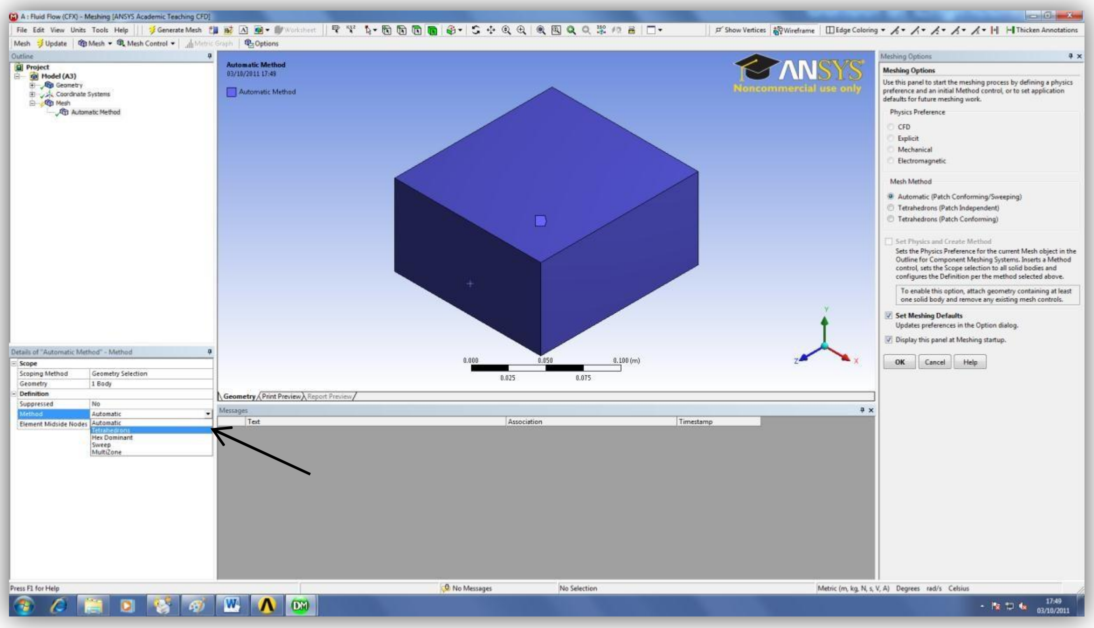


Figure 11: This prepares the view for later wanted operations.

Step 12: Go to algorithms and choose Patch Independent.

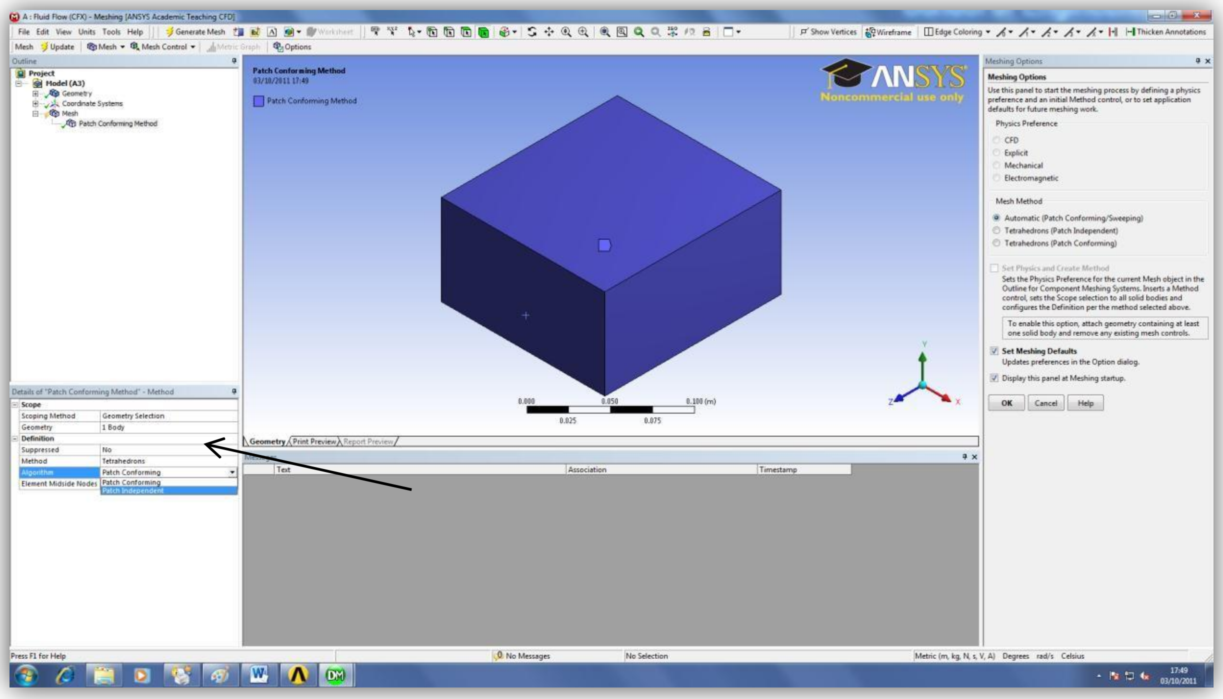


Figure12: Now that you have specified the mesh properties, you can proceed to the next step .

Step13: press the Update icon and then press on the Generate Mesh icon.

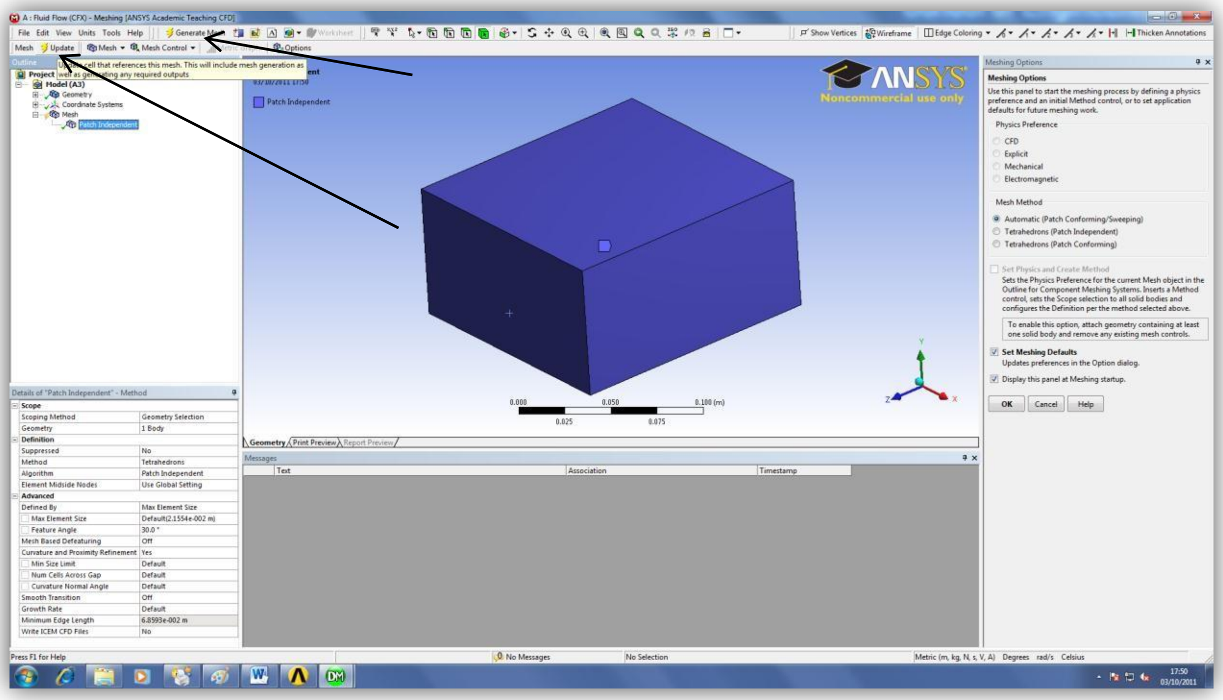


Figure13: For our case we will want to now the dimensions of the inflow section of the pipe.

Step14: click on mesh, now it's visible to the user the generated mesh.

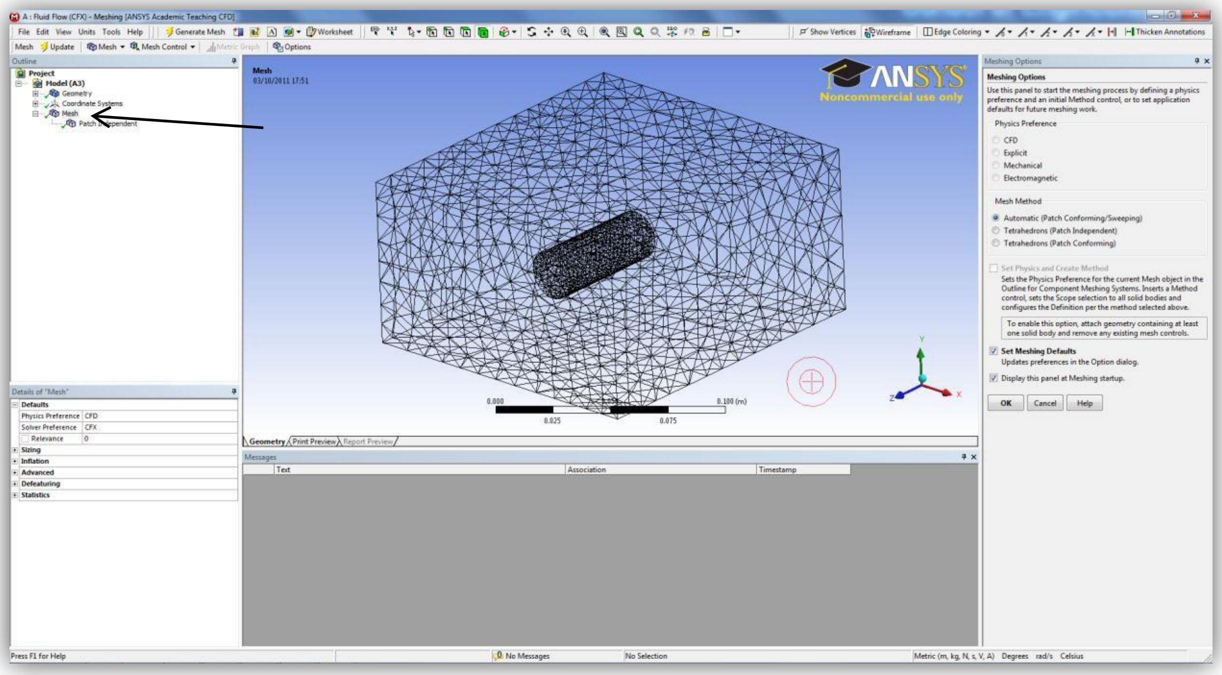


Figure 14: Click on the middle button to rotate the view to inspect your mesh.

Step15: Go to work bench, you will see there is a green tick beside the mesh congratulations you can now proceed to the setup.

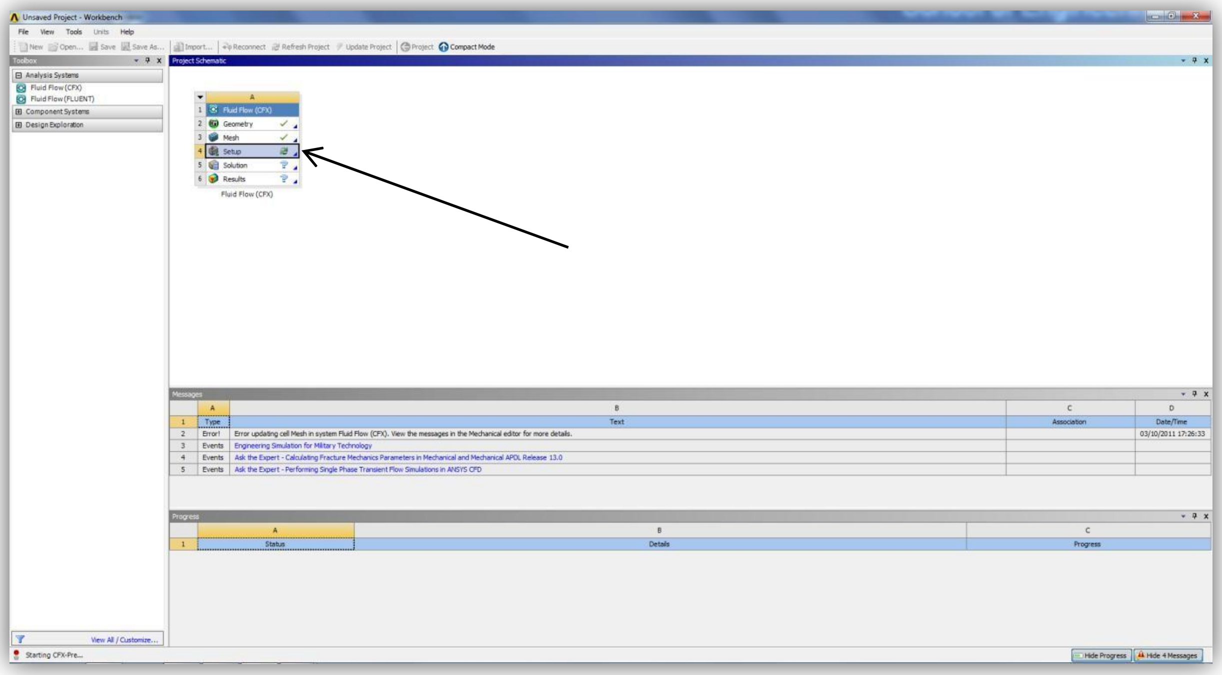
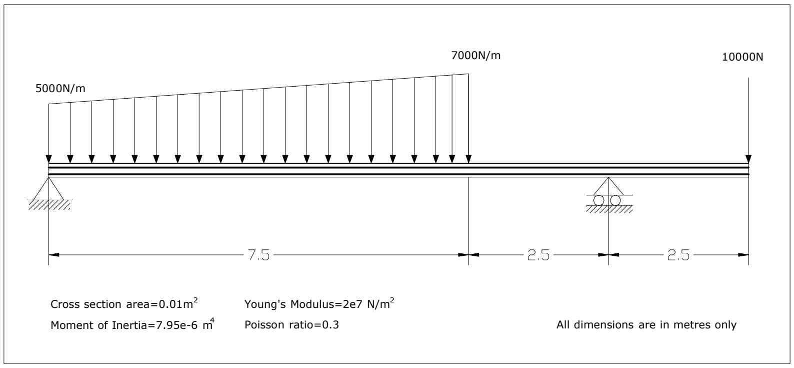


Figure15: Check the messages window if there are any errors you will have to go back in steps and check where you went wrong.

1. Static Analysis of a Beam

Aim : To find the deflections at the nodes and to draw the shear force and bending moment diagrams of beam shown in figure.



Data Given :

Cross sectional Area of beam = $0.01m^2$
Young's modulus = $2\times10^7\ N/m^2$
Poisson's ratio = 0.3

ANSYS Procedure

1. **Pre processor :** A typical analysis in ANSYS begins with pre processing where data such as the geometry, materials and element types are specified.

   i) **Set preferences :** The preferences dialog box allows to choose the desired engineering discipline for context filtering of menu choices.
      - Turn on structural
      - Select structural discipline options as h-method

   ii) **Define element types and options :** Select proper element from this dialog box.
   Preprocessor → Element type → Add/Edit/Delete → Select Beam 2DElastic3

   iii) **Define real constants :** Real constant provide additional geometry information. In this problem cross sectional area and moment of inertia are the real constants. Moment of inertia is needed to identify the shape of the cross section.

Cross section area = $0.01m^2$

Moment of inertia = $7.95\times10^{-6}m^4$ or 7.95e-6 m^4

iv) **Define material properties :** Material properties are constitutive properties of a material such as young's modulus and poisson's ratio.

In this problem Young's modulus = $2\times10^7\ N/m^2$

Poisson's ratio = 0.3

v) **Modeling :** This problem has Discretised into three elements formed from four nodes. In the world co-ordinate system the co-ordinates of the four nodes are as follows.

1(0,0) , 2(7.5,0) , 3(10,0) , 4(12.5,0)

Preprocessor → Modeling → Create → Nodes → InActive CS

After entering co-ordinates of each node click on $\boxed{Apply}$ to enter next node click on $\boxed{O.K}$ after entering the last node.

Elements : In this problem Beam cross section is not varying so no need to set the element attributes.

Preprocessor → Modeling → Create → Elements → ThruNodes

Select two nodes to create an element. Then click on $\boxed{Apply}$ and repeat the same procedure for the complete beam.

2. **Solution :** Boundary conditions(Displacement constraints) and loads can be applied in this stage.

i) Displacement Constraints :

Solution → Loads → Apply → Structural → Displacements → On Nodes

Select Node-1 as displacement constraint and click on $\boxed{Apply}$. In this dialog box click on All DOF and Click on $\boxed{O.K}$

Select Node-3 and click on $\boxed{Apply}$. In this dialog box click on UY and click on $\boxed{O.K}$.

ii) **Applying forces :**

Solution → Loads → Apply → Pressure on Beams

Select the element where the continuous varying load is acting. In this dialog box enter pressure at Node I = 5000N/m, Pressure at Node J = 7000N/m.

Solution → Loads → Apply → Force/Moment on Nodes

Select Node-4 and click on $\boxed{Apply}$. In this dialog box select UY and enter UY= $-10,000N$

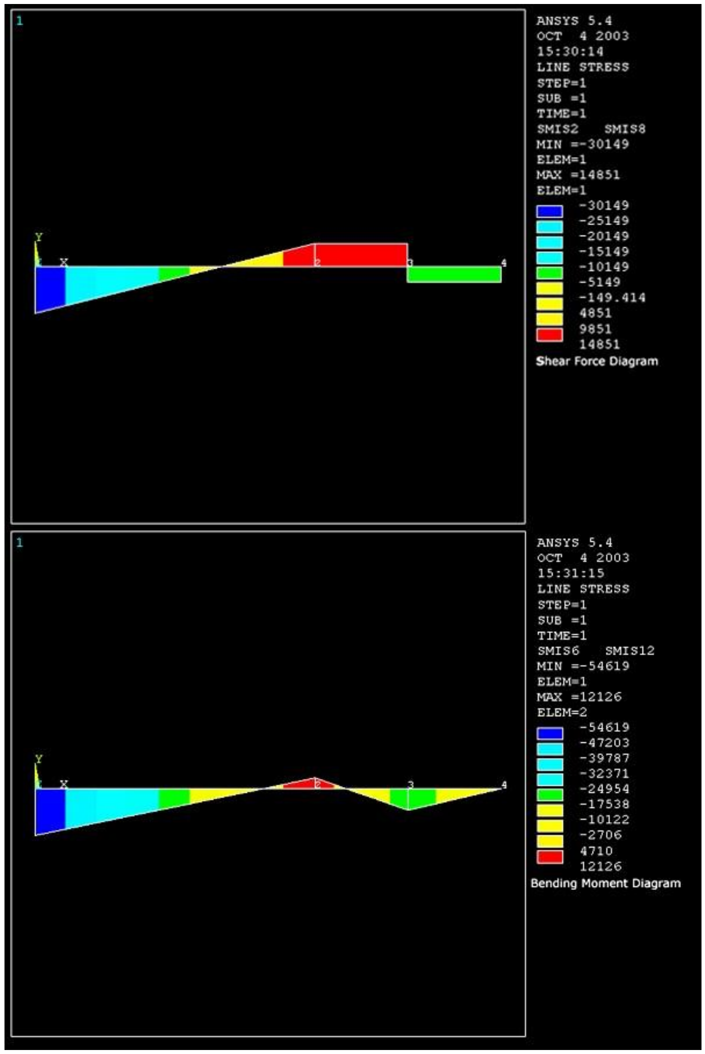
iii) **Solve :** Solution → Solve → Current L.S

3. **Post processor :** Post processor is used to review the results through graphics display and tabular listing.

Shear Force and Bending Moment diagrams can be obtained by defining element table.
Define sequence numbers 2 and 8 for Shear Force diagram.
Define sequence numbers 6 and 12 for Bending Moment diagram
General Post processor → Element table → Define table → Add
In this dialog box scroll down the left text box and select By sequence num Type 2 in the right side down text box. Then click on *Apply*. Repeat the same procedure for 8,6,12 numbers.

Shear force diagram:
General Post processor → Plot Results → Line Element Res
In this dialog box select Element table item at Node I =2
select Element table item at Node J =8
Click on *O.K*.

Bending Moment diagram:
General Post processor → Plot Results → Line Element Res
In this dialog box select Element table item at Node I =6
select Element table item at Node J =12
Click on *O.K*.


ANSYS 5.4
OCT 4 2003
15:30:14
LINE STRESS
STEP=1
SUB =1
TIME=1
SMIS2 SMIS8
MIN =-30149
ELEM=1
MAX =14851
ELEM=1
-30149
-25149
-20149
-15149
-10149
-5149
-149.414
4851
9851
14851
Shear Force Diagram
ANSYS 5.4
OCT 4 2003
15:31:15
LINE STRESS
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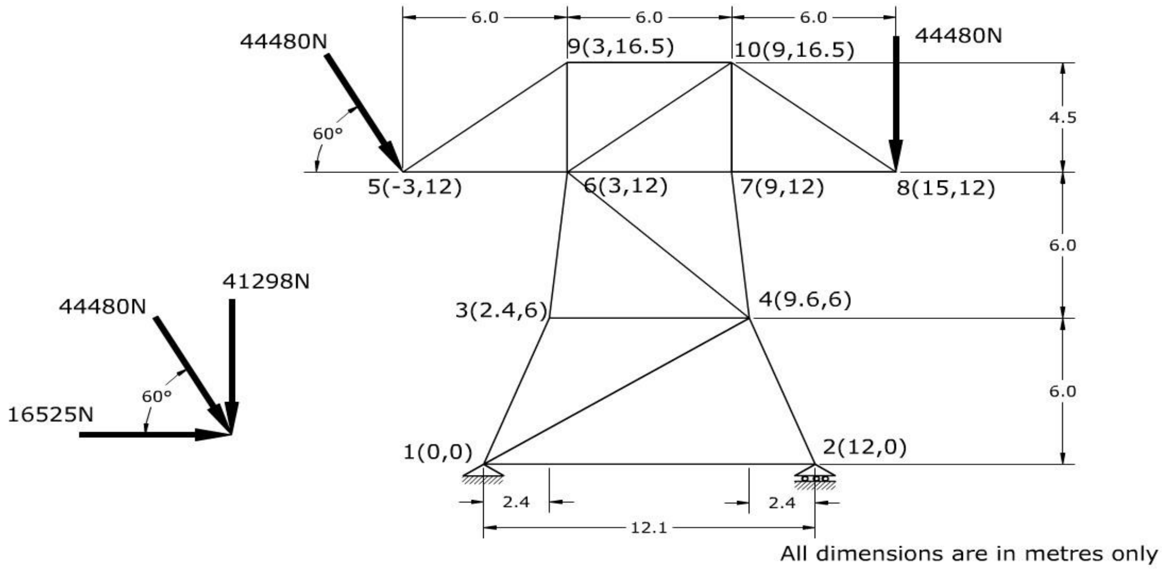
SUB =1
TIME=1
SMIS6 SMIS12
MIN =-54619
ELEM=1
MAX =12126
ELEM=2
-54619
-47203
-39787
-32371
-24954
-17538
-10122
-2706
4710
12126
Bending Moment Diagram

2. Static Analysis of a Truss

Aim : To find the deflections at the nodes for the truss configuration shown in figure.



Data Given :

$$\theta = \tan^{-1}\left(\frac{2.5}{1}\right)$$

Cross sectional Area of beam = $0.01m^2$
At Node-5 Force is acting at an angle

$$\theta = 68.11°$$

Inclined force at Node-5 F_1=44480N.
Horizontal component of Force F_1 = $44480 \times \cos(68.11) = 16525.6N$

Vertical component of Force F_1 = $44480 \times \sin(68.11) = 41298.64N$

Force acting at Node-8 is in vertically downward direction i.e F_2=44480N
Based on the truss dimensions Co-ordinates of the nodes in World Co-ordinate system are as follows :
1-(0,0) , 2-(12,0) , 3-(2.4,6) , 4-(9.6,6) , 5-(-3,12) , 6-(3,12) , 7-(9,12) , 8-(15,12) , 9-(3,16.5) , 10-(9,16.5). All dimensions are in meters only.

ANSYS Procedure

4. **Pre processor :** A typical analysis in ANSYS begins with pre processing where data such as the geometry, materials and element types are specified.

   i) **Set preferences :** The preferences dialog box allows to choose the desired engineering discipline for context filtering of menu choices.
      - Turn on structural
      - Select structural discipline options as h-method

ii) **Define element types and options :** Select proper element from this dialog box.

Preprocessor $\rightarrow$ Element type $\rightarrow$ Add/Edit/Delete
Select Beam Link-2D spar-1.

iii) **Define real constants :** Real constant provide additional geometry information. In this problem links of the entire truss configuration is of same cross sectional area.

Cross section area = $0.01m^2$

iv) **Define material properties :** Material properties are constitutive properties of a material such as young's modulus and poisson's ratio. Assume the material as isotropic.

In this problem Young's modulus = $2 \times 10^7 \; N/m^2$

Poisson's ratio = 0.27

v) **Modeling :** This problem has Discretised into 17 elements formed from 10 nodes. In the world co-ordinate system the co-ordinates of the four nodes are as follows.

1-(0,0) , 2-(12,0) , 3-(2.4,6) , 4-(9.6,6) , 5-(-3,12) , 6-(3,12) , 7-(9,12) , 8-(15,12) , 9-(3,16.5) , 10-(9,16.5). All dimensions are in meters only.

Preprocessor $\rightarrow$ Modeling $\rightarrow$ Create $\rightarrow$ Nodes $\rightarrow$ InActive CS

After entering co-ordinates of each node click on *Apply* to enter next node click on *O.K* after entering the last node.

Elements : In this problem link is assumed as isotropic so no need to set the element attributes.

Preprocessor $\rightarrow$ Modeling $\rightarrow$ Create $\rightarrow$ Elements $\rightarrow$ ThruNodes

Select two nodes to create an element. Then click on *Apply* and repeat the same procedure for the complete truss.

5. **Solution :** Boundary conditions(Displacement constraints) and loads can be applied in this stage.

i) Displacement Constraints :

Solution $\rightarrow$ Loads $\rightarrow$ Apply $\rightarrow$ Structural $\rightarrow$ Displacements $\rightarrow$ On Nodes

Select Node-1 as displacement constraint and click on *Apply*. In this dialog box click on All DOF and Click on *O.K*

Select Node-2 and click on *Apply*. In this dialog box click on UY and click on *O.K*.

ii) **Applying forces :**

Solution $\rightarrow$ Loads $\rightarrow$ Apply $\rightarrow$ Force/Moment on Nodes

Select Node-5 and click on *Apply*. In this dialog box select UX and enter UX= 16525N.

Again pick node-5 UY= $-41298N$

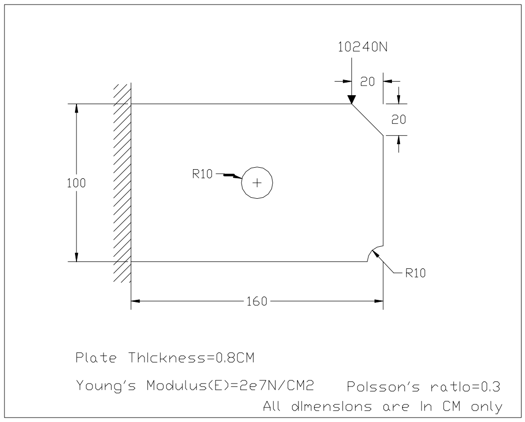
Node-8 UY= $-44480N$

iii) **Solve :** Solution → Solve → Current L.S

6. **Post processor :** Post processor is used to review the results through graphics display and tabular listing.
   General Post processor → Plot Results → Nodal Solution
   In this dialog box select items to be contoured as DOF Solution and translation as USUM.
   Item to be plotted is Def+Undeformed. Then click on *O.K*

3. Static Analysis of a Plate

Aim : To find the Von Mosses stress distribution and factor of safety for the given plate.



Procedure

Part Model

Prepart model by taking a work plane in the front view. Draw the sketch with given dimensions and extrude it to get the given plate.

Analysis

1. To start analysis in solid works add the solid works simulations menu in the menu bar. To add the menu Select tools ->Options->Solidworks simulation.
2. Select new study from solid works simulation give a name to that study.
3. Follow the simulation tool bar. Select the contraints button and select left side edge of the plate to fix the plate.
4. Add material to the model. Select material from the material library. For the given plate select steel.
5. Click on apply force button enter force as 10240N.
6. Select Mesh and RUN button to solve the problem.
7. Click on Result button to get the results in the required format.

Precautions

1. Select correct edge or face while applying constraints or forces.
2. Refine the mesh size till the convergence occurs in induced stresses.

Result : VonMosses stresses and factor of safety are determined for given plate.

LABORATORY MANUAL

AUTOMOTIVE ENGINES LABORATORY

Course Code: A19PC2AE04

II B.Tech II Semester (A19)

DEPARTMENT OF AUTOMOBILE ENGINEERING

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, HYDERABAD

List of Experiments

S.No	Name of the Experiment
1	Valve timing diagram for 4-stroke Diesel engine
2	Valve timing diagram for 4-stroke petrol engine
3	Port timing diagram for 2-stroke petrol engine
4	Performance test on 4-stroke single cylinder Diesel engine
5	Performance test on 4-stroke single cylinder petrol engine
6	Heat balance test on 4-stroke single cylinder Diesel engine
7	Morse test on multi-cylinder petrol engine
8	Optimum cooling temperature test on single cylinder Diesel engine
9	Performance evaluation on computerized Diesel engine
10	Performance test on reciprocating compressor test rig
11	Dismantling, inspection and assembling of multi-cylinder petrol engine
12	Dismantling inspection and assembling of multi-cylinder Diesel engine

Valve Timing Diagram for Four - Stroke Diesel Engine

Aim:

To determine and draw the actual valve timing diagram for a four-stroke diesel engine.

Instrumentation:

Four stroke diesel engine cut section, steel rule, thread, chalk piece.

Theory:

Valve timing is the regulation of the points in the cycle at which the valves are set to open and close. In the ideal cycle inlet and exhaust valve open and close at dead centers, but in actual cycles, they open before dead centers and close after dead centers. This deviation is because of the following two factors, one is mechanical and other is dynamic.

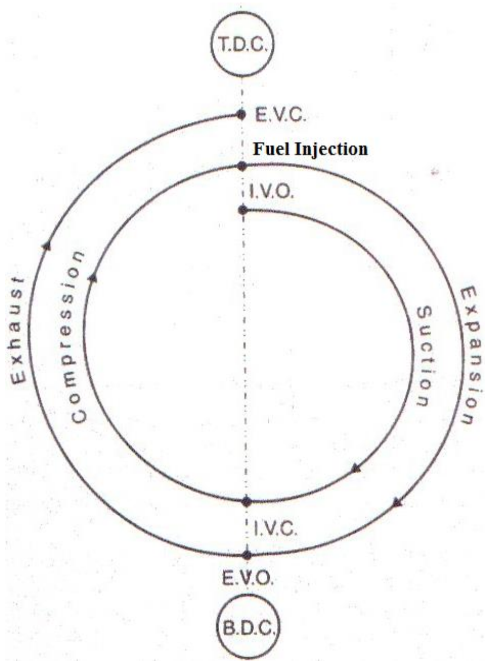
A). Mechanical factors:

The puppet valves of the reciprocating engines are opened and closed by cam mechanisms. To avoid noise and wear the valve should opened slowly and can't close abruptly, else it will bounce on its seat. Thus, the valve opening and closing periods are spread over a considerable number of crankshaft degrees. As a result, the opening of valve must commence ahead of time at which it is fully opened i.e. before dead centers and for the same reason close after the dead centers.

B). Dynamic factors:

The dynamic effects of gas flow taking into considerations, to set the actual valve timing of an engine, generally, the exhaust valve set to open before BDC. If the exhaust valve does not start to open until BDC, the pressure in the cylinder would be above atmospheric pressure and work required to expel the gases from cylinder is high, so the overall effect of opening the valve prior to the BDC, results overall gain in output.

The period when the both inlet and exhaust valves are open, for an instant of time is called valve overlap. The advantage of valve overlap is while the fresh charge enters into the cylinder the remained exhaust gas will be pushed away from the cylinder, this phenomenon known as the "Ram Pressure Effect".



TDC - Top Dead Center
BDC - Bottom Dead Center
IVO - Inlet Valve Open
IVC - Inlet Valve Close
EVO - Exhaust Valve Open
EVC - Exhaust Valve Close

Theoretical valve timing diagram

Procedure:

1. The circumference of the flywheel is measured with the help of thread and scale.
2. By turning the flywheel, various events are marked on it

They are:

Top dead center (TDC)

Bottom dead center (BDC)

Inlet valve opening (IVO)

Inlet valve closing (IVC)

Exhaust valve opening (EVO)

Exhaust valve closing (EVC)

TDC: The fly wheel is slowly rotated and point where the piston reaches the top most position in the cylinder is marked on the flywheel as top dead center.

IVO: As the flywheel is slowly rotated with help of handle, piston moves in the cylinder. Opening and closing of valves accomplished with the help of push rods which operate with the help of a cam. These rods are aided with spring loaded mechanisms. The inlet valve opens before TDC position when push rod tightens. This is marked as IVO.

BDC: The fly wheel is slowly rotated and point where the piston reaches the bottom most position in the cylinder is marked on the flywheel as bottom dead center.

IVC: The flywheel is further rotated, the push rod then passes through the phase in which it loosens from tight position. The point is marked as IVC.

EVO and EVC: The exhaust valve opening and closing are determined in the same way as that of inlet valve.

3. Valve overlap calculated by using the formula.
4. Valve timing diagram is neatly illustrated.

Observations:

Circumference of the flywheel (L) = ………………… cm.

S. No	Event	Distance from nearest Dead center (cm)
1	Inlet valve opening before TDC	L_1 =
2	Inlet valve closing after BDC	L_2 =
3	Exhaust valve opening before BDC	L_3 =
4	Exhaust valve closing after TDC	L_4 =
5	Valve overlap	$L_1 + L_4$ =

Calculations:

Circumference of flywheel = 360^0 = L

$\Theta_1 = 360 * (L_1 / L) = ……..^0$

$\Theta_2 = 360 * (L_2 / L) = ……..^0$

$\Theta_3 = 360 * (L_3 / L) = ……..^0$

$\Theta_4 = 360 * (L_4 / L) = ……...^0$

Suction period $= 180^0 + \Theta_1 + \Theta_2 = …………..^0$

Compression period $= 180^0 - \Theta_2 = …………..^0$

Expansion period $= 180^0 - \Theta_3 = …………^0$

Exhaust period $= 180^0 + \Theta_3 + \Theta_4 = …………^0$

Valve overlap $= \Theta_1 + \Theta_4 = ……………..^0$

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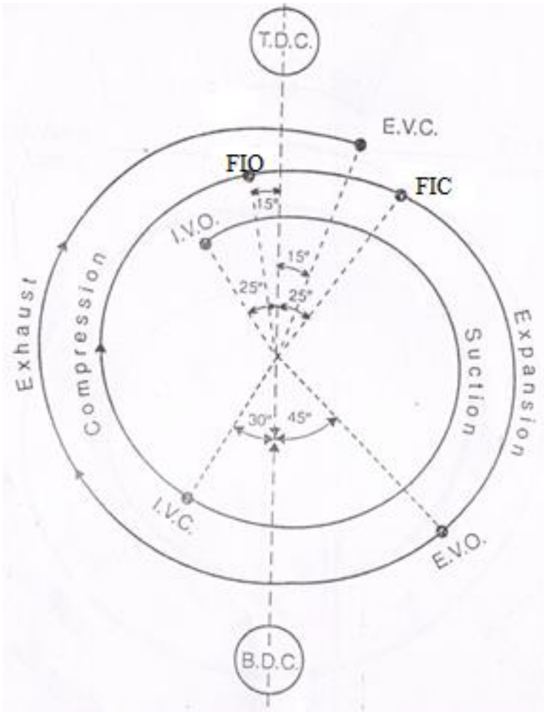
Model of Actual valve timing diagram:



TDC - Top Dead Center
BDC - Bottom Dead Center
IVO - Inlet Valve Open
IVC - Inlet Valve Close
EVO - Exhaust Valve Open
EVC - Exhaust Valve Close

FIO – Fuel Injection Open

FIC – Fuel Injection Close

Precautions:

1. The valve opening is to be taken as the point where it begins to open.

2.The valve closure is taken as the point where valve closes completely.

3. The flywheel is to be rotated in proper direction.

Result:

Actual valve timings of four stroke diesel engine is determined and valve timing diagram drawn.

Prepared by	**Verified by (1)**	**Verified by (2)**	**Approved by**

Valve Timing Diagram for Four- Stroke Petrol Engine

Aim:

To determine and draw the actual valve timing diagram for a four-stroke petrol engine.

Instrumentation:

Four stroke petrol engine cut section, steel rule, thread, chalk piece.

Theory:

Valve timing is the regulation of the points in the cycle at which the valves are set to open and close. In the ideal cycle inlet and exhaust valve open and close at dead centers, but in actual cycles, they open before dead centers and close after dead centers. This deviation is because of the following two factors, one is mechanical and other is dynamic.

A). Mechanical factors:

The puppet valves of the reciprocating engines are opened and closed by cam mechanisms. To avoid noise and wear the valve should opened slowly and can’t close abruptly, else it will bounce on its seat. Thus, the valve opening and closing periods are spread over a considerable number of crankshaft degrees. As a result, the opening of valve must commence ahead of time at which it is fully opened i.e. before dead centers and for the same reason close after the dead centers.

B). Dynamic factors:

The dynamic effects of gas flow taking into considerations, to set the actual valve timing of an engine. Generally, the exhaust valve set to open before BDC. If the exhaust valve does not start to open until BDC, the pressure in the cylinder would be above atmospheric pressure and work required to expel the gases from cylinder is high, so the overall effect of opening the valve prior to the time is as the piston reaches BDC, results overall gain in output.

The period when the both inlet and exhaust valves are open, for an instant of time is called valve overlap. The advantage of valve overlap is while the fresh charge enters into the cylinder the remained exhaust gas will be pushed away from the cylinder, this phenomenon known as the “Ram Pressure Effect”.

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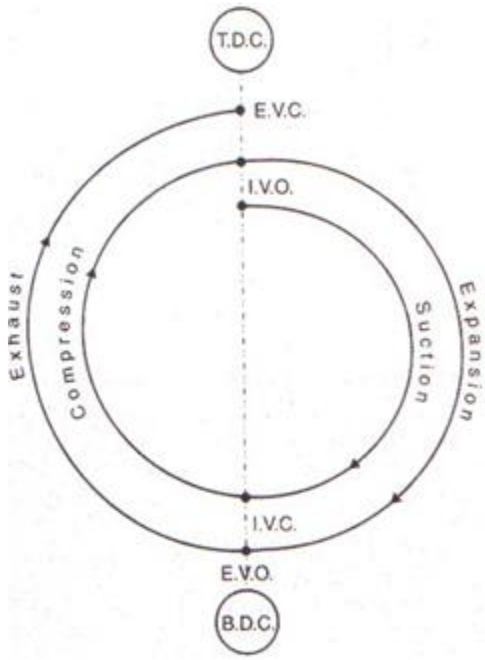


TDC - Top Dead Center
BDC - Bottom Dead Center
IVO - Inlet Valve Open
IVC - Inlet Valve Close
EVO - Exhaust Valve Open
EVC - Exhaust Valve Close

Theoretical valve timing diagram

Procedure:

1. The circumference of the flywheel is measured with the help of thread and scale.
2. By turning the flywheel, various events are marked on it

They are:

Top dead center (TDC)

Bottom dead center (BDC)

Inlet valve opening (IVO)

Inlet valve closing (IVC)

Exhaust valve opening (EVO)

Exhaust valve closing (EVC)

TDC: The fly wheel is slowly rotated and point where the piston reaches the top most position in the cylinder is marked on the flywheel as top dead center.

IVO: As the flywheel is slowly rotated with help of handle, piston moves in the cylinder. Opening and closing of valves accomplished with the help of push rods which operate with the help of a cam. These rods are aided with spring loaded mechanisms. The inlet valve opens before TDC position when push rod tightens. This is marked as IVO.

BDC: The fly wheel is slowly rotated and point where the piston reaches the bottom most position in the cylinder is marked on the flywheel as bottom dead center.

IVC: The flywheel is further rotated; the push rod then passes through the phase in which it loosens from tight position. The point is marked as IVC.

EVO and EVC: The exhaust valve opening and closing are determined in the same way as that of inlet valve.

3. Valve overlap calculated by using the formula.
4. Valve timing diagram is neatly illustrated.

Observations:

Circumference of the flywheel (L) = ………………… cm.

S. No	Event	Distance from nearest Dead center (cm)
1	Inlet valve opening before TDC	L_1 =
2	Inlet valve closing after BDC	L_2 =
3	Exhaust valve opening before BDC	L_3 =
4	Exhaust valve closing after TDC	L_4 =
5	Valve overlap	$L_1 + L_4$ =

Calculations:

Circumference of flywheel = 360^0 = L

$\Theta_1 = 360^* (L_1/ L)$ = ……..^{0}

$\Theta_2 = 360^* (L_2/ L)$ = ……..^{0}

$\Theta_3 = 360^* (L_3/ L)$ = ……..^{0}

$\Theta_4 = 360^* (L_4/ L)$ = ……...^{0}

Suction period = $180^0 + \Theta_1 + \Theta_2$ = …………..^{0}

Compression period = $180^0 - \Theta_2$ = …………..^{0}

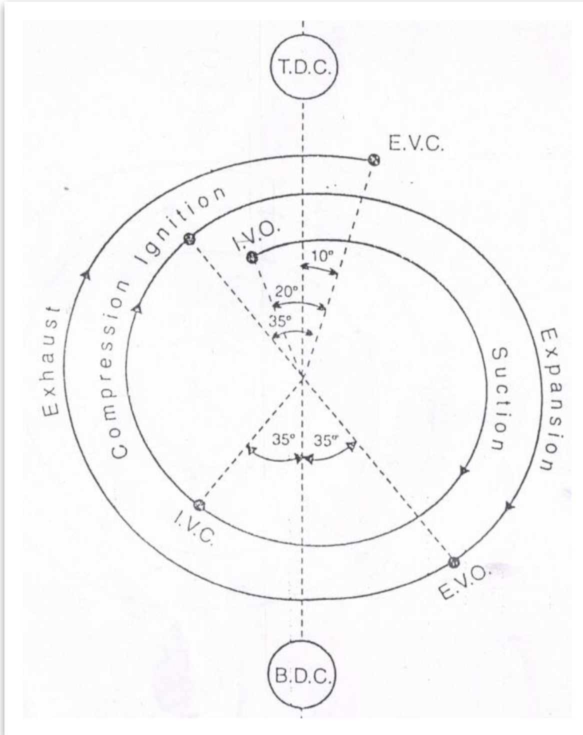
Expansion period = $180^0 - \Theta_3$ = …………^{0}

Exhaust period = $180^0 + \Theta_3 + \Theta_4$ = …………^{0}

Valve overlap = $\Theta_1 + \Theta_4$ = ……………..^{0}

`

Model of actual valve timing diagram



Precautions:

1. The valve opening is to be taken as the point where it begins to open.
2. The valve closure is taken as the point where valve closes completely.
3. The flywheel is to be rotated in proper direction.

Result:

Actual valve timings of four stroke petrol engine is determined and valve timing diagram drawn.

Prepared by **Verified by (1)** **Verified by (2)** **Approved by**

Port Timing Diagram for Two - Stroke Petrol Engine

Aim:

To determine and draw the actual port timing for a Two - stroke petrol engine.

Instrumentation:

Engine cut section model, thread, chalk piece, steel rule.

Theory:

The term port timing refers to the relationship between cylinder volume uncovered by the piston and position of flywheel. In a two-stroke engine, the cycle is completed in two strokes. The difference between two stroke and four stroke engines is, in the method of filling cylinder with fresh charge and removing the burnt gases from the cylinder. In a four stroke engine these operations performed by the engine piston during suction and exhaust strokes respectively.

In a two-stroke engine, suction is accomplished by air compression in crankcase. The induction of compressed air removes the products of combustion, through exhaust port. Therefore, no separate strokes required for these two operations. Only two strokes are required to complete the cycle, one for compression of fresh charge and other for power stroke. The charge (air fuel mixture) is sucked through spring loaded intake valves when the pressure in the crank case reduces due to upward motion of piston during compression stroke. After the compression, ignition and expansion takes place usual way. During the expansion stroke, the charge in the crank case compressed. Near the end of compression, the piston uncovers the exhaust port and cylinder pressure drops to atmospheric pressure as the combustion products leaves the cylinder.

Further motion of piston uncovers the transfer port, permitting the slightly compressed air or mixture in the crank case to enter the engine cylinder. The top of the piston usually has projection to deflect the fresh charge to sweep up to top of the cylinder, before flowing to the exhaust ports. This serves the double purpose of scavenging the upper part of cylinder of combustion products and preventing the fresh charge from flowing directly to the exhaust ports. The same objective can be achieved without piston deflector by proper sloping of the transfer port. During the upward motion of the piston from BDC, the transfer and exhaust ports close, compression of charge begins and cycle is repeated.

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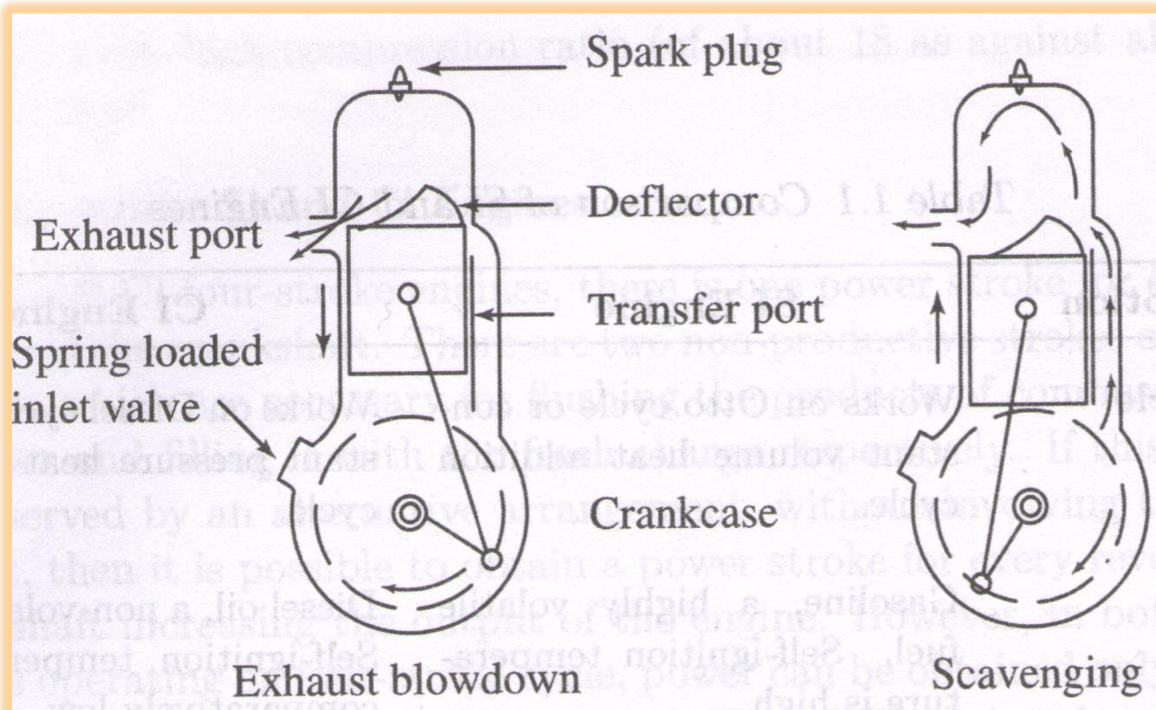
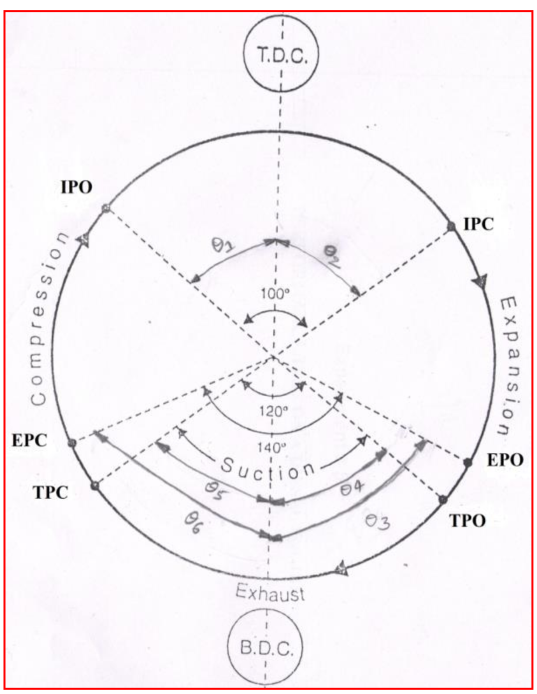


Two - stroke SI engine with scavenging

<u>Actual model of Port timing diagram:</u>



IPO - Intake port opening
IPC - Intake port closing
TPO - Transvese port opening
TPC - Transvese port closing
EPO - Exhaust port opening
EPC - Exhaust port closing

`

Procedure:

1. Initially circumference of the flywheel is measured. A pointer is attached above the flywheel such that it coincides with BDC marked on the flywheel at the starting of engine. This pointer is used for marking specific points.
2. The flywheel is rotated. The instant at which inlet port starts to open is determined and corresponding point is marked on the flywheel. This when converted to degree gives IPO.
3. The position when piston completely closes the intake port marked as IPC.
4. The points EPO and EPC corresponding to exhaust port opening and exhaust port closing are marked similar to that IPO and IPC.
5. The position when the transfer port opens and closes marked as TPO and TPC.
6. Port timing diagram is neatly illustrated.

Observation Table:

Circumference of the flywheel (L) = ………………… cm.

S. No	Event	Distance from the nearest dead center (cm)
1	Inlet Port opening before TDC	L_1=
2	Inlet Port closing after TDC	L_2=
3	Exhaust port opening before BDC	L_3=
4	Transverse port opening before BDC	L_4=
5	Transverse port closing after BDC	L_5=
6	Exhaust port closing after BDC	L_6=

Calculations:

Circumference of flywheel = 360^0 = L

$\Theta_1 = 360^* (L_1/ L) = ……..^0$

$\Theta_2 = 360^* (L_2/ L) = ……..^0$

$\Theta_3 = 360^* (L_3/ L) = ……..^0$

$\Theta_4 = 360^* (L_4/ L) = ……...^0$

$\Theta_5 = 360^* (L_5/ L) = ……...^0$

$\Theta_6 = 360^* (L_6/ L) = ……...^0$

Suction Period = $\theta_4 + \theta_5$ = ……………^{0}

Compression Period = 180 - θ_6 = …………^{0}

Expansion Period = 180 – θ_3 =…………^{0}

`

Exhaust Period = $\theta_3 + \theta_6$ = ……………^{0}

Precautions:

1. The ports opening and closing are to be taken as the point when it just begins to open.
2. The flywheel is to be rotated in proper direction.

Result:

Port timing diagram for a given two stroke engine is determined.

Prepared by **Verified by (1)** **Verified by (2)** **Approved by**

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Performance Test on Four-Stroke Single Cylinder Diesel Engine

Aim:

The experiment is conducted

a. To study and understand the performance characteristics of the engine.

b. To draw Performance curves.

Apparatus:

1. Diesel Engine test rig with Eddy current dynamometer.
2. Digital speedometer.
3. Measuring system for the air flow and fuel consumption.
4. Load cell with digital load indicator.

Engine Specifications:

Brake Power: 3.7 kW

Rated Speed: 1500 rpm

No. of cylinders: 1

Compression ratio: 16.5:1 (Variable)

Bore: 80 mm

Stroke: 110 mm

Theory:

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat engine. They are classified as external and internal combustion engines. In an external combustion engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An internal combustion engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. Internal combustion engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

Diesel engine is an internal combustion engine, which uses diesel oil as a fuel and operates on two or four stroke. In a four stroke Diesel engine, the working cycle takes place in two revolutions of the crankshaft or four strokes of the piston. In this engine, pure air is sucked into the engine and the fuel is injected with the fuel injector combustion taking place at the end of the compression stroke. The power will develop and the performance of the engine depends on the condition of operation.

`

Engine performance is indication of the degree of success with which it is doing its assigned job of conversion of chemical energy of supplied to the engine into useful work. The purpose of testing the engine is to verify whether the engine is performing well as per the specifications given by the manufacturer. In addition to this, the tests are also conducted to assess the effects of different parameters on the performance of engine. For power generation the engine has to turn at constant speed hence, the test is conducted at constant speed while the load increased from zero to full load with different steps.

Procedure:

1. Check the fuel level in the tank.
2. Allow the water to flow to the engine and the calorimeter and adjust the flow rate to 6 LPM & 3 LPM respectively.
3. Release the load if any on the dynamometer.
4. Open the three-way cock so that fuel flows to the engine.
5. Start the engine by cranking.
6. Allow to attain the steady state.
7. Switch on the Load controller and slowly load the engine by rotating the knob clockwise.
8. Note the following readings for particular condition,
   a) Engine Speed
   b) Time taken for 10 cc of diesel consumption
   c) Rotameter reading.
   d) Manometer readings
9. Repeat the experiment for different loads and note down the above readings.
10. After the completion release the load and then stop the engine by cutting the fuel supply.
11. Allow the water to flow for few minutes and then turn it off.

`

Observations:

S. No	Speed (rpm)	Load in kg	Manometer readings (cm)			Time for 10cc of fuel consumption in (sec)
			h_1	h_2	$h_1 - h_2$	

Calculations:

1. **Mass of fuel consumed, m_f =** $\frac{X_{cc} \times \text{Specific gravity of fuel}}{1000 \times t}$ kg/sec

Where, Specific gravity of Diesel = 0.827

X cc = volume of fuel consumed = 10cc

t = time taken for 10cc of fuel consumption in seconds

2. **Heat input, HI =** $m_f \times$ Calorific Value of Fuel **k**W

Where, Calorific Value of Diesel = 44600 kJ/kg

3. **Output or Brake Power, BP** = $\frac{2\pi NT}{60 \times 1000}$ **k**W

Where, N is speed in rpm

T = Torque on the load indicator

T = Load x r x 9.81 N-m Load in kg's

r = Torque arm radius = 0.125 m

4. **Specific Fuel Consumption, SFC =** $\frac{m_f \times 3600}{BP}$ kg/kW – hr

Where, m_f = mass of fuel in kg/sec

BP- brake power in kW

`

5. Brake Thermal Efficiency, η_{bth} = $\frac{BP}{m_f \times CV} \times 100$

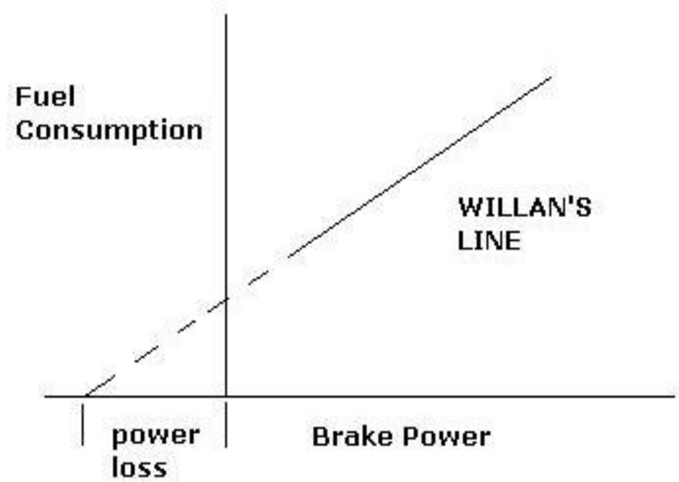
Where, BP - Brake power in kW

CV - Calorific value of fuel = 44600 kJ/kg

6. Mechanical Efficiency, η_{mech} = $\frac{BP}{IP} \times 100$

Determine the IP = Indicated Power, using Willan's line method as follows

- Draw the Graph of Fuel consumption Vs Brake power
- Extend the line obtained till it cuts the Brake power axis
- The point where it cuts the brake power axis till the zero point will give the Power losses (Friction Power loss)
- With this the IP can be found using the relation: IP = BP + FP



c. **Calculation of head of air, ha** = $\frac{h_w \times \rho_{water}}{\rho_{air}}$ in m.

Where, ρ_{water} = 1000 kg/m³

ρ_{air} = 1.2 Kg/m³ @ R.T.P

h_w is the head in water column in 'm' of water

d. **Volumetric efficiency, η_{vol}** = $\frac{Q_a}{Q_{th}} \times 100$

Q_a = Actual volume of air = $C_d a\sqrt{2gh_a}$

Where , C_d = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = $\frac{\pi}{4}d^2 = \frac{\pi}{4}0.02^2$, d = diameter of orifice.

h_a = head in air column, m of air

Q_{th} = Theoretical volume of air = $\frac{(\pi/4) \times D^2 \times L \times N}{60 \times 2}$

Where,

D = Bore diameter of the engine = 0.08 m

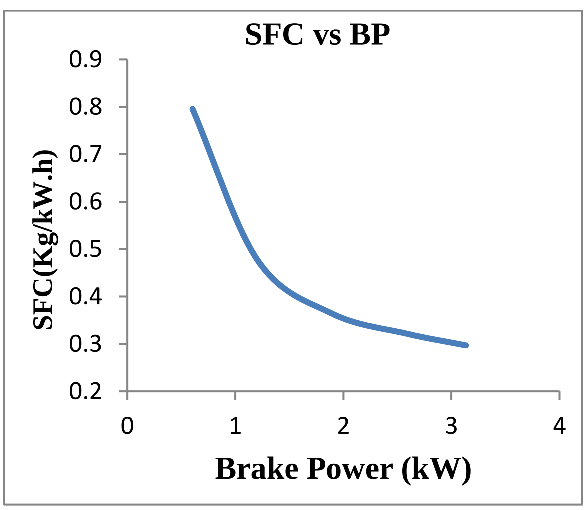
L = Length of the Stroke = 0.110 m

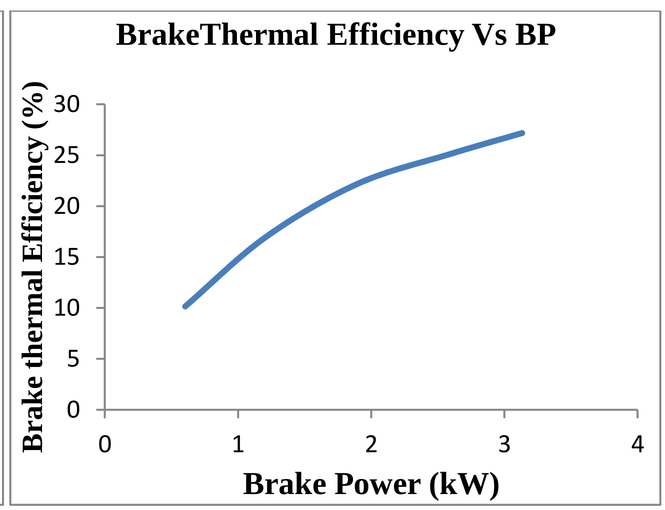
N = Engine speed in rpm

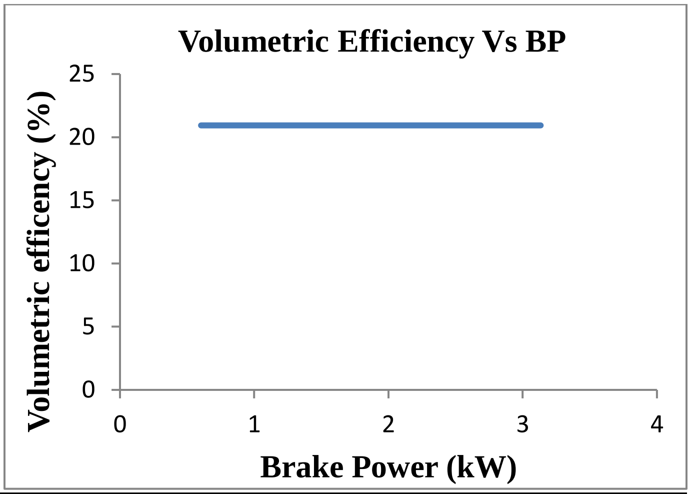
Tabulation:

S. No	Brake Power (kW)	Indicated Power (kW)	Fuel consumption kg/s	SFC (kg/Kw.h)	Brake Thermal Efficiency (%)	Mechanical Efficiency (%)	Volumetric Efficiency (%)
1							
2							
3							
4							
5							

Model graphs:







Precautions:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water
3. Do not forget to give electrical earth and neutral connections correctly.
4. It is recommended to run the engine at 1500rpm otherwise the rotating parts and bearing of engine may run out.

Results:

Graphs to be plotted:

1) SFC v/s BP
2) η_{bth} v/s BP
3) η_{mech} v/s BP
4) η_{vol} v/s BP
5) η_{ith} v/s BP

Prepared by **Verified by (1)** **Verified by (2)** **Approved by**

Performance test on 4-Stroke Petrol engine

Aim:

The experiment is conducted

a. To study and understand the performance characteristics of the engine and
b. To draw Performance curves.

Apparatus:

1. Petrol Engine test rig with Eddy current dynamometer.
2. Digital speedometer.
3. Measuring system for the air flow, fuel consumption.
4. Load cell with digital load indicator.

Engine Specifications:

Brake Power: 2.2 kW

Rated Speed: 3000 rpm

No. of cylinders: 1

Compression ratio: 8:1 (Variable)

Bore: 70 mm

Stroke: 67 mm

Theory:

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a heat engine. They are classified as external and internal combustion engines. In an external combustion engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An internal combustion engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

Gasoline engine is an internal combustion engine, which uses petrol as a fuel and operates on two or four stroke. In a 4-stroke gasoline engine, the working cycle takes place in two revolutions of the crankshaft or 4 strokes of the piston. In this engine, air fuel mixture enter into the cylinder where the spark is ignited at the end of the compression stroke. The power developed and the performance of the engine depends on the condition of operation.

Engine performance is indication of the degree of success with which it is doing its assigned job of conversion of chemical energy supplied to the engine into useful work. The purpose of testing the engine is to verify whether the engine is performing well as per the specifications given by the manufacturer. In addition to this, the tests are also conducted to assess the effects of different parameters on the performance of engine. For power generation, the engine has to run at constant speed hence, the test is conducted at constant speed while the load increased from zero to full load with different steps.

Procedure:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Release the load if any on the dynamometer.
5. Open the three-way cock so that fuel flows to the engine.
6. Set the accelerator to the minimum condition.
7. Set the compression ratio by operating the wheel provided.
8. Start the engine by cranking.
9. Allow to attain the steady state.
10. Load the engine by means of load controller
11. Note the following readings for particular condition,
    a. Engine Speed
    b. Time taken for 10 cc of petrol consumption
    c. Manometer readings, in cm of water
    d. Load on the engine.
12. Repeat the experiment for different loads and note down the above readings.
13. After the completion of the test release the load and then switch of the engine by pressing the ignition cut off switch and then turn off the panel.

`

Observations:

S. No	Speed (rpm)	Load in (kg)	Manometer readings (cm)			Time for 10cc of fuel consumption in (sec)
			h_1	h_2	$h_1 - h_2$	

Calculations:

1. **Mass of fuel consumed, m_f =** $\frac{X_{cc} \times \text{Specific gravity of fuel}}{1000 \times t}$ kg/sec

   Where, Specific gravity of Diesel = 0.751

   X cc = volume of fuel consumed = 10 cc

   t = time taken for 10cc of fuel consumption in seconds

2. **Heat input, HI =** $m_f \times$ Calorific value of fuel **k**W

   Where, Calorific value of Petrol = 46,500 kJ/kg

3. **Output or Brake Power, BP =** $\frac{2\pi NT}{60 \times 1000}$ **k**W

   Where, N is speed in rpm

   T = Torque on the load indicator

   T = load x r x 9.81 N-m

   r = Torque arm radius = 0.125 m

4. **Specific Fuel Consumption, SFC =** $\frac{m_f \times 3600}{BP}$ kg/kW – hr

   Where, m_f = mass of fuel in kg/sec

   BP- brake power in kW

5. **Brake Thermal Efficiency, η_{bth} =** $\frac{BP}{m_f \times CV} \times 100$

   Where, BP - Brake power in kW

   CV - Calorific value of fuel

`

6. Calculation of head of air, h_a = $\frac{h_w \times \rho_{water}}{\rho_{air}}$ in m

Where , ρ_{water} = 1000 kg/m³

ρ_{air} = 1.2 Kg/m³ @ R.T.P

h_w is the head in water column in 'm' of water

5. Volumetric efficiency, η_{vol} = $\frac{V_a}{V_{th}} \times 100$

V_a = Actual volume of air = $C_d a\sqrt{2gh_a}$

Where, C_d = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = $\frac{\pi}{4}0.02^2$

h_a = head in air column, m of air

V_{th} = Theoretical volume of air = $\frac{(\pi/4) \times D^2 \times L \times N}{60 \times 2}$

Where, D = Bore diameter of the engine = 0.08 m

L = Length of the Stroke = 0.110 m

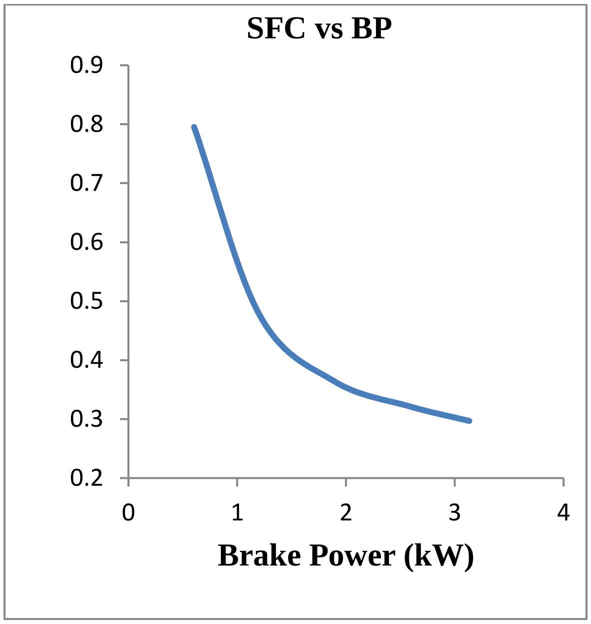
N = Engine speed in rpm

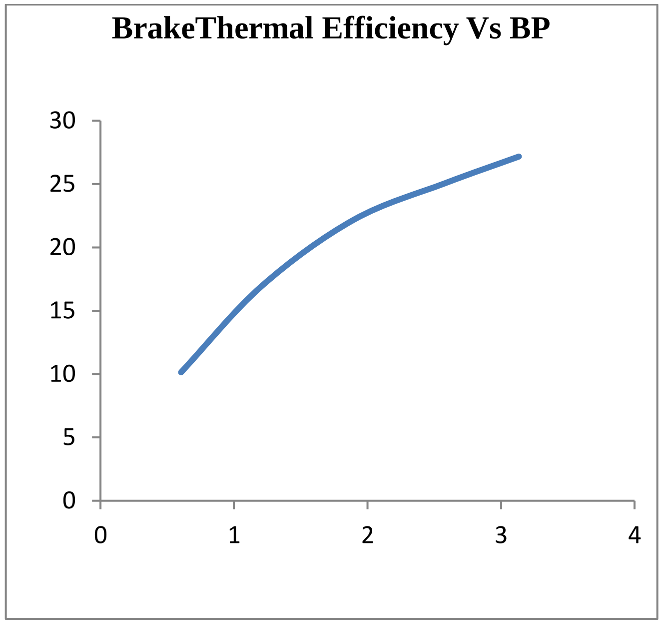
Tabulation:

S. No	Brake Power (kW)	Fuel consumption (kg/s)	SFC (Kg/Kw-h)	Brake Thermal Efficiency (%)	Volumetric Efficiency (%)
1					
2					
3					
4					
5					

`

Model graphs:





Precautions:

1. Do not run the engine without the supply of water.
2. Note that the range for water supply provided is an approximate standard value.
3. Always set the accelerator knob to the minimum condition and start the engine (if provided).
4. Switch off the ignition of auxiliary while doing in the engine arrangement.

Result:

Graphs to be plotted:

1.SFC v/s BP

2.η_{bth} v/s BP

3.η_{vol} v/s BP

Prepared by **Verified by (1)** **Verified by (2)** **Approved by**

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Heat balance test on 4-stroke single cylinder Diesel engine

Aim

To conduct a heat balance test on 4-stroke single cylinder Diesel engine at different loads and draw heat balance sheet.

Apparatus

1. Diesel engine test rig with Eddy current dynamometer.
2. Digital speedometer.
3. Measuring system for the air flow
4. Measuring system for fuel consumption
5. Load cell with digital load indicator.
6. Digital temperature indicator with channel selector
7. Rotameters.

Engine specifications

Brake power : 3.7 kW

Speed : 1500 rpm

No of cylinders : 1

Compression ratio: 16.5:1 (Variable)

Bore : 80 mm

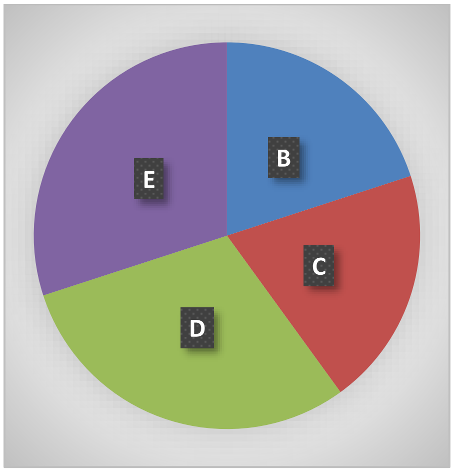
Stroke : 110 mm

Theory

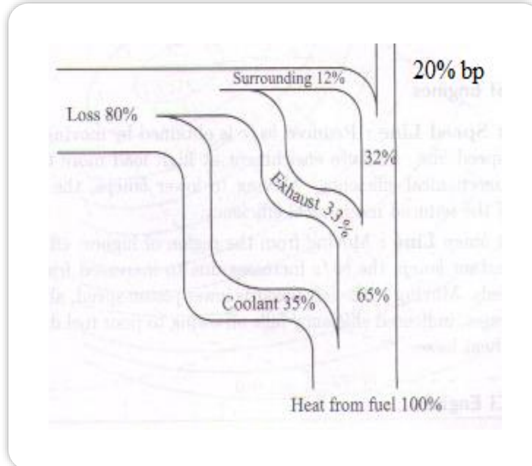
Energy supplied to an engine is the heat value of the fuel consumed. Only a part of this energy transformed into useful work, the rest of it is going as waste. The two main parts of heat which are not available for useful work are the heat carried away by the **exhaust gases** and the **cooling medium.** A typical heat balance for compression ignition engines is shown in figure1. In order to prepare heat balance sheet for an engine a test has to be conducted to measure the speed, load, fuel and air consumption, exhaust gas temperature, rate of flow of cooling water and its temperature rise while flowing through the water jackets and calorimeter. There is no direct method to measure the radiation losses and heat lost due to incomplete combustion. Generally, heat lost due to incomplete combustion and radiation losses are calculated by the measured heat loss from the heat supplied.

Heat balance for an engine can be represented with the help of Pie chart and Sankey diagram

`



Pie Chart



Sankey Diagram

Procedure

1. Check the fuel level in the tank.
2. Allow the water to flow to the engine and the calorimeter and adjust the flow rate to 6 LPM & 3 LPM respectively.
3. Release the load if any on the dynamometer.
4. Open the three-way cock so that fuel flows to the engine.
5. Start the engine by cranking.
6. Allow to attain the steady state.
7. Switch on the Load controller and slowly load the engine by rotating the knob clockwise.
8. Note the following readings at various loads.
9. Engine speed.
10. Time taken for 10 cc of diesel consumption.
11. Rotameter reading.
12. Manometer readings.
13. Temperatures at different locations.
14. After the completion release the load and then stop the engine by cutting the fuel supply.
15. Allow the water to flow for few minutes and then turn it off.

Calculations

1. **Mass of fuel consumed, m_f** = $\frac{X_{cc} \times \text{Specific gravity of fuel}}{1000 \times t}$ kg/sec

Where, Specific gravity of Diesel = 0.82

X cc = volume of fuel consumed = 10 cc

t = time taken for 10cc of fuel consumption in seconds

Observation table

S.No.	Load (kg)	Speed (rpm)	Manometer readings (cm of water)			Time taken for 10 cc of fuel consumption (sec.)	Temperatures (°C)						Rotameter reading (lpm)	
			h_1	h_2	Δh		T_1	T_2	T_3	T_4	T_5	T_6	L_1	L_2
1														
2														
3														
4														
5														

2. **Output or Brake Power, BP** $= \frac{2\pi NT}{60\times1000}$ kW

Where, N = speed in Rpm

T = Torque on the load indicator

T = Load x r x 9.81 N-m

r = Torque arm radius = 0.125 m

3. **Heat input, HI - - - - - - - - - - - - - (A)**

A = $m_f \times$ Calorific value of fuel **k**W

Where, Calorific Value of Diesel = 44600 kJ/kg

4. **Heat to BP - - - - - - - - - - - - - - - - (B)**

B = Output or Brake Power, BP = $\frac{2\pi NT}{60\times1000}$ kW

5. **Heat to cooling water - - - - - - - - (C)**

C = $m_{we} \times c_{pw} \times (T_2 - T_3)$ **k**W

Where, m_{we} = Cooling water flow rate to the engine from rotameter = $\frac{LPM}{60}$ kg/sec

C_{pw} = Specific Heat of water = 4.18 kJ/kg

6. **Heat to exhaust gases - - - - - - - (D)**

D = $(m_f + m_a) \times c_{pg} \times (T_5 - T_1)$ **k**W

$$c_{pg} = \frac{m_{wc} \times C_{pw} \times (T_2 - T_4)}{(m_f + m_a) X (T_6 - T_5)} \quad » \quad D = \frac{m_{wc} \times C_{pw} \times (T_5 - T_1) X \ (T_2 - 4)}{(T_6 - T_5)}$$

`

Where m_{wc} = water flow rate to the exhaust gas calorimeter from rotameter $= \frac{LPM}{60}$ kg/sec

T_1= Air inlet temperature.

T_2 = Water Inlet temperature to engine and calorimeter

T_3 = Water outlet temperature from the engine

T_4= Water outlet temperature from the calorimeter

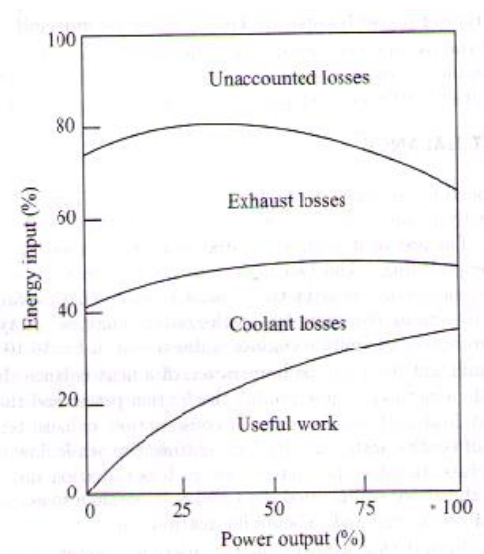
T_5 = Exhaust gas temperature at inlet to calorimeter

T_6 = Exhaust gas temperature at outlet from the calorimeter

Heat Unaccounted E = A – (B+C+D) kW

Result Table

S.No.	Load (kg)	Speed (rpm)	Qs (A)	BP (B)	%BP (B/A)	Q_W (C)	%Q_W (C/A)	Q_{eg} (D)	%Q_{eg} (D/A)	Q_{UA} (E)	%Q_{UA} (E/A)
1	0										
2	4										
3	8										
4	12										
5	16										



Heat Balance Diagram

Heat Balance Sheet

Sl. No.	Particulars	Heat Content (kW)	%
1	Heat Input – A		100
2	Heat to BP – B		B/A =
3	Heat to Cooling Water – C		C/A =
4	Heat to Exhaust Gases – D		D/A =
5	Heat Unaccounted – E		E/A =

Result: The test was conducted on a given engine and the heat balance sheet is prepared.

Prepared by **Verified by (1)** **Verified by (2)** **Approved by**

MORSE TEST ON MULTI CYLINDER PETROL ENGINE

AIM OF EXPERIMENT:

To Evaluate Engine Friction by conducting Morse test on Four Stroke Multi Cylinder Petrol Engine Test Rig.

APPARATUS REQUIRED:

- Multi-Cylinder Petrol Engine Test Rig
- Eddy current Dynamometer
- Ignition Cut off Switches

INTRODUCTION:

The multi cylinder engine is a four cylinder four strokes vertical water cooled engine working on Otto cycle. The prime movers using petroleum products as the source of energy are being increasingly important in the modern world. It is needless to say that the countless number of examples of these prime movers is being used right from household captive power to hauling of aircrafts. The prime movers using petroleum products fall into two categories, viz., Reciprocating & Rotary (Turbines) Engines.

The Reciprocating engines are commonly used ones, further divided into Diesel, Petrol, Paraffin, Kerosene, Gas driven ones. While the rest are discussed elsewhere in standard text books, the petrol engine which is of our present concern fall into the category of spark ignition prime mover which produces maximum power for minimum range as compared to any other reciprocating prime movers.

The understanding of fuel Consumption Vs power (Specific Fuel Consumption = SFC) and Efficiency is important from application point of view to get the maximum benefit at minimum cost. The following paragraphs deal with the engine and the test.

DESCRIPTION OF SETUP:

The test rig consists of four stroke four cylinder petrol Engines to be tested for performance and Morse test is connected to eddy current dynamometer with torque controller for applying load. The arrangement is made for the following measurements of the setup

1. The engine is provided with self-starter arrangement consisting of a battery
2. The water flow for cooling the engine is measured separately by using water meter which is mounted on the frame.
3. The different eddy current loadings are achieved by operating the controller knob provided on the panel board
4. The mechanical energy is measured by torque arm of the dynamometer.

The whole instrumentation is mounted on a self-contained unit ready for operation.

`

SPECIFICATIONS:

• Engine Type	:	Four Stroke Four Cylinder Engine
• Engine Make	:	Maruthi (Zen)
• Fuel	:	Petrol
• Rated Power output	:	10HP at 1500 RPM
• Bore Diameter 'd'	:	61mm
• Stroke Length 'L'	:	72mm
• Compression Ratio	:	8.7:1
• Starting	:	Ignition
• Cooling System	:	Water Cooled
• Loading	:	Eddy current with torque controller
• Lubrication	:	SAE 20-40
• Speed Measurement	:	Digital Speed Indicator with sensor
• Temperature Measurement	:	Digital Temperature indicator 0^0-799.9^0C
• Temperature Scanner	:	8 Channels
• Fuel Flow Rate Measurement	:	Digital indicator with load cell
• Air Flow Measurement	:	U-Tube Manometer connected to air box having an orifice (diameter of orifice is 18 mm)

Before Starting the Engine**:**

The following things has to be observed before starting the engine

- Check for sufficient level of fuel in the fuel tank
- Allow water to flow through the engine head as well as in the dynamometer and don't attempt to operate the dynamometer without proper water supply
- Check all the ignition cut-off switches provided for conducting Morse test are engaged properly
- Check for absolute level of water column in the manometer for measuring the air flow rate to the engine
- Make sure there is no load applied to the dynamometer and check the spring balance to read zero before starting
- Connect the battery lines correctly

Running the Engine**:**

The fuel level, cooling arrangement and lubricating system are checked. The engine is started by the key provided. For this, the key is turned so that heating of the engine takes place after

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this key is further turned so that engine is started. If air is blocked in the fuel line then remove it by removing the pipe. The water flowing in the engine cooling system is adjusted so that sufficient water is flowing in the system. The engine is allowed to run idle for 5 minutes to achieve steady state.

THEORY:

Morse test is used to find a close estimate of indicated power (IP) of a multi-cylinder Engine. In this test the engine is coupled to a suitable eddy current dynamometer and the brake power is determined by running the engine at the required speed. The first cylinder is cut out by interrupting the ignition to the first cylinder in the case of a petrol engine.

As a result of cutting out the first cylinder, engine speed will drop. Load on the engine is removed so that the original speed is attained. The brake power under this load is determined and recorded (BP_1). The first cylinder operation is restored normal and the second cylinder is cut-out. The engine speed will again vary. By adjusting the load on the engine speed brought to original speed and the new BP is recorded (BP_2). Same procedure is continued till the last cylinder is cut-out.

Maximum Load Calculation:

Maximum load that can be applied on the engine at the running condition is calculated as follows:

The engine specifications gives that the break power at 1500 rpm is HP

The formula for Break power = $BP_{load} = \frac{2\times\pi\times N\times T\times C}{60\times1000}$ kW

PROCEDURE:

1. Remove all loads on the engine.
2. Start the engine using ignition key.
3. Adjust the throttle to obtain the desired speed of the engine.
4. Load the engine to half of its maximum load by using the knob provided at the torque controller and adjust the throttle position to any desire speed.
5. Cut-off the first cylinder by cutting off the ignition provided at the engine.
6. The speed of engine decreases. Attain the normal speed by adjusting the load without adjusting the throttle valve.
7. Repeat the experiment by cutting off other cylinders one at a time and note down all the readings.

OBSERVATION & CALCULATION TABLE:

S.No	Cylinder Description	Engine Speed in RPM	Load in Kg	Brake Power in KW	Indicated Power in KW	Frictional Power in KW
1	All Cylinders are					

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	Firing					
2	1^{St} Cylinder Cut off					
3	2^{nd} Cylinder Cut off					
4	3^{rd} Cylinder Cut off					
5	4^{th} Cylinder Cut off					

Model Calculation

1.Total Brake Power when all cylinders firing

$$BP_{load} = \frac{2\pi NTC}{60 \times 1000} \text{ kW}$$

Here torque = W×r in Nm

Fore (W) = m×g in N

Where m= load in kg and

Acceleration due to gravity (g) = 9.81 m/s^2.

Dynamometer constant (C)=1.6

2.Brake Power when 1^{st} cylinder is cutoff

$$BP_1 = \frac{2\pi NTC}{60 \times 1000} \text{ kW}$$

3.Brake Power when 2^{nd} cylinder is cutoff

$$BP_2 = \frac{2\pi NTC}{60 \times 1000} \text{ kW}$$

4.Brake Power when 3^{rd} cylinder is cutoff

$$BP_3 = \frac{2\pi NTC}{60 \times 1000} \text{ kW}$$

5.Brake Power when 4^{th} cylinder is cutoff

$$BP_4 = \frac{2\pi NTC}{60 \times 1000} \text{ kW}$$

6.Indicated Power when 1^{st} cylinder is not firing

$$IP_1 = BP - BP_1$$

Similarly for second, third & fourth cylinders are not firing

$$IP_2 = BP - BP_2$$
$$IP_3 = BP - BP_3$$
$$IP_4 = BP - BP_4$$

Total Indicated power IP $= IP_1 + IP_2 + IP_3 + IP_4$ kW

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7.Total Frictional Power

$$\mathbf{FP} = [(\mathrm{IP})_{\mathrm{Total}} - (\mathrm{BP})_{\mathrm{load}}]$$

8.Mechanical Efficiency η_m

$$\eta_m = \frac{BP}{IP}\ X\,100$$

IP=Indicated Power when all the cylinders are working
BP = Break Power when all the cylinders are working
BP_1= Break Power when 1st cylinder cut off
BP_2= Break Power when 2nd cylinder cut off
BP_3= Break Power when 3rd cylinder cut off
BP_4= Indicated Power when 4th cylinder cut off
IP_1= Indicated Power when 1st cylinder
IP_2= Indicated Power when 2nd cylinder
IP_3= Indicated Power when 3rd cylinder
IP_4= Indicated Power when 4th cylinder

RESULTS:

1. Indicated power =
2. Frictional power =
3. Mechanical Efficiency =

DISCUSSIONS:

(To be written by the students)

PRECAUTIONS:

1. Do not run the engine without water supply
2. Do not shut down the engine when load is applied to dynamometer.
3. After completion of experiments turn off the fuel supply valve.
4. Do not turn off water supply immediately when experiments completes wait for 15 to 30 minutes to maintain the engine temperature cool.
5. Change engine oil when oil turns to black colour (approx. once in 6 months).
6. Engage clutch after engine maintains speed.
7. Always only one cylinder should be cut out at a time.
8. While the engine is running, cutting off more than one cylinder should not be done.
9. While tanking readings do not alter the knob provided at the torque controller.
10. Fuel supply should not be varied while conducting the experiment.

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Questions

1. Can Morse Test be conducted on a single cylinder engine?
2. What is the purpose of conducting the Morse test?
3. What are the precautions to be taken during conducting the Morse test?

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OPTIMUM COOLING TEMERATURE TEST SINGLE CYLINDER DIESEL ENGINE

AIM OF EXPERIMENT:

To conduct optimum cooling water flow and optimum cooling water temperature test on a diesel engine at a given load.

APPARATUS REQUIRED:

1. Diesel engine test rig with electrical dynamometer.
2. Digital speedometer
3. Digital temperature indicator to measure different temperatures sensed by different thermocouples.
4. Voltmeter and Ammeter.
5. Measuring system for the fuel consumption, circulating water flow.

ENGINE SPECIFICATIONS:

Brake power	: 3.7 kW
Speed	: 1500rpm
Number of cylinders	: 1
Compression ratio	: 16.5:1
Bore	: 80 mm
Stroke	: 110mm
Type of ignition	: compression ignition
Method of loading	: Eddy current dynamometer
Orifice diameter	: 20 mm

THEORY:

Cooling is provided to avoid the bad effects of overheating as listed below:

1. The high temperature reduces the strength of the piston and piston rings and uneven expansion of cylinder and piston may cause the seizure of the piston.
2. The high temperature causes the decomposition of the lubricating oil and lubrication between the cylinder wall and piston and may break down resulting in a scuffing of the piston.
3. Overheating of the valves may cause the scuff of the valve guides due to lubrication break down.
4. The tendency of the detonation increases with increase in temperature of the cylinder body.

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To avoid the adverse effects mentioned above, it is necessary to cool the engine. the cooling system used for I.C. engine generally carries 30-35% of the total heat generated in the cylinder due to combustion of the fuel.

It is also necessary that the temperature of the engine should be maintained above a particular temperature. this is essential for easy running and better evaporation of fuel. over cooling of the engine is also undesirable for its safety and smooth running of the engine.

For this reasons, the engine is tested at constant speed and various load steps. for each load step, fuel consumption rates are to be found out by a varying the water flow rates.

Full load of the engine is calculated as follows:

The engine specifications give the power output as 3.7kW at the rated speed of 1500rpm.

Brake power equation for the engine is

5. **Brake Power, BP** $= \frac{2\pi NT}{60\times1000}$ **k**W

Where, N is speed in rpm

T = Torque on the load indicator

T = Load x r x 9.81 N-m   Load in kg's

r = Torque arm radius = 0.125 m

Therefore, the full load is calculated as given below:

$I_{max}=\frac{BP\times60X1000}{2\pi N \text{ x r x}9.81}$ When the load on the engine is increased in steps, its speed decreases. Then governor adjusts the fuel supply to maintain the engine speed constant. corresponding to each load the fuel consumption, speed and load are to be recorded. The SFC, IP, mechanical efficiency is to be calculated and plotted against BP.

Engine description: the engine is a four stroke, single cylinder water cooled and vertical diesel engine.

Cooling system: water cooled.

Loading system: The engine is fitted with an eddy current dynamometer loading.

The engine can be loaded in steps of 0, 1/4, 1/2, 3/4 and full load.

Fuel measurement: The fuel tank is fitted on the panel frame and it is in turn connected to the engine through a graduated burette.

Air flow measurement: an air drum fitted on the panel frame connected with a flexible air hose to the engine facilitates air flow measurement. For this, an orifice meter is fitted to the air drum whose pressure tapings are connected to a U-tube manometer, which enables calculation of the quantity of air drawn into engine cylinder.

Cooling water flow measurement: the quantity of water flowing through engine jacket and calorimeter can be measured individually with the help of 2 separate rotameters provided with test rig.

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PROCEDURE:

connect water line to the engine jacket inlet.

1. Fill up fuel into the fuel tank mounted on the panel frame necessary care should be taken by pouring the fuel into fuel tank.
2. Check the lubricating oil in the engine sump with the help of a dipstick provided.
3. Decompress the engine by a decompression lever provided on the top of the engine head.
4. Crank the engine slowly with the help of handle provided and ascertain proper flow of fuel into the pump and in turn through the nozzle into the cylinder. increase cranking rate and pull the decompression lever down, now the engine starts. allow the engine to run and stabilize at approximately 1500rpm.
5. Now load the engine by the desired load step (0,1/4,1/2,3/4 and full load) at which the optimum cooling water flow to be found out
6. Open gate valves (control valve) and set to full flow rate.
7. Record the following parameters indicated on the panel instruments for different water flow rates.
   - i. Speed of the engine from rpm indicator.
   - ii. Rate of fuel from burette (time taken for 10cc of fuel consumption).
   - iii. Load on the engine from loadindicator.
   - iv. Engine jacket outlet temperature (t3)

16. 8. After the completion release the load and then stop the engine by cutting the fuel supply.

17. 9. Allow the water to flow for few minutes and then turn it off.

OBSERVATIONS:

LOAD: …………….. kg (load may be 0,1/4,1/2,3/4 and full load).

Sl.No.	Water flow rate through engine jacket (cc/s)	Time taken for consumption of 10 cc of fuel τ (in sec)	Temperature of cooling water outlet through engine jackett_5 (°C)
1.	150		
2.	125		
3.	100		
4.	75		
5.	50		

RESULT TABLE:

Sl.No.	Mass of fuel consumed (kg/hr)	SFC (kg/kWh)	Water flow rate through engine jacket (LPM)	Temperature of cooling water outlet through engine jackett$_5$ (°C)
1 2 3 4 5				

MODEL CALCULATIONS:

Calculation for the load of………………..(preferably for third reading)

1. Mass of fuel consumed : (m_f)in kg/hr

$$m_f = \frac{(x_{cc} \times \text{sp.gravity of fuel} \times 3600)}{(\tau_{sec} \times 1000)} \text{ kg/hr}$$

x_{cc} = Volume of fuel consumed = 10 cc

Sp. Gravity of fuel (Diesel) = 0.838

τ_{sec} = Time taken for x_{cc} fuel consumption in seconds

Brake Power, BP $= \frac{2\pi NT}{60 \times 1000}$ **k**W

2. Specific fuel consumption: SFC in kg/kWh

$$\text{SFC} = \frac{\text{mass of fuel consumed in kg per hour}}{\text{Brake Power}}$$

$$= \frac{m_f}{\text{B.P.}} \text{kg/kWh}$$

RESULT:

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The experiment was conducted and the graphs are drawn.The optimum cooling water flow rate is determined by plotting the graph between brake specific fuel consumption and water flow rates.

DISCUSSION:

The optimum cooling water flow will be the flow rate at which the SFC is minimum. From the experiment it has been found that the optimum water flow through the engine jacket is …………cc/s at the load of …………(0,1/4,1/2,3/4 or full load).

The following graphs are to be drawn:

1. SFC v/s engine jacket water flow rate
2. t_3 v/s engine jacket water flow rate

PRECAUTIONS:

1. After applying the load allow the engine to run for some time to obtain steady state conditions then take readings.
2. While taking readings do not alter flow rates.
3. The engine should not be overloaded.
4. Stop the engine only after unloading the engine.

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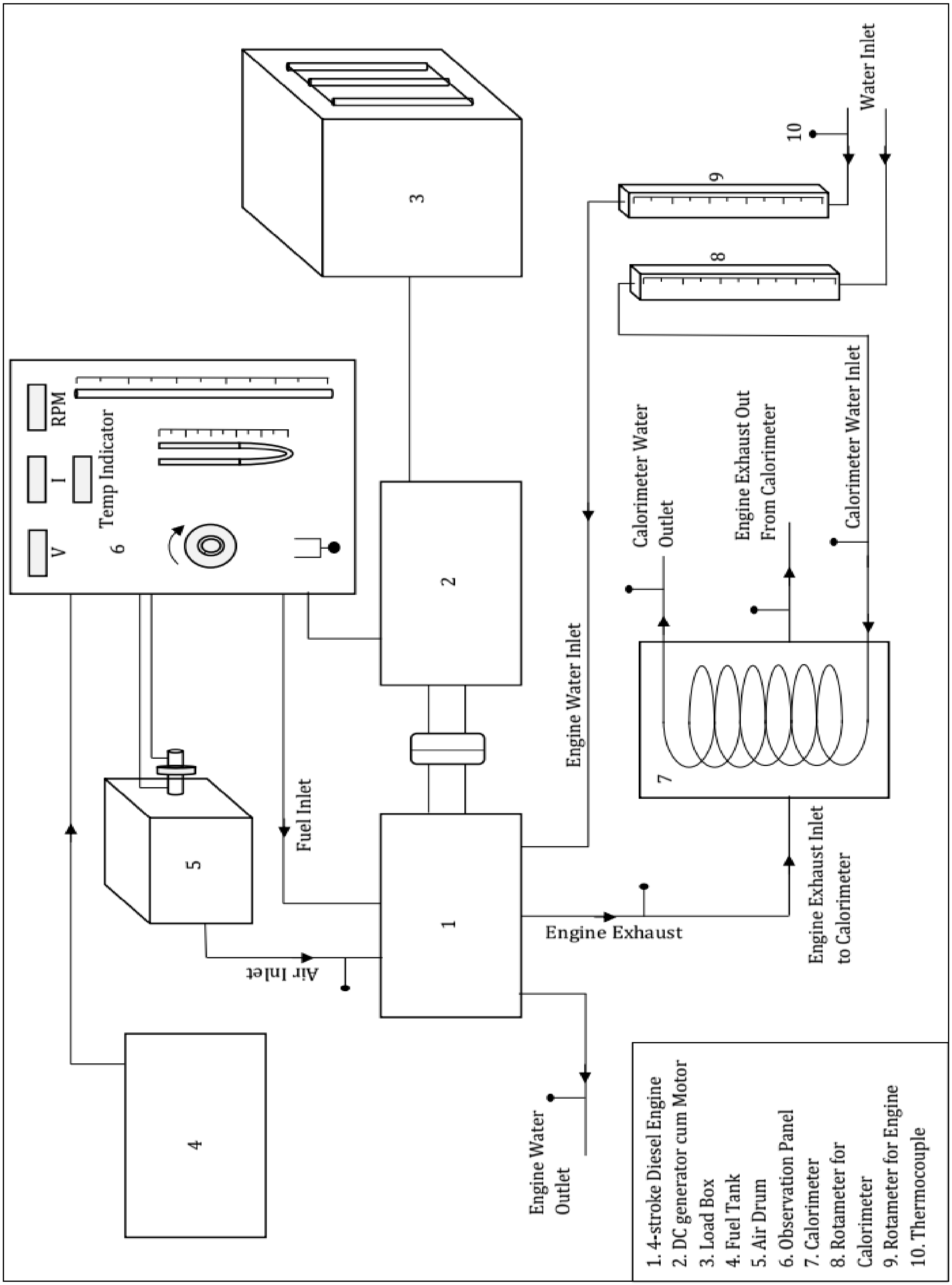

Fig. Schematic Diagram for Diesel Engine Experimental Set-up

Performance Test on Computerized Diesel Engine

Aim

To study the performance of single cylinder, 4 stroke, computerised Diesel engine connected to eddy current dynamometer in computerized mode.

Apparatus

1. Computerized Diesel engine test rig with Eddy current dynamometer.

Engine and set up details

Engine power : 5.2 kW

Engine max speed : 1500 RPM

Cylinder bore : 87.5mm

Stroke length : 110mm

Compression ratio : 17.5

Stoke type : Four

No. of cylinders : One

Speed type : Constant

Cooling type : Water

Dynamometer type : Eddy current

Theoretical constants

Fuel density : 830 kg/m^3

Calorific value : 42000 kJ/kg

Orifice coefficient of discharge : 0.60

Sp heat of exhaust gas : 1.1 kJ/kg-K

Max sp heat of exhaust gas : 1.25 kJ/kg-K

Min sp heat of exhaust gas : 1.1 kJ/kg-K

Specific heat of water : 4.186 kJ/kg-K

Water density : 1000 kg/m^3

Ambient temperature : 30 ^{O}C

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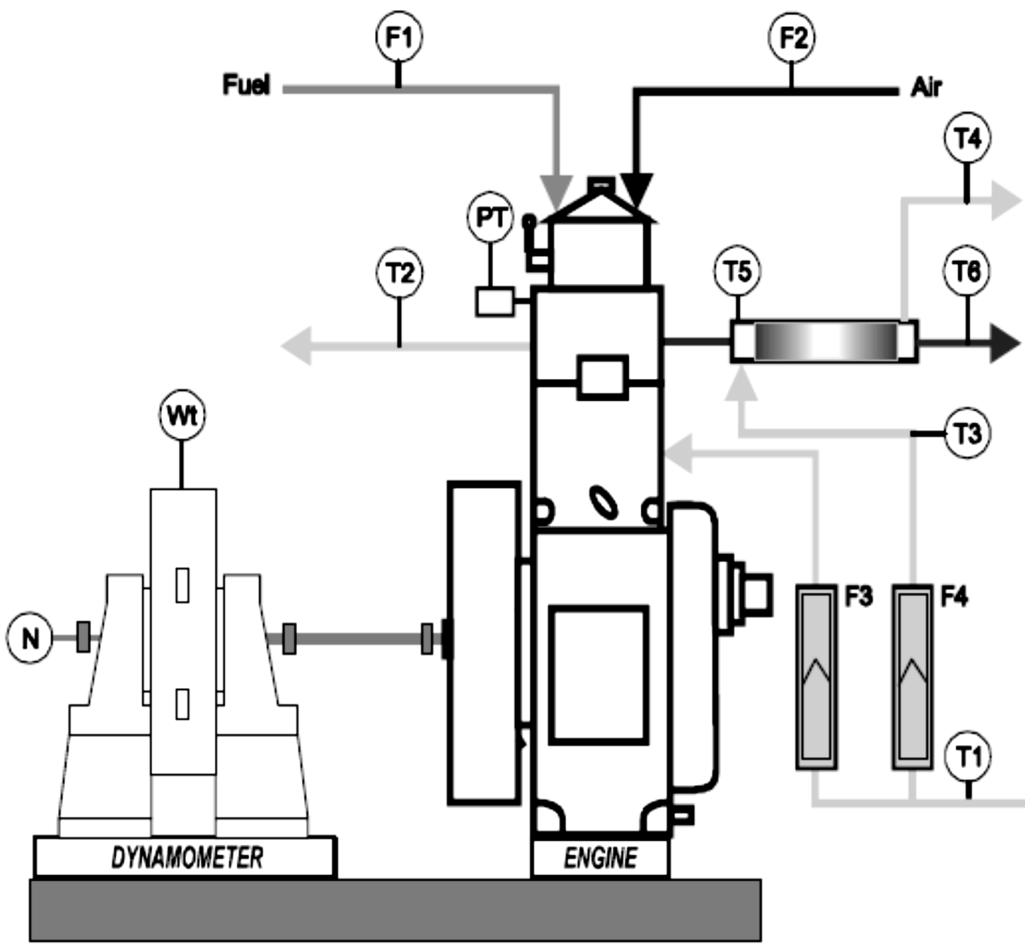
Theory

The setup consists of single cylinder, four stroke, Diesel engine connected to eddy current type dynamometer for loading. It is provided with necessary instruments for combustion pressure and crank-angle measurements. These signals are interfaced to computer through engine indicator for Pθ−PV diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The set up has stand-alone panel box consisting of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rotameters are provided for cooling water and calorimeter water flow measurement. The setup enables study of engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio and heat balance. Labview based Engine Performance Analysis software package "Enginesoft" is provided for on line performance evaluation. A computerized Diesel injection pressure measurement is optionally provided.



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Procedure

- Ensure cooling water circulation for eddy current dynamometer and piezo sensor, engine and calorimeter.
- Start the set up and run the engine at no load for 4-5 minutes.
- Switch on the computer and run "Enginesoft".
- Gradually increase load on the engine.
- Wait for steady state (for @ 3 minutes) and log the data in the "Enginesoft".
- Gradually decrease the load.
- View the results and performance plots in "Enginesoft".

Result Table

S. No.	Load (kg)	Torque (N-m)	Fuel Consumption (kg/h)	SFC (kg/kWh)	IMEP (bar)	BMEP (bar)	FMEP (bar)	η_{bth}, (%)	η_{ith} (%)	η_{vol} (%)	η_{mech} (%)
1											
2											
3											
4											
5											

Graphs to be plotted

1. BMEP, IMEP & FMEP Vs. Load
2. SFC & fuel consumption Vs. Load
3. η_{bth}, & η_{ith}, Vs. Load
4. Torque, η_{mech} & η_{vol} Vs. Load

Discussion

Diesel engines are widely used for transportation and power generation around the world. Thay are employed particularly in the field of heavy transportation and agriculture on account of their higher thermal efficiency and durability. However, diesel engines are the major contributors of oxides of nitrogen and particulate emissions.

Engine performance is represented by typical characteristics curves which are functions of engine operating parameters. Brake thermal efficiency indicates the ability of the combustion system to accept the experimental fuel and provides comparable means of assessing how efficient the energy in the fuel is converted to mechanical output. It is worth noting the increase in the engine efficiency with load. As the load increases the brake thermal efficiency increases.

The specific fuel consumption (SFC) is the ratio of the mass of fuel consumed to the energy produced by an engine. The increase in SFC depends on the type of engine and also on its condition of operation such as load and speed. However, from a thermodynamic point of view, the thermal efficiency is more appropriate than SFC for evaluation of engine performance under different fuel compositions. At lower loads SFC is high due to low mechanical efficiency. There is a noticeable reduction in specific fuel consumption with increasing load. As the load increases the fuel consumption decreases. However, SFC increases at high loads owning to the increased fuel waste associated with high fuel-air ratios.

Mechanical efficiency indicates how good an engine is inverting the indicated power to useful power. Brake output depends on brake mean effective pressure and piston speed. Brake mean effective pressure depends on indicated mean effective pressure and frictional mean effective pressure. As the load increases the indicated power increases. Also as the load increases the mechanical efficiency increases.

Result: The performance test on computerized Diesel engine is conducted and performance curves are plotted.

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Permanence Test on Reciprocating Air Compressor Test Rig

Aim:

The experiment is to conduct at various pressures to determine the Volumetric efficiency and Isothermal efficiency of reciprocating air compressor.

Instrumentation:

Two stage reciprocating air compressor with various fittings like intercooler, manometer, pressure gauge, digital temperature indicator, digital Rpm indicator and stop clock.

Specifications:

Diameter of low pressure cylinder: 70 mm

Length of stroke: 85 mm

Diameter of orifice: 20 mm

Compressor capacity: 3hp

Air tank capacity: 160 Liter

Theory:

A compressor is a device, which sucks in air at atmospheric pressure & increases its pressure by compressing it. If the air is compressed in a single cylinder it is called as a single stage compressor. If the air is compressed in two or more cylinders it is called as a multi stage compressor. In a two-stage compressor, the air is sucked from atmosphere & compressed in the first cylinder called the low-pressure cylinder. The compressed air then passes through an inter cooler where its temperature is reduced. The air is then passed into the high-pressure cylinder where it is further compressed. The air further goes to the air tank where it is stored.

Volumetric efficiency of an air compressor is defined as the ratio of actual volume of air compressed per stroke to the swept volume of the compressor at NTP conditions. Isothermal efficiency is defined as the ratio of work done on air in an isothermal process to the actual work done in compressing the air. An important application of compressed air is in running of mining machines, where electric motors and IC engines cannot be use because of fire risks due to the pressure of inflammable gases and also used in spray paintings, tyre inflation centers.

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Procedure:

1. Check the necessary electrical connections and also for the direction of the motor.
2. Check the lubricating oil level in the compressor.
3. Start the compressor by switching on the motor.
4. Observe the increase of the pressure inside the air tank.
5. Maintain the required pressure by slowly operating the discharge valve (open/close).
6. Now note down the following readings
   - Speed of the compressor.
   - Manometer reading.
   - Delivery pressure.
   - Temperatures.
   - Energy meter reading.
7. Repeat the experiment for different delivery pressures.
8. Once the set of readings are taken switch of the compressor.
9. The air stored in the tank is discharged, be careful while doing so, because the compressed air passing through the small area also acts as an air jet which may damage your surroundings.
10. Repeat the above two steps after every experiment.

Observations:

S. No.	Compressor Speed N (rpm)	Delivery Pressure, 'P' (kg/cm^2)	Time for 'n' revolutions of energy meter, 'T' (sec)	Manometer meter reading (cm)		
				h_1	h_2	h_w
1						
2						
3						
4						
5						

`

Calculations:

5. Air head, h_a

$$h_a = \frac{h_w \, \rho_{water}}{\rho_{air}} \text{ m of air}$$

Where,

h_w is water column reading in **m** of water.

ρ_{water} is density of the water = 1000 kg/m³

ρ_{air} is the density of the air = 1.293 kg/m³

2. Actual vol. of air compressed at NTP, Va

$$V_a = C_d \, a \sqrt{(2gh_a)} \quad m^3/s$$

Where,

h_a is air head causing the flow in **m** of air.

C_d = co efficient of discharge of orifice = 0.62

a = Area of orifice = $(\pi d^2) / 4$

Where, d = diameter of orifice = 0.02m

3. Theoritical volume of air compressed, V_{th}

$$V_{th} = \frac{(\pi/4) \times D^2 \times L \times N}{60} \quad m^3/s$$

Where,

D is the diameter of the LP cylinder = 0.07m.

L is Stroke Length = 0.085m

N is speed of the compressor in Rpm

4. **Input Power, IP**

$$\text{Input Power} = \frac{3600 \times n \times \eta_m}{K \times T} \quad kW$$

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Where,

n = No. of revolutions of energy meter (Say 10)

K = Energy meter constant = 1600 revs/kW-hr

T = time for 10 rev. of energy meter in seconds

η_m = efficiency of belt transmission = 75%

5. Isothermal Work done, WD

$$\mathbf{WD = Pa \times Va \ln r \quad kW}$$

Where,

P_a – Atmospheric pressure = 101.325 kPa

V_a = Actual volume of air compressed m^3/s

r = Compression ratio

$$r = \frac{\text{Delivery gauge pressure+Atmospheric pressure}}{\text{Atmospheric pressure}}$$

Where Atmospheric pressure = 101.325 kPa

Note: To convert delivery pressure from kg/cm^2 to kPa multiply by 98.1

Tabulations:

S. No	Head of air h_a, m	Act. Vol. of air compressed V_a m^3/s	Theo. Vol. of air compressed V_{th}, m^3/s	Isothermal work done kW	Isothermal efficiency η_{iso}, %	Volumetric efficiency, η_{vol}, %
1						
2						
3						
4						
5						
6						

`

Graphs to be plotted:

1. Delivery Pressure vs. η_{vol}
2. Delivery Pressure vs. η_{iso}

Precautions:

1. Do not forget to give electrical earth connections correctly.

6. Do not touch any moving parts.

Result:

Prepared by **Verified by (1)** **Verified by (2)** **Approved by**

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Dismantling, inspection and assembly of multi-cylinder petrol engine

Aim:

To disassemble, inspect and assemble given multi-cylinder petrol engine.

Tools Required:

Petrol engine, slotted head screw driver, monkey pliers, plug spanner, star screw driver, ratchet, piston compressor, spanners, allen key, mallet, box spanner set, spider puller remover, cir clip pliers, wire brush, valve remover and engine support stand.

Theory:

Engine is the most important system of vehicle that converts heat energy into mechanical energy by fuel consumption. Engine block is the foundation for other parts of the engine and is made of aluminum alloys or cast iron. Engine block is closed by engine head and the engine head seals the engine cylinder. Engine cylinder head is usually made of aluminum alloys or cast iron. Provisions for the fuel and air intake and exhaust are provided, in which inlet and outlet valves are fitted. Also provisions for cooling and lubrication are provided. Piston, connecting rod and crankshaft are the parts which fit inside the cylinder block. As the fuel burns inside the cylinder, the energy of fuel makes the piston to reciprocate. The connecting rod is connected to the piston and transmits the movement to the crankshaft. The crankshaft converts the reciprocating motion into rotary motion. The rotary motion is transmitted to wheels through transmission system and vehicle propels.

Engine Removal:

Engine removal is disconnecting all the systems attached to it. The process of engine removal may vary depending upon the type of engine. The general procedure is as follows.

1. Remove the hood.
2. Disconnect battery cables.
3. Remove the drain cock from the radiator and drain the coolant
4. Remove the drain plug from the oil sump and drain the oil.
5. Remove the radiator.
6. Remove air filter.
7. Remove the distributor and spark plug wiring.
8. Remove the starter assembly and timing chain.
9. Remove the alternator.
10. Remove switches and sensors.

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11. Remove the throttle linkage, cable or wiring.
12. Mark accessory brackets and remove accessories.
13. Remove exhaust components.
14. Remove and plug the fuel line.
15. Separate the engine and transmission/transaxle.
16. Disconnect speedometer cable, transmission shift linkage and clutch cable.
17. Unbolt the engine mounts.
18. Remove the engine from the vehicle.

Procedure of disassembling the engine:

There are some basic rules for dismantle engine irrespective of capacity and type. Engine dismantling should be carried out in a sequence as follows.

1. Document engine information.
2. Thoroughly clean the engine exterior of dirt, grease, and debris.
3. Remove subassemblies like oil filter and engine flywheel.
4. Remove the spark plug.
5. Disconnect linkages and springs from the carburettor and remove the carburettor.
6. Remove the ignition coil or electronic ignition system.
7. Remove the intake and exhaust manifolds.
8. Remove the cylinder head cover.
9. Remove the camshaft and valve lifters.
10. Remove the valves, valve springs, and valve spring retainers.
11. Remove the cylinder head.
12. Check gaskets and seals for signs of leakage.
13. Rotate the engine on its stand in upside down position.
14. Remove oil sump.
15. Remove oil strainer and oil pump.
16. Remove the connecting rod-bearing cap from the connecting rod.
17. Disconnect the connecting rod from the crankshaft.
18. Carefully push and remove the piston and connecting rod assembly out of the cylinder.
19. Repeat the procedure for all the pistons.
20. Piston pin circlip is removed by circlip pliers to allow pull out the piston pin from the piston.
21. Remove the crankshaft.

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22. Remove any bearings or seals in the crankcase.

Inspection:

After dismantling the total engine inspect the parts

1. Inspect timing belt and idler pulleys, check the turning smoothness of the timing belt idler pulleys.
2. Inspect cylinder head for flatness and check for cracks at top due to the thermal and mechanical stress.
3. Inspect the valves, valve springs and check for tension.
4. Inspect camshaft, cam journal oil clearance and cam lobes.
5. Inspect the wear and tear of the rocker arm.
6. Inspect intake and exhaust manifold, check the carbon deposits and for any cracks.
7. Check the crankshaft thrust clearance, oil clearance.
8. Inspect piston diameter and oil clearance.
9. Inspect piston ring area and Grooves, check for the free movement of the piston rings.
10. Inspect for piston ring end gap.
11. Inspect connecting rods.
12. Inspect crankshaft for run out.
13. Inspect main journals and crank pins.

Assembly steps are same as the steps done for dismantling in reveres way.

Result:

Dismantling, inspection and assembly of the given single cylinder petrol engine is done.

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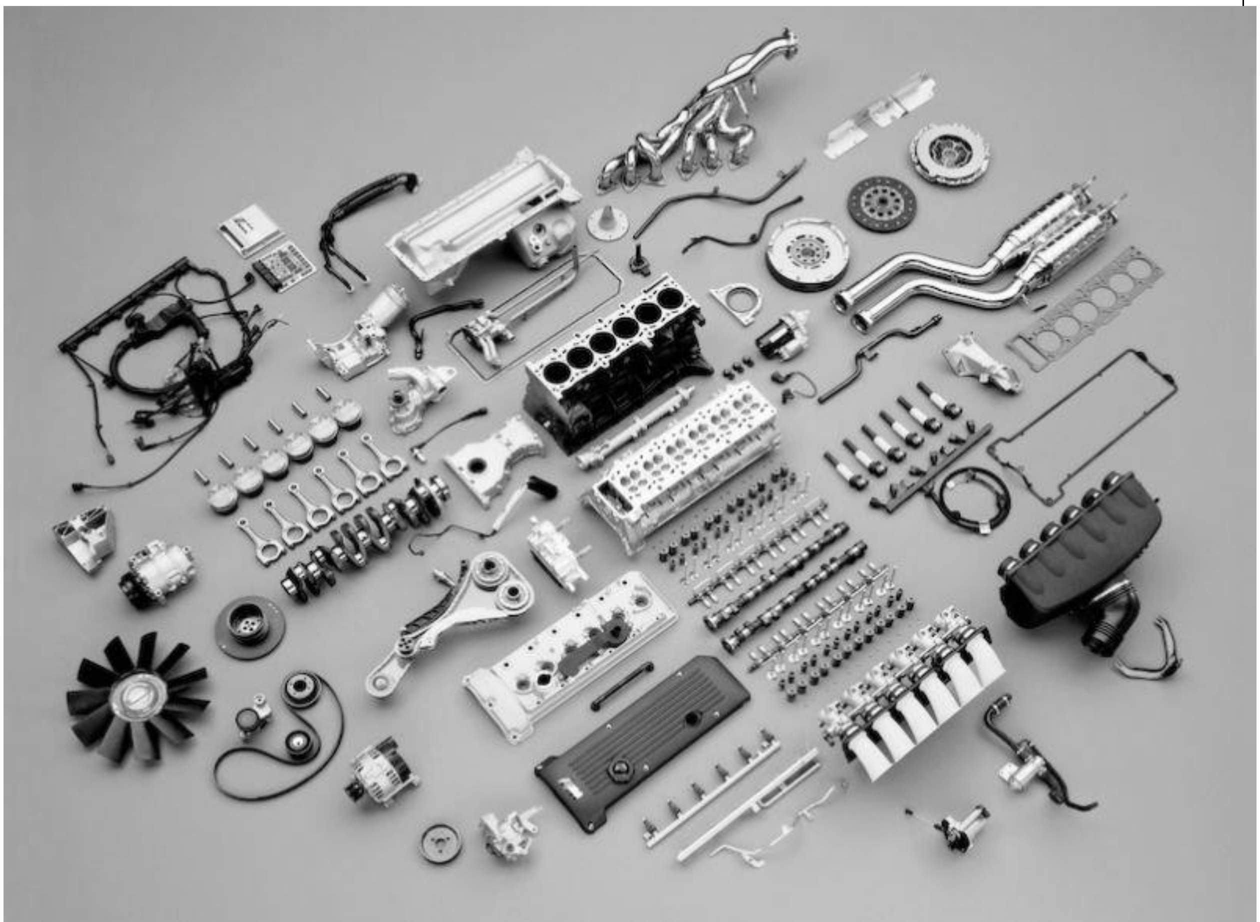
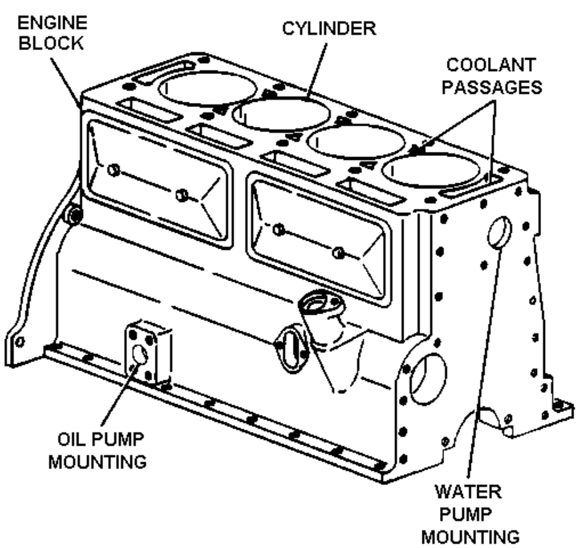


Engine parts



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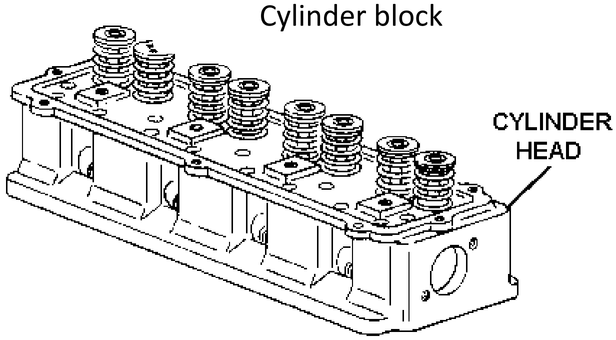
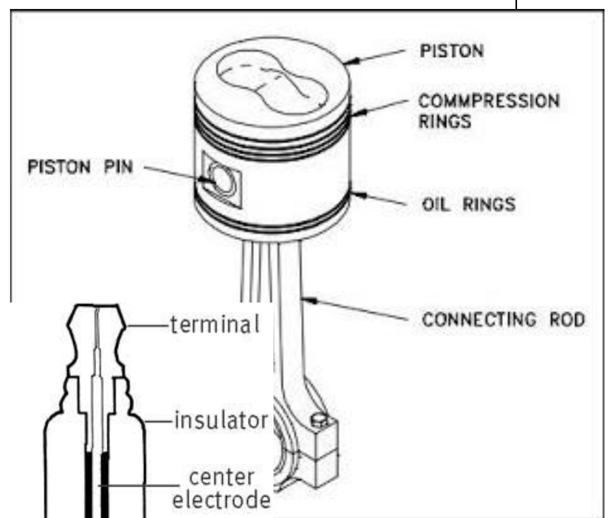
Cylinder block

Cylinder head





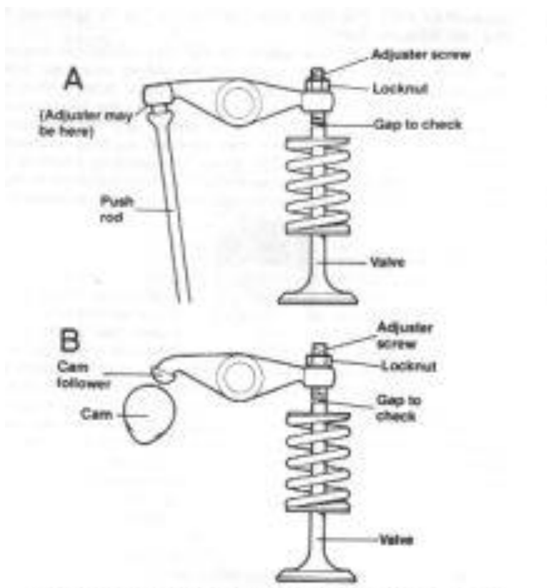
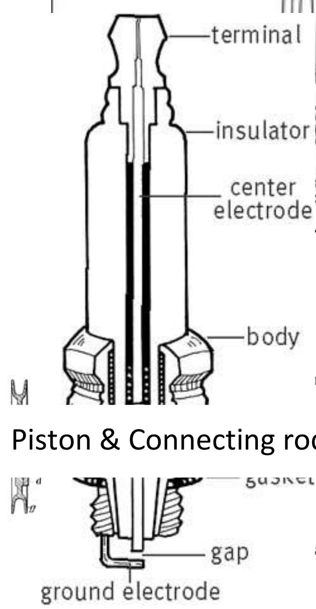
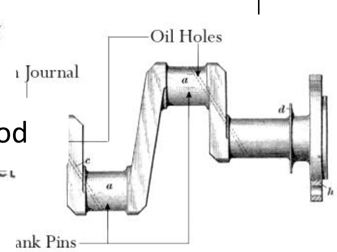


Fig. 1.17 Comparison of overhead valve and overhead camshaft operation



Piston & Connecting rod



Crankshaft

Spark plug

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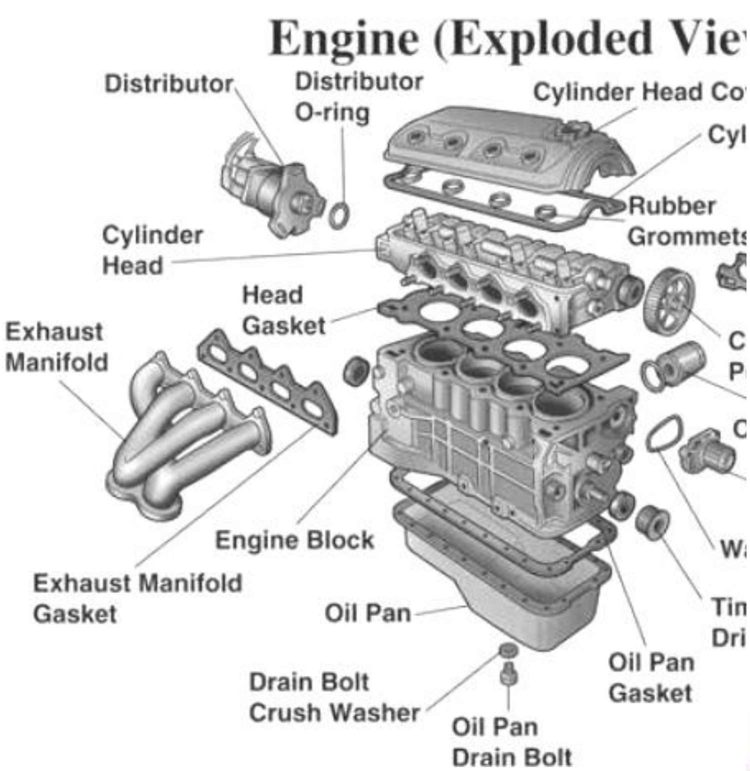
IC engine Major Parts, Its Function, Materials and Manufacturing Method

Parts of IC engine



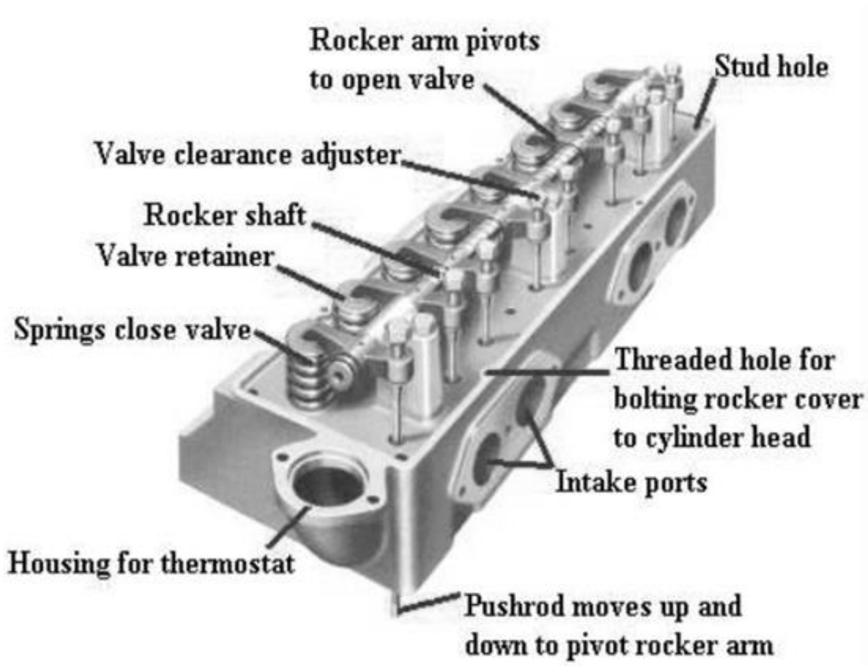
Cylinder Block

- It is a container fitted with piston, where the fuel is burnt and power is produced.

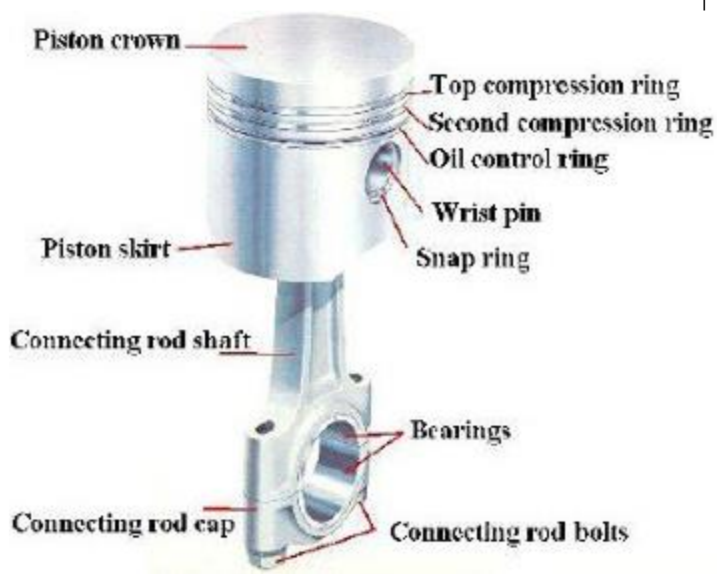
- Cylinder is the main body of IC engine. Cylinder is a part in which the intake of fuel, compression of fuel and burning of fuel take place. The main function of cylinder is to guide the piston.
- For cooling of cylinder a water jacket (for liquid cooling used in most of cars) or fin (for air cooling used in most of bikes) are situated at the outer side of cylinder.
- At the upper end of cylinder, cylinder head and at the bottom end crank case is bolted.
- **Material :** Ductile (Nodular) Cast Iron ,30C8 (Low Carbon Steel)
- **Manufacturing method :** Casting, Forging and after that heat transfer , Machining
- Cast iron has high compressive strength to handle the pressure and temperature. It is made by casting and usually cast in one piece.

Cylinder Head / Cylinder Cover

- One end of the cylinder is closed by means of cylinder head. This consists of inlet valve for admitting air fuel mixture and exhaust valve for removing the products of combustion.
- The inlet valve, exhaust valve, spark plug, injector etc. are bolted on the cylinder head. The main function of cylinder head is to seal the cylinder block and not to permit entry and exit of gases on cover head valve engine.
- **Material:** Aluminium alloys
- **Manufacturing Method:** Casting
- Cylinder head is usually made by cast iron or aluminum. It is made by casting or forging and usually in one piece.



Piston



- Piston is used to reciprocate inside the cylinder.
- It transmits the energy to crankshaft through connecting rod.
- **Material:** Aluminum Alloy 4652 because of its Low Specific Gravity.
- **Manufacturing Method:** Casting

Piston Rings

- These are used to maintain a pressure tight seal between the piston and cylinder walls and also it transfer the heat from the piston head to cylinder walls.
- These rings are fitted in grooves which have been cut in the piston. They are split at one end so they can expand or slipped over the end of piston.
- **Material:** cast iron of fine grain and high elastic material
- **Manufacturing Method:** Pot casting method
- Piston ring is usually made by fine grain of cast iron which has high elasticity and it is not affected by the working pressure. Sometime piston rings are made by alloy spring steel. It is made by forging.

Piston Pin:

- Piston pin is made by hardened steel so it can support and
  allow to connecting rod to swivel. It is usually made by forging.

Gudgeon pin or piston pin

- These are hardened steel parallel spindles fitted through the piston bosses and the small end bushes or eyes to allow the connecting rods to swivel. It connects the piston to connecting rod. It is made hollow for lightness.
- **Material:** Plain Carbon steel 10C4

Connecting Rod

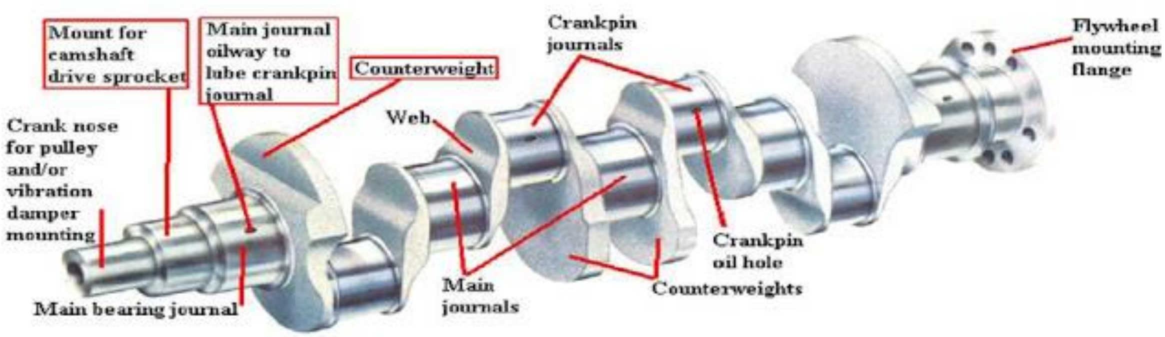
- One end of the connecting rod is connected to piston through piston pin while the other is connected to crank through crank pin.
- It transmits the reciprocatory motion of piston to rotary crank.
- There are two end of connecting rod one is known as big end and other as small end. Big end is connected to the crankshaft and the small end is connected to the piston by use of piston pin.
- **Material:** Low Carbon steel 30C8
- **Manufacturing Methods:** Forging and after that heat treatment. It should have high strength. So it is made by alloy steel but in small engine it is made by aluminum to achieve lighter weight. It is made by forging.

Crank

- It is a lever between connecting rod and crank shaft.

Crank Shaft

- The function of crank shaft is to transform reciprocating motion in to a rotary motion.
- The crankshaft of an internal combustion engine receives the efforts or thrust supplied by piston to the connecting rod and converts the reciprocating motion of piston into rotary motion of crankshaft.
- The crankshaft mounts in bearing so it can rotate freely.
- The shape and size of crankshaft depends on the number and arrangement of cylinders.
- **Material:** 37C15 Alloy Steel.
- **Manufacturing Method:** Casting
- It should have high tensile strength. So the crankshaft made by high tensile steel or sometime by cast iron. It is usually made by forging.



Fly wheel

- Fly wheel is a rotating mass used as an energy storing device.
- A flywheel is secured on the crankshaft. The main function of flywheel is to rotate the shaft during preparatory stroke. It also makes crankshaft rotation more uniform.
- **Material :** cast Iron
- **Manufacturing Method :** Casting

Crank Case

- It supports and covers the cylinder and the crank shaft. It is used to store the lubricating oil.
- The main body of the engine to which the cylinder are attached and which contains the crankshaft and crankshaft bearing is called crankcase. It serves as the lubricating system too and sometime it is called oil sump. All the oil for lubrication is placed in it.

Poppet Valves

- A valve is a device that regulates, directs or controls the flow of a fluid (gases, liquids, fluidized solids, or slurries) by opening, closing, or partially obstructing various passageways.
- The intake and exhaust valves open at the proper time to let in air and fuel and to let out exhaust.
- Note that both valves are closed during compression and combustion so that the combustion chamber is sealed.
- **Materials:** Phosphorus Bronze and Monel metal.

Inlet valve and Exhaust valve:

- Inlet valve admits the air and fuel into the cylinder. It is usually made by silicon chrome steel with about 3% carbon. It is made by forging.
- Exhaust valve discharge the exhaust gases. It is made by austenitic steal. It is also made by forging.

Spark Plug

- The main function of a sparkplug is to conduct the high potential from the ignition system into the combustion chamber.

- It provides the proper gap across which spark is produced by applying high voltage , to ignite the mixture in the ignition chamber.
- **Manufacturing Method:** Each major element of the spark plug—the center electrode, the side electrode, the insulator, and the shell—is manufactured in a continuous in-line assembly process. Then, the side electrode is attached to the shell and the center electrode is fitted inside the insulator. Finally, the major parts are assembled into a single unit.

Engine Bearing

- The crankshaft is supported by bearing .
- Everywhere there is rotary action in the engine , bearings are used to support the moving parts.
- Its purpose is reduce the friction and allow parts to move freely.
- Engine bearing should have lubricant property and strength to withstand in moving load. So its half is made of steel or bronze back to which a lining of relatively soft bearing material is applied.

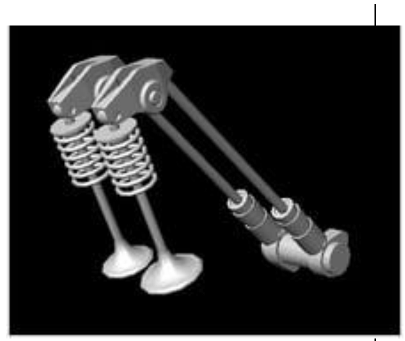
Carburetor

- The function of a carburetor is to atomize and meter the liquid fuel and mix it with the air as it enters the induction system of the engine.
- Maintaining fuel-air proportion under all conditions of operation appropriate to the conditions.

Manifold

- The main function of manifold is to supply the air fuel mixture and collects the exhaust gases equally form all cylinder. In an internal combustion engine two manifold are used, one for intake and other for exhaust.
- **Material :** Aluminium alloy -Alloy 4600

Pushrod



- Pushrod is used when the camshaft is situated at the bottom end of cylinder. It carries the camshaft motion to the valves which are situated at the cylinder head.

Rocker Arm

- Rocker Arms are typically in between the pushrod and the intake and exhaust valves. They allow the pushrods to push up on the rocker arms and therefore push down on the valves.
- **Material :** Medium Carbon steel

- **Manufacturing methods :** Forging

Cam Shaft

- Camshaft is used in IC engine to control the opening and closing of valves at proper timing.
- For proper engine output inlet valve should open at the end of exhaust stroke and closed at the end of intake stroke.
- So to regulate its timing, a cam is use which is oval in shape and it exerts a pressure on the valve to open and release to close.
- It is drive by the timing belt which drives by crankshaft. It is placed at the top or at the bottom of cylinder.

- **Material:** Plain Carbon steel 10C4
- **Manufacturing Method:** Grinding, Case Hardening

Dismantling, inspection and assembly of multi-cylinder diesel engine

Aim:

To disassemble, inspect and assemble given multi-cylinder diesel engine.

Tools Required:

Diesel engine, slotted head screw driver, monkey pliers, plug spanner, star screw driver, ratchet, piston compressor, spanners, allen key, mallet, box spanner set, spider puller remover, circlip pliers, wire brush, valve remover and engine support stand.

Theory:

Engine is the most important system of vehicle that converts heat energy into mechanical energy by fuel consumption. Engine block is the foundation for other parts of the engine, and is made of aluminum alloys and cast iron. Engine block is closed by engine head, and the engine head seals the engine cylinder. Engine cylinder head is usually made of aluminum alloys and cast iron. Provisions for the fuel and air intake and exhaust are provided, in which inlet and outlet valves are fitted. Also provisions for cooling and lubrication are provided. Piston, connecting rod and crankshaft are the parts which fit inside the cylinder block. As the fuel burns inside the cylinder, the energy of fuel makes the piston to reciprocate. The connecting rod is connected to the piston and transmits the movement to the crankshaft. The crankshaft converts the reciprocating motion into rotary motion. The rotary motion is transmitted to wheels through transmission system and vehicle propels.

Engine Removal:

Engine removal is disconnecting all the systems attached to it. The process of engine removal and disassembly may vary depending upon the type of engine. The general procedure is as follows.

1. Remove the hood.
2. Disconnect battery cables.
3. Remove the drain cock from the radiator and drain the coolant

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4. Remove the drain plug from the oil sump and drain the oil.
5. Remove the radiator.
6. Remove air filter.
7. Remove the fuel line.
8. Remove the starter assembly and timing chain.
9. Remove the alternator.
10. Remove switches and sensors.
11. Remove the throttle linkage, cable or wiring.
12. Mark accessory brackets and remove accessories.
13. Remove exhaust components.
14. Separate the engine and transmission/transaxle.
15. Disconnect speedometer cable, transmission shift linkage and clutch cable.
16. Unbolt the engine mounts.
17. Remove the engine from the vehicle.

Procedure of disassembling the engine:

There are some basic rules for dismantle engine irrespective of capacity and type. Engine dismantling should be carried out in a sequence as follows.

1. Document engine information.
2. Thoroughly clean the engine exterior of dirt, grease, and debris.
3. Remove subassemblies like oil filter and engine flywheel.
4. Remove the fuel injector.
5. Disconnect the fuel lines from the fuel injection pump and remove it.
6. Remove the intake and exhaust manifolds.
7. Remove the cylinder head cover.
8. Remove the camshaft and valve lifters.

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9. Remove the valves, valve springs, and valve spring retainers.
10. Remove the cylinder head.
11. Check gaskets and seals for signs of leakage.
12. Rotate the engine on its stand in upside down position.
13. Remove oil sump.
14. Remove oil strainer and oil pump.
15. Remove the connecting rod-bearing cap from the connecting rod.
16. Disconnect the connecting rod from the crankshaft.
17. Remove the crankshaft.
18. Carefully push and remove the piston and connecting rod assembly out of the cylinder.
19. Repeat the procedure for all the pistons.
20. Piston pin circlip is removed by circlip pliers to allow pull out the piston pin from the piston.
21. Remove any bearings or seals in the crankcase.

Inspection:

After dismantling the total engine inspect the parts

1. Inspect timing belt and idler pulleys, check the turning smoothness of the timing belt idler pulleys.
2. Inspect cylinder head for flatness and check for cracks at top due to the thermal and mechanical stress.
3. Inspect the valves, valve springs and check for tension.
4. Inspect camshaft, cam journal oil clearance and cam lobes.
5. Inspect the wear and tear of the rocker arm.
6. Inspect intake and exhaust manifold, check the carbon deposits and for any cracks.
7. Check the crankshaft thrust clearance, oil clearance.

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8. Inspect piston diameter and oil clearance.
9. Inspect piston ring area and Grooves, check for the free movement of the piston rings.
10. Inspect for piston ring end gap.
11. Inspect connecting rods.
12. Inspect crankshaft for run out.
13. Inspect main journals and crank pins.

Assembly steps are same as the steps done for dismantling in reveres way.

Result:

Dismantling, inspection and assembly of the given multi cylinder diesel engine is done.

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Experiment Title:

Testing of batteries and battery maintenance

Aim:

Servicing, testing and charging of given battery

Tools:

Battery Charger and battery Tester

Servicing of batteries:

1. Check your battery to make sure its terminal connections are clean, snug and protected from the elements
2. Signs of corrosion or leakage could mean that your battery is no longer operating
3. Check for cracks in battery terminals which may allow leakage to electrolyte
4. Check for broken cables or connections
5. Check for electrolyte fuel level, this can be seen by removing the vent caps and add distilled water if needed
6. Keep the battery in cooler places whenever possible. Heat damages batteries
7. Scrub corrosion from the terminals with a solution of water and baking soda

Connecting and Testing Battery:

1. Before connecting the tester, clean the battery posts or side terminals with a wire brush and a mixture of baking soda and water. When testing side-post batteries, install and tighten lead terminal adapters. A set of adapters is included with the tester
2. Do not test at or with steel bolts, to avoid damage, never use a wrench to tighten the adapters more than ¼ turn
3. Connect the red clamp to the positive (+) terminal, connect the black clamp to the negative (–) terminal
4. For a proper connection, rock the clamps back and forth. The tester requires that both sides of each clamp be firmly connected before testing. A poor connection will

produce a check connection or wiggle clamps message. If the message appears, clean the terminals and reconnect the clamps.

5. Scroll to and select in vehicle or out of vehicle for a battery not connected to a vehicle
6. The performance of the starting and charging systems depends on the battery's condition
7. It is important that the battery is good and fully charged before any further system testing
8. Scroll to and select automotive, motorcycle, marine, lawn and garden, group 31 or commercial-4d/8d
9. Press enter button to begin the testing process
10. Scroll to and select Standard, Agm Flat Plate, Agm Spiral, or Gel where applicable

Select the below standard

Standard	Description	Range
CA	Cranking Amps	100-2000
CCA	Cold Cranking Amps	100-2000
MCA	Marine Cranking Amps	100-2000

11. Scroll to and select the numeric rating units. Hold down the up or down arrows to increase the scrolling speed, press E to start test.
12. After several seconds the tester displays the decision on the battery's condition and the measured voltage. The tester also displays your selected battery rating and the rating units.
13. To view the State of Health of the battery, press side arrow to print out the test results including the State of Health graph

Fig. Battery Tester

Basic Charging Methods:

Constant Voltage:

A constant voltage charger is basically a DC power supply which in its simplest form may consist of a step down transformer from the mains with a rectifier to provide the DC voltage to charge the battery. Such simple designs are often found in cheap car battery chargers. The lead-acid cells used for cars and backup power systems typically use constant voltage chargers. In addition, lithium-ion cells often use constant voltage systems, although these usually are more complex with added circuitry to protect both the batteries and the user safety.

Constant Current:

Constant current chargers vary the voltage they apply to the battery to maintain a constant current flow, switching off when the voltage reaches the level of a full charge. This design is usually used for nickel-cadmium and nickel-metal hydride cells or batteries.

Charging Rates:

Batteries can be charged at different rates depending on the requirement. Typical rates are shown below:

- Slow Charge = Overnight or 14-16 hours charging at 0.1C rate
- Quick Charge = 3 to 6 Hours charging at 0.3C rate
- Fast Charge = Less than 1 hour charging at 1.0C rate

Fast charging also causes increased Joule heating of the cell because of the higher currents involved and the higher temperature in turn causes an increase in the rate of the chemical conversion processes.

Simple Guidelines for Charging Lead Acid Batteries:

1. Charge in a well-ventilated area. Hydrogen gas generated during charging is explosive.

2. Choose the appropriate charge program for flooded, gel and AGM batteries. Check manufacturer's specifications on recommended voltage thresholds.

3. Charge lead acid batteries after each use to prevent sulfation. Do not store on low charge.

4. The plates of flooded batteries must always be fully submerged in electrolyte. Fill battery with distilled or de-ionized water to cover the plates if low. Tap water may be acceptable in some regions. Never add electrolyte.

5. Fill water level to designated level *after* charging. Overfilling when the battery is empty can cause acid spillage.

6. Formation of gas bubbles in a flooded lead acid indicates that the battery is reaching full state-of-charge (hydrogen on negative plate and oxygen on positive plate).

7. Reduce float charge if the ambient temperature is higher than 29°C (85°F).

8. Do not allow a lead acid to freeze. An empty battery freezes sooner than one that is fully charged. Never charge a frozen battery.

9. Do not charge at temperatures above 49°C (120°F).

Slow charging

1. Slow charging can be carried out in relatively simple chargers and should not result in the battery overheating. When charging is complete batteries should be removed from the charger.
2. Nicad batteries are generally the most robust type with respect to overcharging and can be left on trickle charge for very long periods since their recombination process tends to keep the voltage down to a safe level. The constant recombination keeps internal cell pressure high, so the seals gradually leak. It also keeps the cell temperature above ambient, and higher temperatures shorten life. So life is still better if you take it off the charger.
3. Lead acid batteries are slightly less robust but can tolerate a short duration trickle charge. Flooded batteries tend to use up their water, and SLAs tend to die early from grid corrosion. Lead-acids should either be left sitting, or float-charged (held at a constant voltage well below the gassing point).
4. NiMH cells on the other hand will be damaged by prolonged trickle charge.
5. Lithium ion cells however cannot tolerate overcharging or overvoltage and the charge should be terminated immediately when the upper voltage limit is reached.

Fast / Quick Charging:

As the charging rate increases, so do the dangers of overcharging or overheating the battery. Preventing the battery from overheating and terminating the charge when the battery reaches full charge become much more critical. Each cell chemistry has its own characteristic charging curve and battery chargers must be designed to detect the end of charge conditions for the specific chemistry involved.

Fast charging and quick charging require more complex chargers. Since these chargers must be designed for specific cell chemistries, it is not normally possible to charge one cell type in a charger that was designed for another cell chemistry and damage is likely to occur. Universal chargers, able to charge all cell types, must have sensing devices to identify the cell type and apply the appropriate charging profile.

Procedure

Simple Calculations

Amps =Ah / hours, For Example

To charge a 100Ah battery in 12 hours we need 8.3Amps (recommended)

Operating Procedure:

1. Use 230V AC,50 Hz Single phase power supply with Proper Earthing to avoid any shocks
2. Do not switch ON the charger now
3. Connect the + Terminal (RED) to the Battery + Terminal & - Terminal (BLACK) to the Battery – Terminal
4. Now Switch ON the charger
5. Select the Proper Battery Voltage
6. Check the Ah of the battery
7. Use the formula to find out the Amps required (Amps = Ah/hours required to charge) (Normally use 12 Hours to charge the batteries)
8. Use the Fine Control to adjust the Amps rating required
9. Do not Short the terminals of the battery
10. Keep the Battery charger in a Dry place and avoid Moisture area

Do's

1. Always use the Mains power supply with proper earthing
2. Check the regularly the charging cable for wear n tear, if needed replace it
3. Clean the machine regularly and keep dust free

DON'TS

1. Never interchange the Battery terminals
2. Never over charge the battery (always check the Ah rating)
3. Avoid Moisture environment and environment temperature should be below 49 ^{0}C

Results: Battery testing and servicing is done, obtained values are noted and studied

Experiment Title:
Diagnosis of ignition system faults

Aim:

To service the ignition system, spark plug cleaning and testing

Tools Required:

Tools Box, spark plug tester and cleaner

Servicing of Ignition System:

Ignition System Inspection:

- Spark plug wires should be visually inspected for cuts or defective insulation and checked for resistance with an ohmmeter
- Good spark plug wires should measure less than 10,000 ohms per foot of length
- Check all spark plug wires for proper routing. All plug wires should be in the factory wiring separator
- Check that all spark plug wires are securely attached to the spark plugs and to the distributor cap or ignition coil(s)
- Remove the distributor cap and carefully check the cap and distributor rotor for faults
- Remove the spark plugs and check for excessive wear or other visible faults. Replace if needed
- Check the spark plug wire or connector with an ohmmeter to be certain of continuity

Spark Plug Inspection:

- Spark plugs should be inspected when an engine performance problem occurs and should be replaced regularly to ensure proper ignition system performance
- Many spark plugs have a service life of over 20,000 miles (32,000 kilometres)
- Platinum-tipped original equipment spark plugs have a typical service life of 60,000 to 100,000 miles (100,000 to 160,000 kilometres)
- Platinum-tipped spark plugs should not be re-gapped
- Using a gapping tool can break the platinum after it has been used in an engine
- As a spark plug wears, the centre electrode becomes rounded

- If the centre electrode is rounded, higher ignition system voltage is required to fire the spark plug

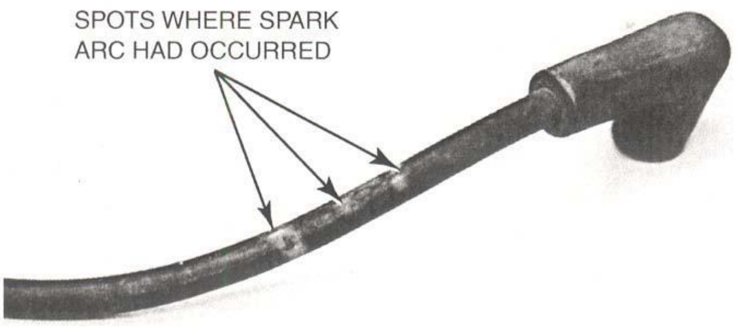


Fig.1 Inspection of spark cable

Testing and Cleaning of Ignition System:

Cleaning of Spark Plug:

Spark plug cleaner is used to clean the spark plug, procedure is as follows:

- First the cleaner unit assembly should be filled with sand. Next the unit has to be connected to the compressed air system which is capable of giving maximum pressure of 12 kg/cm^2 and the minimum pressure of $5kg/cm^2$
- Next turn away the protective shield in cleaner unit assembly and fix the dusted spark plug in the rubber adopter (depending upon the plug thread i.e. M10, M12, M14 & M18 the rubber adopters can be chosen) and operate the double action valve knob at ABRASIVE BLAST POSITION for 10 to 15 seconds by rotating the plug so as to clean in all position followed by operating the Double action Valve knob to AIR BLAST POSITION to remove the sand particles in spark plug for 5 seconds
- The specified pressure should be maintained while cleaning the spark plugs and also see that the cleaner unit contains 500 gms of sand

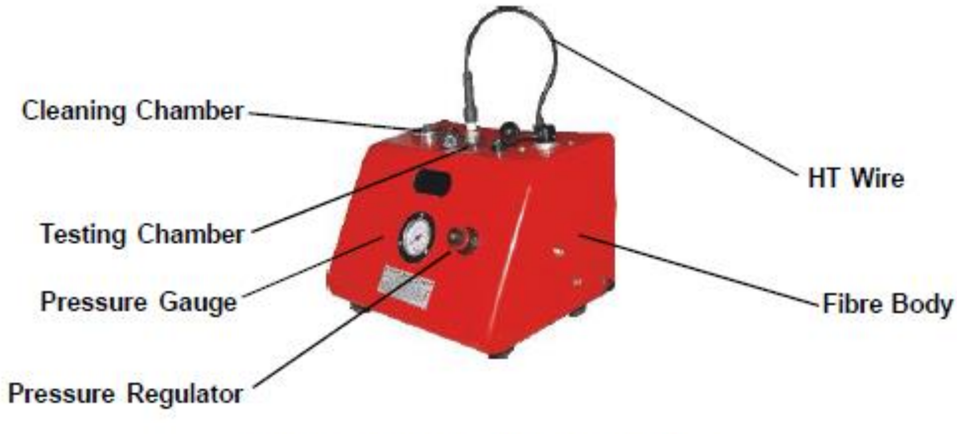


Fig.2 Spark plug cleaner and tester

Testing of Spark:

Spark plug tester is used for testing the ignition system, testing procedure is as follows:

1. Remove the spark plug from the engine and install it in spark tester
2. Either compressed air or air boosted can be used for checking performance of the Spark plug
3. The unit is supplied with M14 & M18 Blind plugs with air screws fixed over the respective plug adopters
4. Now the spark plugs to be checked depending upon the thread size are fixed over the respective plug adopters by removing the Blind plug and Air screw and keeping tight the other adopter, blinder plug & air screw assembly
5. After that fix the HT cable-clip over the spark plug and supply is given
6. Please note that power supply should be given to the unit only after fixing the HT cable-clip over the spark plug
7. A good coil and ignition system should produce a blue spark at the spark tester
8. If they are blue, the spark plug is ok. Else if the sparks are yellow or there is no spark at all then the spark plug is bad.

Checking for spark:

Typical causes of a no-spark (intermittent spark) condition include the following:

1. Weak ignition coil
2. Low or no voltage to the primary (positive) side of the coil
3. High resistance or open coil wire, or spark plug wire
4. Negative side of the coil not being pulsed by the ignition module

5. Defective pickup coil
6. Defective module

Ignition Coil Testing:

1. Remove the ignition coil from the vehicle, take an *ohmmeter*, which measures electrical resistance, you can measure the effectiveness of your ignition coil in a definitive, quantifiable way, rather than in the somewhat subjective way. However, to begin this test, you'll need to remove the vehicle's ignition coil so that you can easily access its electrical terminals.
2. Find the resistance specifications for your ignition coil, most automotive coils will have a resistance reading of about 0.7 - 1.7 ohms for the primary winding and 7,500 - 10,500 ohms for the secondary winding.
3. Position the leads of the ohmmeter on the poles of the primary coil. The distributor will have three electrical contacts - two on either side or one in the middle. These may be either external (jutting out) or internal (sunken in) - it makes no difference. Turn on your ohmmeter and touch one lead to each of the outer electrical contacts. Record the resistance reading - this is the resistance of the coil's *primary winding*

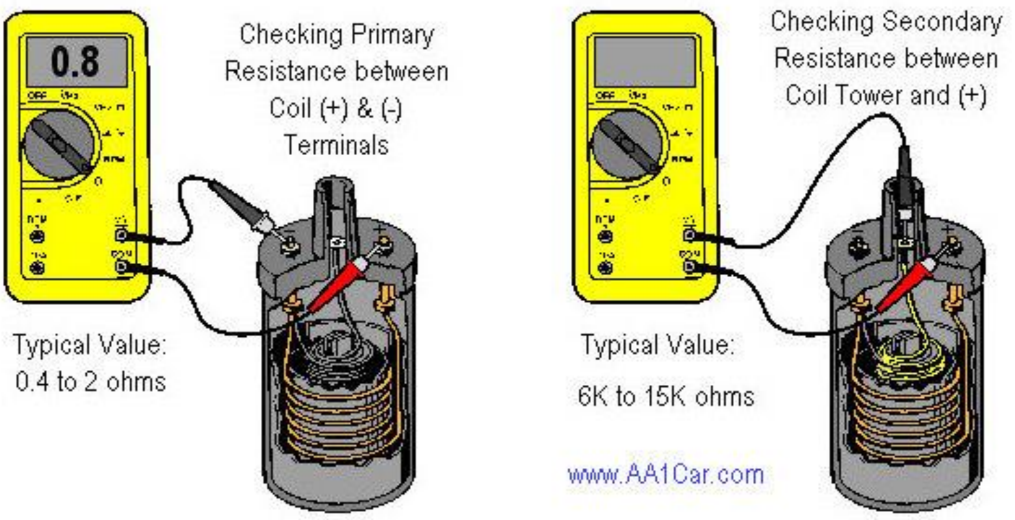


Fig.3 Inspection of ignition coil

4. Position the leads of the ohmmeter on the poles of the secondary coil. Next, keep one lead on one of the outer contacts and touch the other to the central, inner contact of the ignition coil (where the main wire to the distributor connects). Record the resistance reading - this is the resistance of the coil's *secondary winding*.

5. Determine whether the readings you recorded fall within your vehicle's specifications

Firing Order:

1. Firing order means the order that the spark is distributed to the correct spark plug at the right time.
2. The firing order of an engine is determined by crankshaft and camshaft design.
3. The firing order is often cast into the intake manifold for easy reference

4-cylinder in-line engine: 1-3-4-2 or 1-2-4-3
6-cylinder in-line engine: 1-5-3-6-2-4
6-cylinder v-type engine: 1-2-3-4-5-6
8-cylinder in-line engine: 1-4-7-3-8-5-2-6
8-cylinder in-line engine: 1-3-4-2 or 1-2-4-3
8-cylinder v-type engine: 1-5-4-8-6-3-7-2

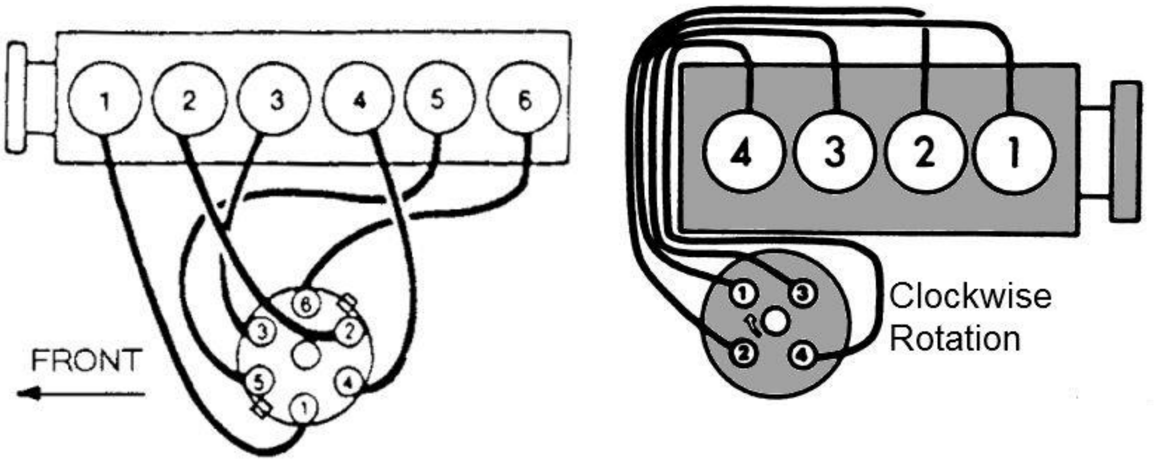


Fig.4 Firing order of different engines

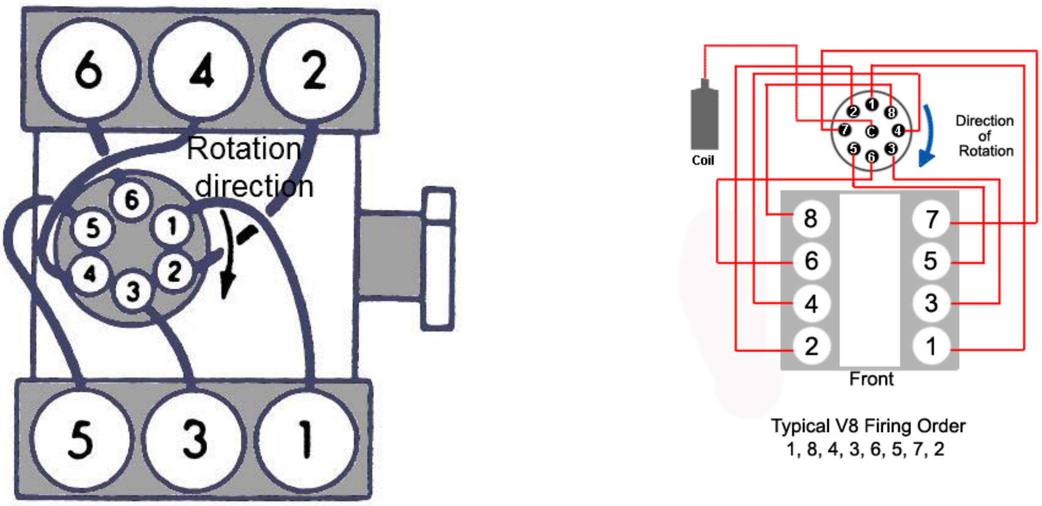


Fig.5 Firing order of different engines

Contact Breaker gap Testing:

Normally the contact breaker gap should be between 0.35 to 0.45 mm. The distributor cap is removed and the engine cranked till the breaker gap is maximum. The gap is then checked by means of a feeler gauge. If it is found to be not correct, the screws on the plate carrying stationary point are loosened by means of screw drive and the plate is adjusted for correct gap.

Results: Ignition system is diagnosed, the obtained values are noted and studied

Experiment Title:
Testing of starting motor

Aim:

Testing of starter motor on electrical test bench.

Tools:

Electrical test bench, starter motor, automotive battery and suitable electrical cables.

Specifications of Test Electrical Bench:

Induction motor : 5 HP, 3 Phase, 1440 rpm

Independent ammeter : 3 No., 0-200 A DC (For Alternator, Starter and Battery)

Common Voltmeter : 0-100 V DC

3PH- 5 Wire System with 415V /50Hz, 15Amps capacity -R/Y/B/N with Grounded

Test bench Dimensions: 900mmx850mmx650mm (LXDXH)

Net Weight : 120 kg

Theory:

A starter is an electric motor that turns over or cranks the engine to start it. It consists of a powerful DC (Direct Current) electric motor and the starter solenoid that is attached to the motor. The starter motor is powered by the battery. To turn over the engine the starter motor requires a very high electric current, which means the battery has to have sufficient power.

A starter motor has several (typically 4) electric windings (field coils) attached to the starter motor housing from the inside. The armature (the rotating part) is connected through the carbon brushes in series with the field coils. On the front end of the armature, there is a small gear that attached to the armature through an overrunning clutch.

When turn the ignition switch, the starter solenoid is energized, it closes the electric circuit and sends the battery power to the starter motor. At the same, the starter solenoid pushes the starter gear forward to mesh it with the engine flywheel ring gear teeth. The flywheel is attached to the engine crankshaft. The starter motor spins, turning over the engine crankshaft allowing the engine to start. This spins the engine over, sucking in air (as well as fuel). At the same time, electricity is sent through the spark plug wires to the plugs, igniting the fuel in the combustion chamber. As the engine turns over, the starter disengages, and the electromagnet stops. The rod retracts into the starter once more, taking the pinion gear out of contact with the flywheel and preventing damage. If the pinion gear remained in contact with the flywheel, it's possible that the engine would spin the starter too fast, causing damage to it.

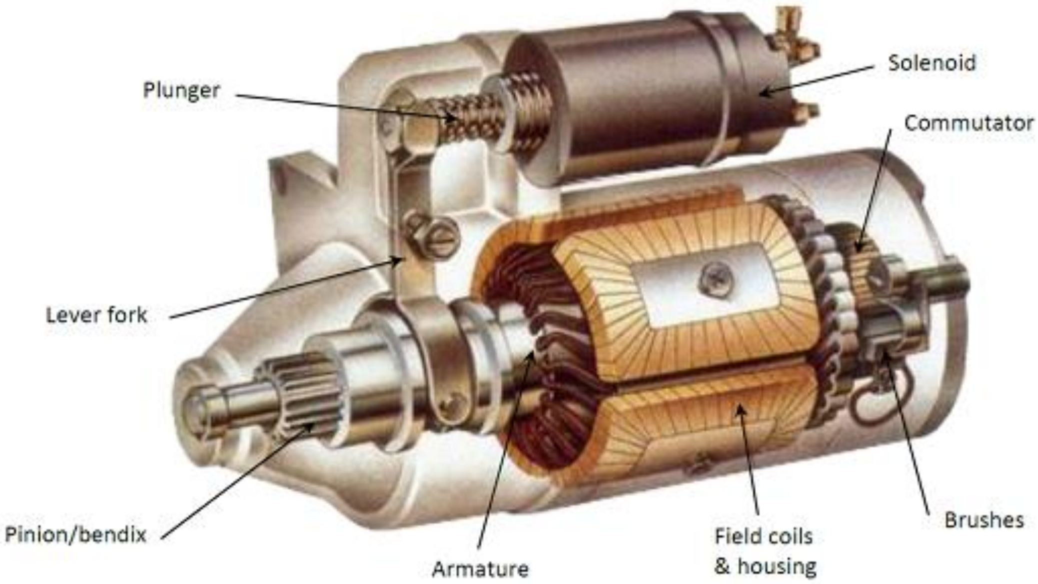


Fig 1. Starter motor cut section

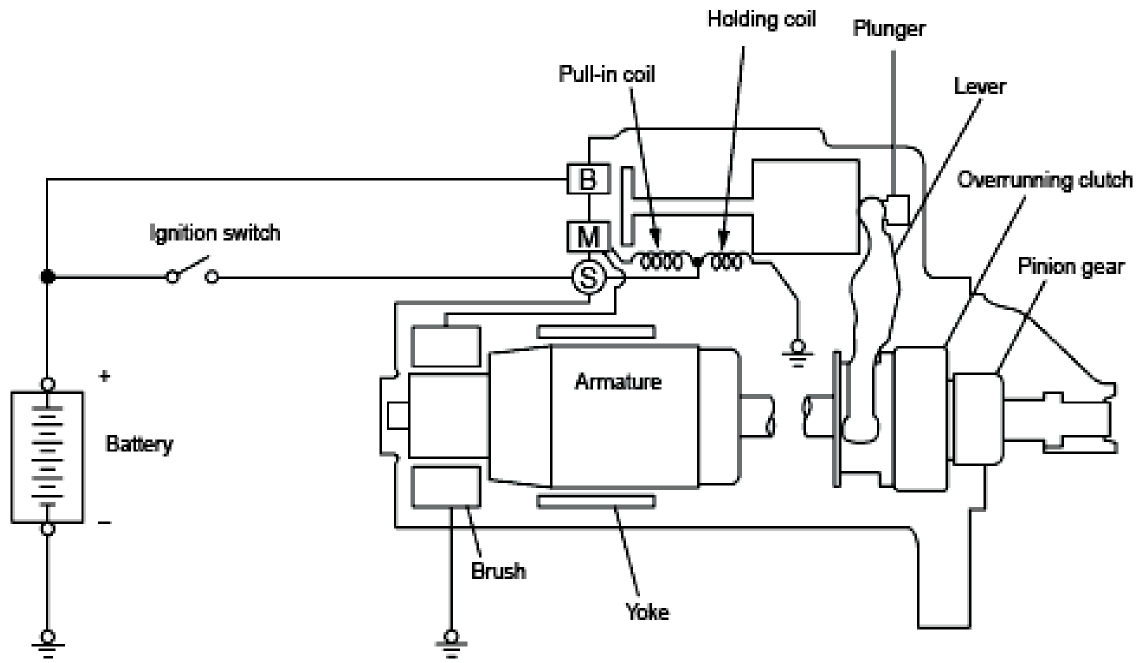


Fig 2. Simple wiring diagram for starter motor

Starter Motor Testing Procedure:

1. Mount the starter motor on the V-block and align it with the motor pulley.
2. Connect the starter motor cable to the test bench. Positive of the test bench to positive terminal of starter motor. Negative of the test bench to the negative terminal of starter motor.
3. Switch ON the main supply MCB and ensure the power indicator is ON. Ensure LED displays with zero.

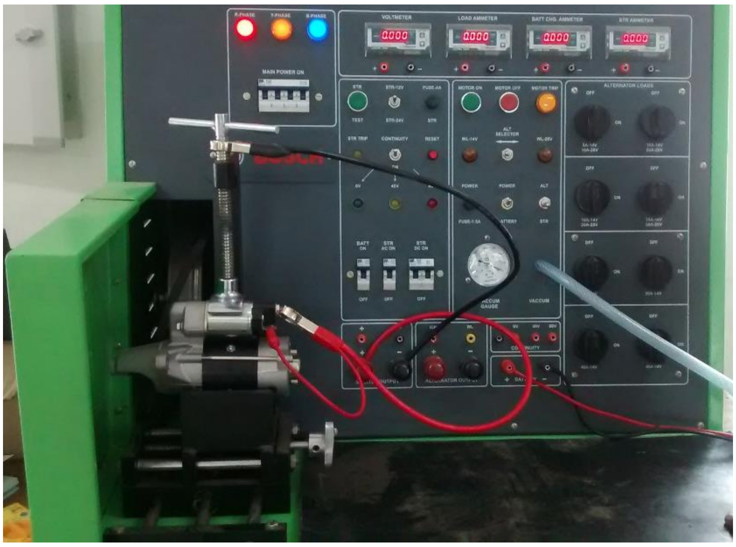


Fig 3. Starter motor test set-up

Continuity Test:

1. Switch ON the continuity test switch.
2. Connect the test leads to appropriate voltage required as 40 V/80 V AC and 6 V DC.
3. Check the continuity by touching the test leads on the points where the continuity is to be seen and check whether the corresponding LED glows.

Power Mode

4. Select the toggle switch (Power/Battery) to power mode.
5. Select the toggle switch (12 V/24 V) to 12 V mode.
6. Select the toggle switch (STR/ALT) to STR mode.
7. Switch ON the STR AC MCB.
8. Switch ON the STR DC MCB.
9. Push the starter push button and hold it (After 3 seconds power will cut-off automatically).
10. Observe the values on the voltmeter and the STR ammeter.

11. Based on the starter motor under test, select voltage drop and the current.

Table 1. Voltage and current in power mode

Trial	Voltmeter (V)	Starter Ammeter (A)
1.		
2.		
3.		

Battery Mode

Repeat the above steps 1 to 8.

12. Switch ON the BATT ON on single pole MCB.

And repeat the above steps 9 to 11.

Table 2. Voltage and current in battery mode

Trial	Voltmeter (V)	Starter Ammeter (A)
1.		
2.		
3.		

Starter Short Circuit Test:

1. When a burnt or short circuited starter motor is tested, the trip indicator immediately switches ON and no further test is possible.
2. To start the test again, press the reset button and then test a good starter motor and ensure the readings.

Results: Testing of starter motor is done and motor condition is analyzed.

Experiment Title:
Testing of alternator

Aim:

Testing of alternator on electrical test bench.

Tools:

Electrical test bench, starter motor, automotive battery and suitable electrical cables.

Specifications of Electrical Test Bench:

Induction motor : 5 HP, 3 Phase, 1440 rpm

Independent ammeter : 3 No., 0-200 A DC (For Alternator, Starter and Battery)

Common Voltmeter : 0-100 V DC

3PH- 5 Wire System with 415V /50Hz, 15Amps capacity -R/Y/B/N with Grounded

Test bench Dimensions : 900mmx850mmx650mm (LXDXH)

Net Weight : 120 kg

Theory:

An automotive charging system is made up of three major components: the battery, the voltage regulator and an alternator. The alternator works with the battery to generate power for the electrical components of a vehicle, like the interior and exterior lights, and the instrument panel. Alternators are typically found near the front of the engine and are driven by the crankshaft pulley to the alternator pulley. The alternators found in most passenger cars and light trucks are constructed using an aluminum outer housing, as the lightweight metal does not magnetize. This is important since aluminum dissipates the tremendous heat generated by producing the electrical power and since the rotor assembly produces a magnetic field.

The primary components of an alternator are

1. Rotor Assembly (rotor shaft, slip rings, claw poles, and field windings)
2. Stator Assembly (three stator windings or coils, output wires, and stator core)

3. Rectifier Assembly (heat sink, diodes, diode plate, and electrical terminals)

The rotor consists of field windings (wire wound into a coil placed over an iron core) mounted on the rotor shaft. Two claw-shaped pole pieces surround the field windings to increase the magnetic field. The fingers on one of the claw-shaped pole pieces produce south (S) poles and the other produces north (N) poles. As the rotor rotates inside the alternator, alternating N-S-N-S polarity and AC current is produced. An external source of electricity is required to excite the magnetic field of the alternator. Slip rings are mounted on the rotor shaft to provide current to the rotor windings. Each end of the field coil connects to the slip rings.

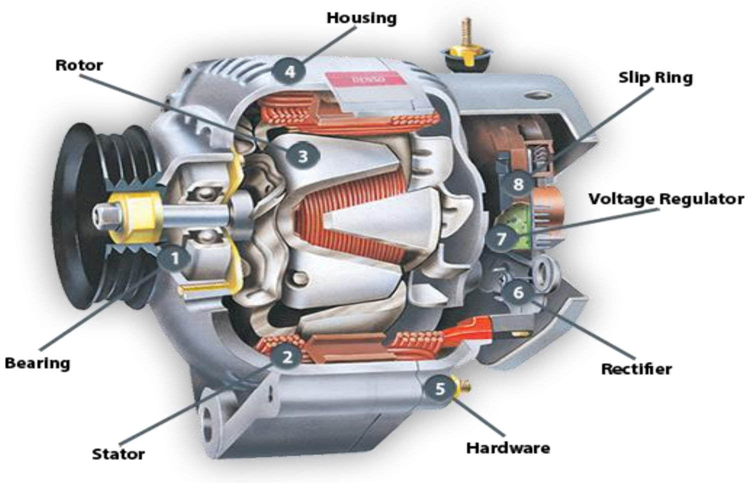


Fig 1. Alternator cut section

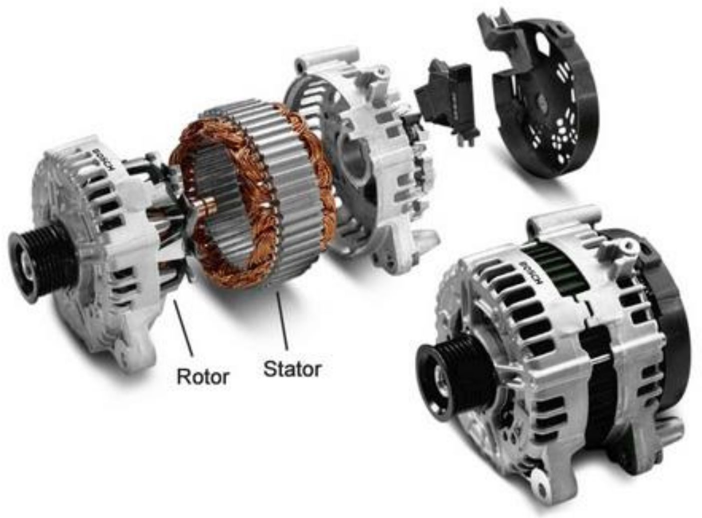


Fig 2. Alternator exploded view

The stator produces the electrical output of the alternator. The stator, which is part of the alternator frame when assembled, consists of three groups of windings or coils which produce three separate AC currents. This is known as three-phase output. One end of the windings is connected to the stator assembly and the other is connected to a rectifier assembly. The windings are wrapped around a soft laminated iron core that concentrates and strengthen the magnetic field around the stator windings. There are two types of stators Y -type stator and delta-type stator.

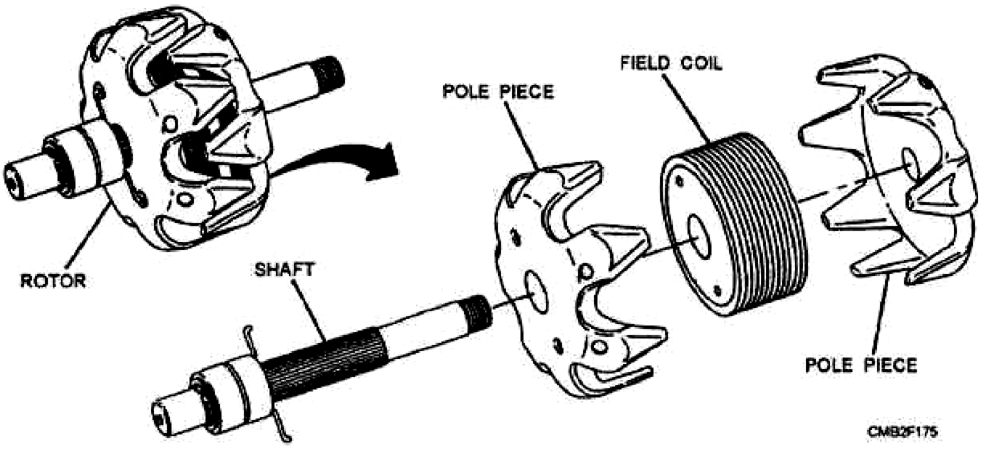


Fig 3. Rotor Assembly

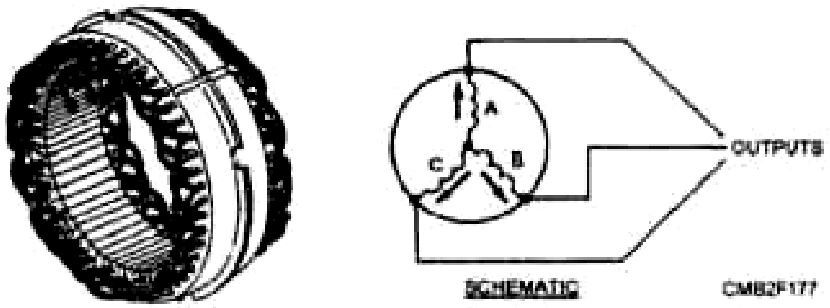


Fig 4. Stator Assembly

The rectifier assembly, also known as a diode assembly, consists of six diodes used to convert stator ac output into dc current. The current flowing from the winding is allowed to pass through an insulated diode. As the current reverses direction, it flows to ground through a grounded diode. The insulated and grounded diodes prevent the reversal of current from the rest of the charging system. By this switching action and the number of pulses created by motion between the windings of the stator and rotor, a fairly even flow of current is supplied to the battery terminal of the alternator. The rectifier diodes are mounted in a heat sink (metal mount for removing excess heat from electronic parts) or diode bridge. Three positive diodes are press-fit in an insulated frame. Three negative diodes are mounted into an uninsulated or grounded frame.

An alternator has a rotating magnet (rotor) which causes the magnetic lines of force to rotate with it. These lines of force are cut by the stationary (stator) windings in the alternator frame, as the rotor turns with the magnet rotating the N and S poles to keep changing positions. When S is up and N is down, current flows in one direction, but when N is up and S is down, current flows in the opposite direction. This is called alternating current as it changes direction twice for each complete revolution. If the rotor speed were increased to 50 revolutions per second, it would produce 50-cycle alternating current.

As the engine rotates the alternator pulley, the rotor spins past three stationary stator windings, or wire coils, surrounding a fixed iron core that makes up the stator. This is referred to as a three-phase current. The coil windings are evenly spaced at intervals of 120 degrees around the iron shaft. The alternating magnetic field from the rotor produces a subsequent alternating current in the stator. This AC current is fed through stator leads into a connecting set of diodes. Two diodes connect to each stator lead to regulate the current. The diodes are used to essentially block and direct the current. Since batteries need DC current, the diodes become a one-way valve that will only allow current to pass in the same direction.

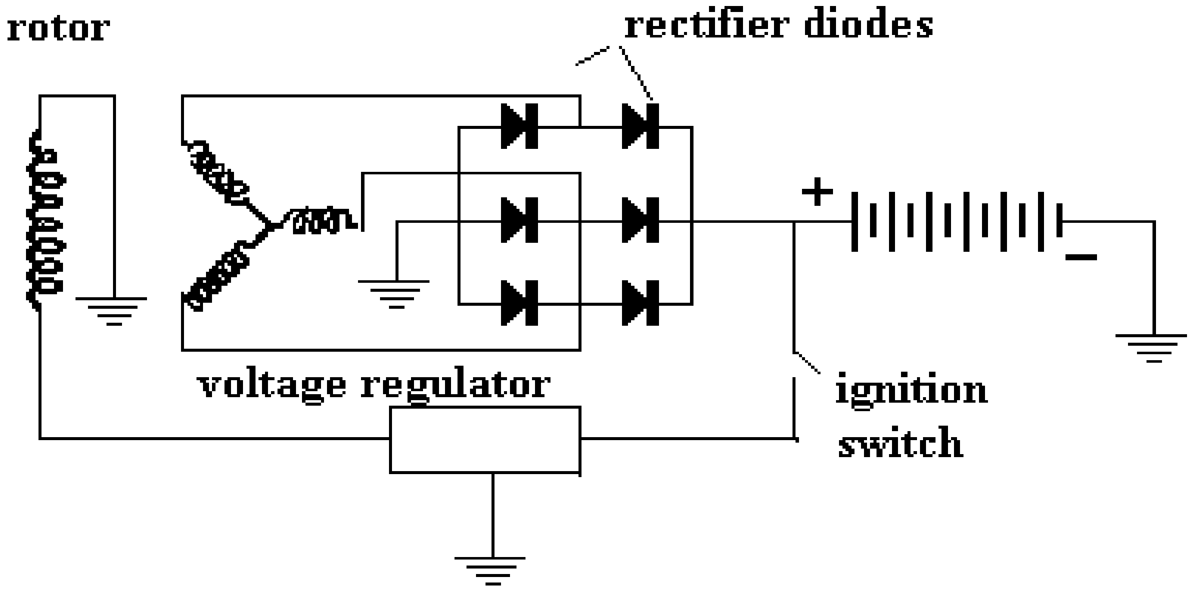


Fig 5. Basic electrical circuit of an alternator

Alternator Testing Procedure:

1. Mount the alternator on the V-block and align it with the motor pulley. Adjust the belt tension accordingly.
2. Connect the alternator cable to the test bench. Positive of the test bench to positive terminal of alternator. Negative of the test bench to the negative terminal of alternator. WL terminal to warning lamp terminal of alternator.
3. Switch ON the main supply MCB and ensure the power ondicator is ON. Ensure LED displays with zero.

Continuity Test:

1. Switch ON the continuity test switch.
2. Connect the test leads to appropriate voltage required as 40 V/80 V AC and 6 V DC.
3. Check the continuity by touching the test leads on the points where the continuity is to be seen and check whether the corresponding LED glows.

Power Mode

1. Select the toggle switch (Power/Battery) to power mode.
2. Select the toggle switch (14 V/28 V) to 14 V mode.
3. Select the toggle switch (STR/ALT) to ALT mode.
4. The warning lamp should glow.
5. Switch ON the 5 A/10 A load switch

Fig 6. Alternator Test Set-up

6. Push MOTOR ON (Green push button switch).
7. The warning lamp goes OFF and the voltmeter reads open circuit voltage of 14.0 - 14.5 V. The load ammeter reads 5 A.
8. Ammeter reads the battery charge current when battery MCB is switched ON (single pole MCB).
9. Increase the load by switching ON more load switches depending on the capacity of the alternator (Max. 40 A) and tabulate the observations.
10. Load up to full load capacity of the alternator and observe the voltage which should be 13.5 V at full load for a specific alternator.
11. If the voltage goes below the specified voltage then the alternator needs to be serviced.
12. Switch OFF all the load switches and switch OFF the motor.

Table 1. Voltage and load in power mode

S.No.	Load (Amp)	Voltmeter (V)
1.		
2.		
3.		
4.		

Battery Mode

Repeat the above steps 1to 3

13. Switch ON the BATT ON on single pole MCB and ensure the power AMP is ON.
14. Connect the 12 V battery to the terminals mentioned as battery.
15. Select the toggle switch (Power/Battery) to battery mode.

Repeat the above steps 5 to 15

Table 2. Voltage, load and charging current in battery mode

S.No.	Load (Amp)	Voltmeter (V)	Battery charging Amperes (A)
1.			
2.			
3.			
4.			
5.			

Note: Run alternator test for 15 minutes only

Results: Testing of alternator is done, load and current flow while charging is analyzed.

Experiment Title:

Drawing of General Electrical Wiring Diagram and Study of Electrical Circuits in an Automobile

Aim:

To draw general electrical wiring diagram and study of electrical circuits in an automobile.

Introduction:

The automotive electrical system contains five electrical circuits. These circuits are as follows.
1. Charging circuit
2. Starting circuit
3. Ignition circuit
4. Lighting circuit
5. Accessory circuit

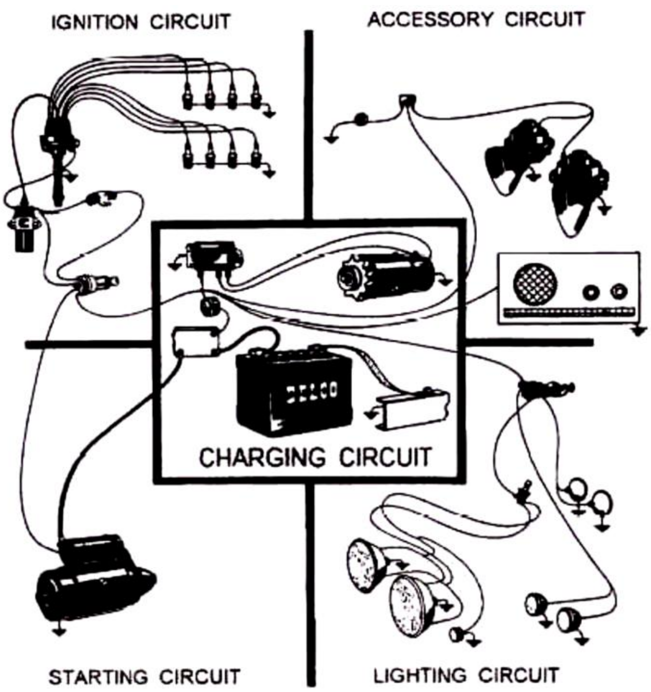


Fig. Automotive electrical circuits

1. Charging Circuit

The charging system performs several functions, which are as follows:

1. It recharges the battery after engine cranking or after the use of electrical accessories with the engine turned off.
2. It supplies all the electricity for the vehicle when the engine is running.
3. It must change output to meet different electrical loads.
4. It provides a voltage output that is slightly higher than battery voltage.

A typical charging circuit consists of the following:

Battery: Provides current to energize or excite the alternator and assists in stabilizing initial alternator output.

Alternator or Generator: Uses mechanical (engine) power to produce electricity.

Alternator Belt: Links the engine crankshaft pulley with alternator/ generator pulley to drive the alternator/ generator.

Voltage Regulator: Ammeter, voltmeter, or warning light to inform the operator of charging system condition.

2. Starting Circuit

1. The internal combustion engine is not capable of self-starting. Automotive engines (both spark-ignition and diesel) are cranked by a small but powerful electric motor. This motor is called a cranking motor, starting motor, or starter.
2. The battery sends current to the starter when the operator turns the ignition switch to start. This causes a pinion gear in the starter to mesh with the teeth of the ring gear, thereby rotating the engine crankshaft for starting.
3. The typical starting circuit consists of the battery, the starter motor and drive mechanism, the ignition switch, the starter relay or solenoid, a neutral safety switch (automatic transmissions), and the wiring to connect these components.

3. Ignition Circuit

The ignition circuit supplies high voltage surges (some as high as 50,000 volts in electronic ignition circuits) to the spark plugs in the engine cylinders. These surges produce electric sparks across the spark plug gaps. The heat from the spark ignites the compressed air-fuel mixture in the combustion chambers. When the engine is idling, the spark appears at the spark plug gap just as the piston nears top dead centre (TDC) on the compression stroke. When the engine is operating at higher speeds, the spark is advanced. It is moved ahead and occurs earlier in the compression stroke. This design gives the compressed mixture more time to bum and deliver its energy to the pistons.

The functions of an ignition circuit are as follows:

1. Provide a method of turning the ignition circuit ON and OFF.
2. Be capable of operating on various supply voltages (battery or alternator voltage).
3. Produce a high voltage arc at the spark plug electrodes to start combustion.
4. Distribute high voltage pulses to each spark plug in the correct sequence.
5. Time the spark so that it occurs as the piston nears TDC on the compression stroke.
6. Vary spark timing with engine speed, load, and other conditions.

4. Lighting Circuit

1. The lighting circuit includes the battery, vehicle frame, all the lights, and various switches that control their use. The lighting circuit is known as a single-wire system since it uses the vehicle frame for the return.
2. The complete lighting circuit of a vehicle can be broken down into individual circuits, each having one or more lights and switches. In each separate circuit, the lights are connected in parallel, and the controlling switch is in series between the group of lights and the battery.
3. The marker lights, for example, are connected in parallel and are controlled by a single switch. In some installations, one switch controls the connections to the battery, while a selector switch determines which of two circuits is energized. The headlights, with their high and low beams, are an example of this type of circuit.
4. In some instances, such as the courtesy lights, several switches may be connected in parallel so that any switch may be used to turn on the light.

5. Instruments, Gauges and Accessories

The instrument panel is placed so that the instruments and gauges can easily be read by the operator. They inform the operator of the vehicle speed, engine temperature, oil pressure, rate of charge or discharge of the battery, amount of fuel in the fuel tank, and distance travelled. Vehicle accessories, such as windshield wipers and horns, provide the operator with much needed safety devices.

Battery Condition Gauge:

The battery condition gauge is one of the most important gauges on the vehicle. The following are the three basic configurations of battery condition gauges- ammeter, voltmeter, and indicator lamp. The ammeter is used to indicate the amount of current flowing to and from the battery. The voltmeter provides a more accurate indication of the condition of the electrical system and is easier to interpret by the operator. The indicator lamp can be used in two different ways to indicate an electrical malfunction.

Temperature Gauge:

The temperature gauge is a very important indicator and the most common uses are to indicate engine coolant, transmission, differential oil, and hydraulic system temperature. Depending on the type of equipment, the gauge may be mechanical, electric, or a warning light.

Speedometer and Tachometers:

Speedometers are used to indicate vehicle speed in miles per hour (mph) or kilometres per hour (kph). In most cases, the speedometer also contains the odometer which keeps a record of the amount of mileage (in miles or kilometres depending on application) that a vehicle has accumulated. A tachometer is a device that is used to measure engine speed in revolutions per minute (rpm). Speedometers and tachometers may be driven either mechanically, electrically, or electronically.

Horn:

The horn currently used on automotive vehicles is the electric vibrating type. The electric vibrating horn system typically consists of a fuse, horn button switch, relay, horn assembly, and related wiring. Most horns have a diaphragm that vibrates by means of an electromagnetic. Tone and volume adjustments are made by loosening the adjusting locknut and turning the adjusting nut.

Windshield Wipers:

The windshield wiper system is one of the most important safety factors on any piece of equipment. A typical electric windshield wiper system consists of a switch, motor assembly, wiper linkage and arms, and wiper blades.

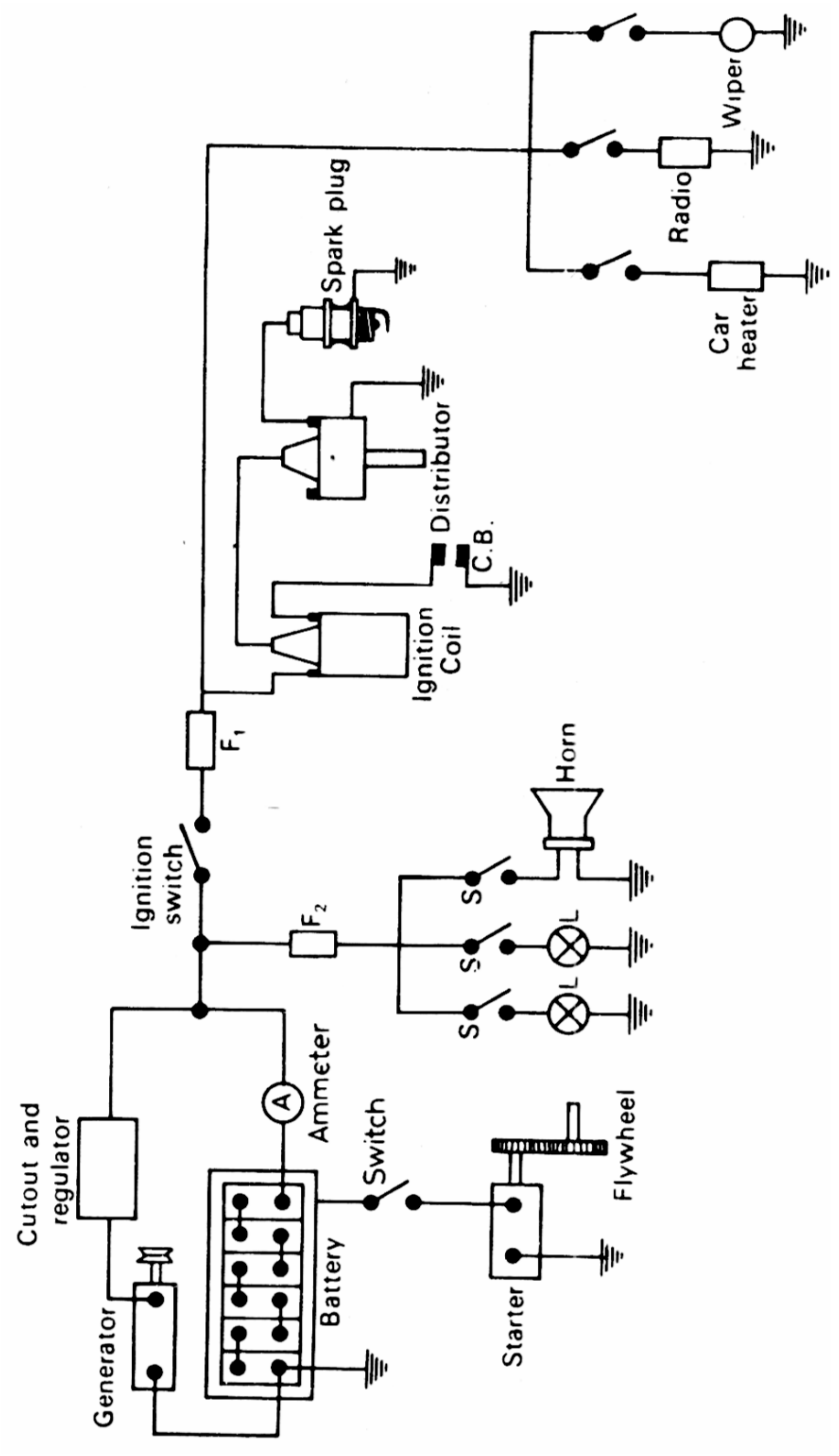
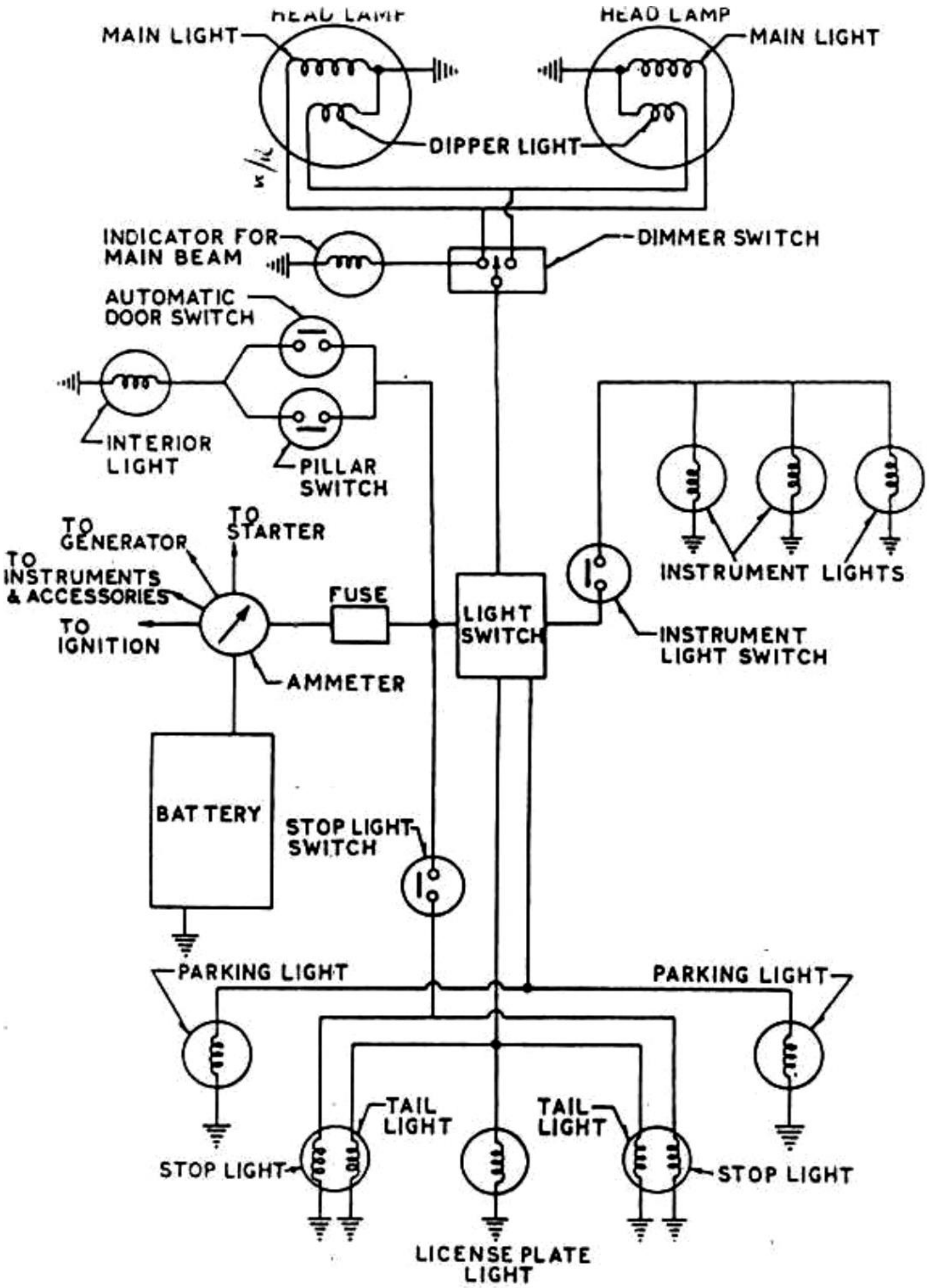


Fig. General electrical wiring diagram of an automobile



HEAD LAMP
HEAD LAMP
MAIN LIGHT
MAIN LIGHT
DIPPER LIGHT
INDICATOR FOR MAIN BEAM
DIMMER SWITCH
AUTOMATIC DOOR SWITCH
INTERIOR LIGHT
PILLAR SWITCH
INSTRUMENT LIGHTS
TO GENERATOR
TO STARTER
TO INSTRUMENTS & ACCESSORIES
TO IGNITION
FUSE
LIGHT SWITCH
INSTRUMENT LIGHT SWITCH
AMMETER
BATTERY
STOP LIGHT SWITCH
PARKING LIGHT
PARKING LIGHT
TAIL LIGHT
TAIL LIGHT
STOP LIGHT
STOP LIGHT
LICENSE PLATE LIGHT

Fig. Lighting and Accessories wiring circuit

Automotive Wiring

Electrical power and control signals must be delivered to electrical devices reliably and safely so that the electrical system functions are not impaired or converted to hazards. All vehicles are not wired in exactly the same manner; however, once you understand the circuit of one vehicle, should be able to trace an electrical circuit of any vehicle using wiring diagrams and colour codes.

One and Two-Wire Circuits: The branch circuits making up the individual systems have one wire to conduct electricity from the battery to the unit requiring it and ground connections at the battery and the unit to complete the circuit. These are called one-wire circuits or branches of a ground return system. In automotive electrical systems with branch circuits that lead to all parts of the equipment, the ground return system saves installation time and eliminates the need for an additional wiring to complete the circuit. The all-metal construction of the automotive equipment makes it possible to use this system.

The two-wire circuit requires two wires to complete the electrical circuit- one wire from the source of electrical energy to the unit it will operate, and another wire to complete the circuit from the unit back to the source of the electrical power. Two-wire circuits provide positive connection for light and electrical brakes on some trailers. The coupling between the trailer and the equipment, although made of metal and a conductor of electricity, has to be jointed to move freely. The rather loose joint or coupling does not provide the positive and continuous connection required to use a ground return system between two vehicles. The two -wire circuit is commonly used on equipment subject to frequent or heavy vibrations. Tracked equipment, off-road vehicles (tactical), and many types of construction equipment are wired in this manner

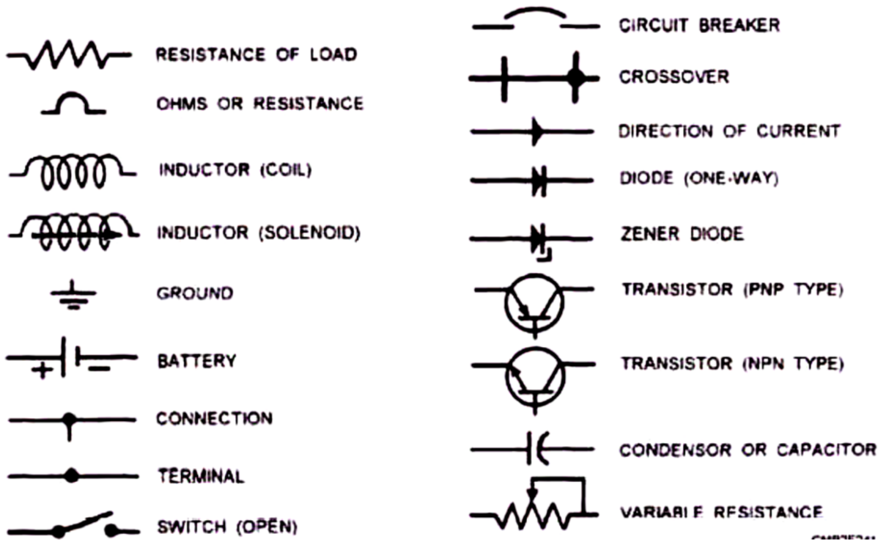


Fig. Wiring diagram symbols

Result:

The general electrical wiring diagram and electrical systems of an automobile is studied.

Experiment Title:
Study and Demonstration of Electronic Fuel Injection

Aim:

To study and demonstrate multi point fuel injection system with all sensors

Tools Required:

Battery, Fuel, MPFI Demo board

Theory:

The basic principle of fuel injection is that if petrol is supplied to an injector (electrically controlled valve), at a constant differential pressure, then the amount of fuel injected will be directly proportional to the injector open time. Most systems are now electronically controlled even if containing some mechanical metering components. This allows the operation of the injection system to be very closely matched to the requirements of the engine. This matching process is carried out during development on test beds and dynamometers, as well as development in the car. The ideal operating data for a large number of engine operating conditions are stored in a read only memory in the ECU. Close control of the fuel quantity injected allows the optimum setting for mixture strength when all operating factors are taken into account. Further advantages of electronic fuel injection control are that overrun cut off can easily be implemented, fuel can be cut at the engine's rpm limit and information on fuel used can be supplied to a trip computer. Fuel injection systems can be classified into two main categories:

a. Single Point Fuel injection
b. Multi Point Fuel Injection

Idle speed and fast idle are also generally controlled by the ECU and a suitable actuator. It is also possible to have a form of closed loop control with electronic fuel injection. This involves a lambda sensor to monitor exhaust gas oxygen content. This allows very accurate control of the mixture strength, as the oxygen content of the exhaust is proportional to the air–fuel ratio. The signal from the lambda sensor is used to adjust the injector open time.

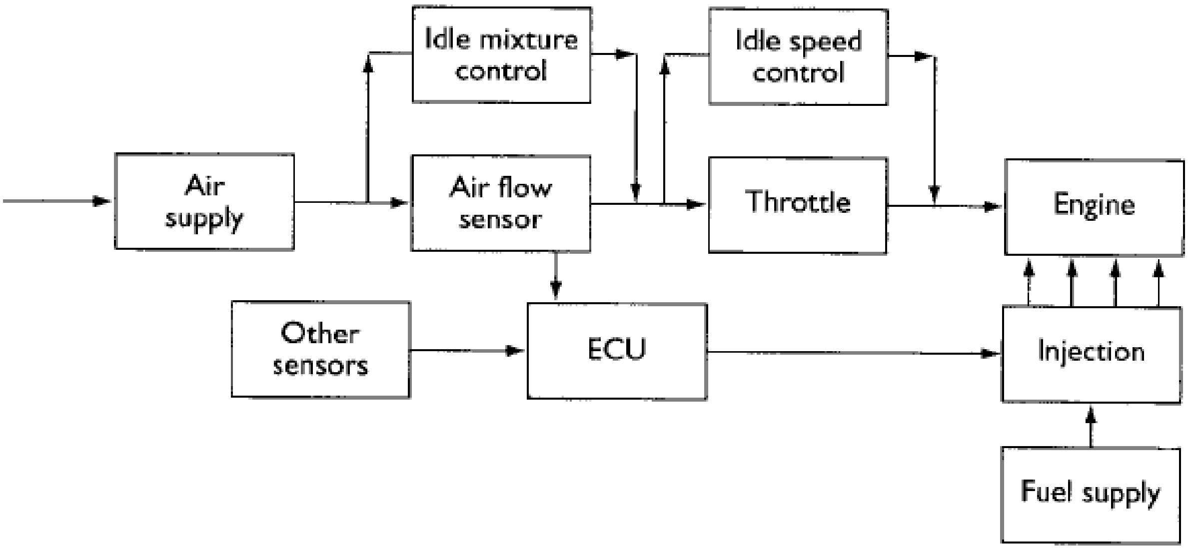


Figure 1. Typical control layout for a fuel injection system

Components of a fuel injection system:

1. Flap type air flow sensor
2. Engine speed sensor
3. Temperature sensor (thermistor)
4. Throttle position sensor
5. Lambda sensor
6. Idle or fast idle control actuator
7. Fuel injector(s)
8. Injector resistors
9. Fuel pump
10. Fuel pressure regulator
11. Cold start injector and thermo-time switch
12. Combination relay
13. Electronic control unit

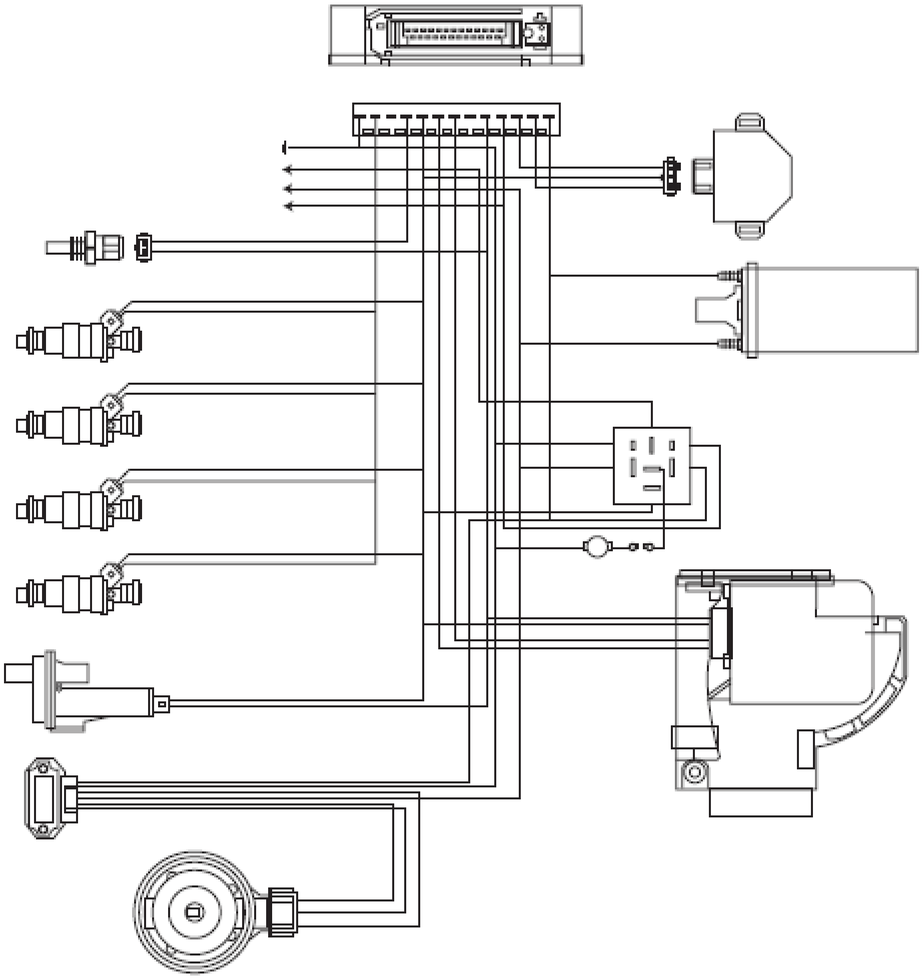


Figure 2. Wiring diagram for Bosch LE2 injection system

Injector timing on earlier systems (simultaneous injection): The ECU will switch on the injectors (by completing the earth circuit) at a predefined time in the engine operating cycle. On many earlier electronic injection systems (typically through until the early 1990s), the injectors were all opened at the same time (on four-cylinder engines), which is referred to as 'simultaneous injection'. With six-cylinder engines the injectors were generally operated in two groups of three injectors; with eight-cylinder engines the injectors were operated in two groups of four; and with 12-cylinder engines there were four groups of three injectors. All of the injectors in a group would open and close at the same time.

Injector timing on later systems (sequential injection): With modern systems the injectors are usually opened individually in sequence (to match the engine firing order); this is known as sequential injection. The injectors are typically opened just prior to the inlet valve opening. All the required fuel is therefore delivered in one 'opening' of the injector. However, there are occasions where a very large quantity of fuel is required, for example during full load acceleration, where the injectors can be opened twice for every operating cycle (half the fuel quantity is delivered at each opening).

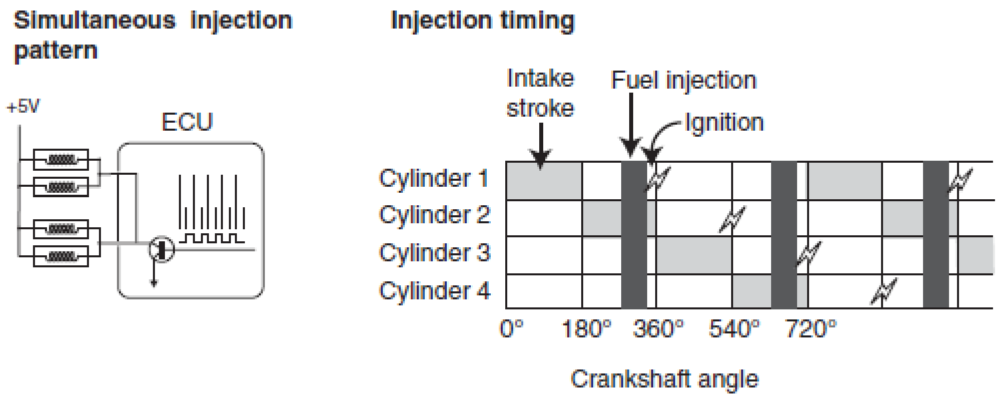


Figure 3. Simultaneous injection

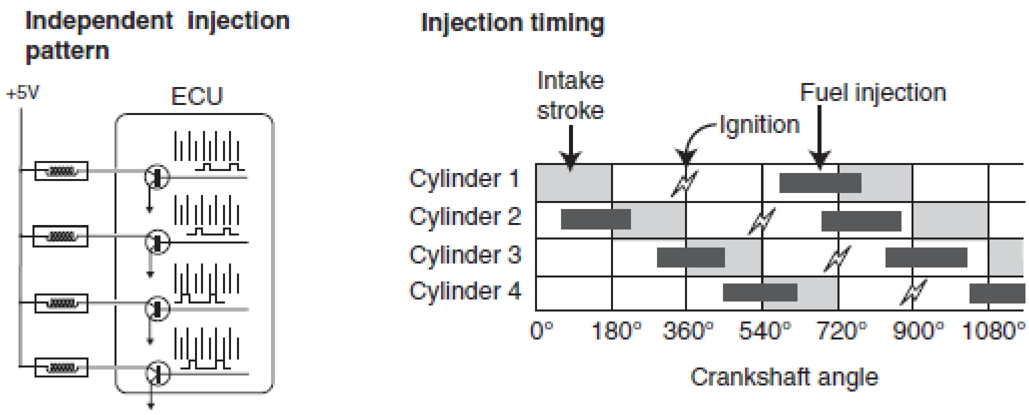


Figure 4. Sequential Injection

Result: Multi-point fuel injection system is understood and demonstrated

Experiment Title:

Pressure measurement using pressure transducer and interfacing it with DAC

Aim:

To measure the pressure using pressure transducer

Apparatus:

Pressure pump, pressure tank, pressure gauges, multimeter, DAC and pressure transducer trainer kit

Theory:

Pressure is defined as the force acting per unit area, measured at a given point or over a surface. This can be in absolute, gauge, or differential units, depending upon the reference taken. The measurement involved can be of a static or dynamic nature

Pressure Transducers: Diaphragms, Bourdon Tube, Bellows, Transduction Methods- Potentiometric Device, Solid - State Devices.

Solid - State Devices: Recent advances in microelectronic circuit technology have been successfully applied for the development of solid-state transducers, especially for pressure measurements. There are two varieties in this category.

1. The first is based on the piezojunction effect. The piezojunction effect, i.e. the variation in the sensitivity of the V - I (Volt - ampere) characteristics of a p - n junction to stress.
2. The piezoresistive - type tranducer consists of a monocrystalline silicon diaphragm with four piezoresistive strain gauges formed integrally in a wheatstone bridge configuration diffused on it to measure the stresses developed due to the applied pressure. The salient features of this device are :

   (a) the mechanical properties of the monocrystalline silicon show low hysteresis and high repeatability

(b) piezoresistive semiconductor gauges formed on the silicon diaphragm exhibit much higher sensitivity compared with conventional bonded or unbonded wire gauges mounted on metal diaphragms

(c) piezoresistive gauges diffused directly onto the diaphragm surface are not likely to suffer from the creep and hysteresis effects inherent in bonded strain gauges

(d) miniaturization of the transducer is easy without any sacrifice in performance and

(e) they exhibit excellent thermal characteristics. The other type of solid-state pressure transducer employs

Specifications	**Typical**	**Maximum**
Input Pressure range	0-30 psi	0-60 psi
Supply voltage	5 Volt DC	6 Volt DC
Sensitivity	3 mV / psi	
Full scale span	90 mV	
Output	pin 2 (+) and pin 4 (-)	pin 1 (+) and pin 3 (-)

Procedure:

1. Make power on to the unit.
2. Adjust zero on digital panel meter (DPM) for zero input pressure using Zero Adjust.
3. Slowly increase the input air pressure upto 30 psi, as read on dial pressure gauge. Set the Gain adjust to read 30.0 psi on DPM.
4. Now slowly change the input air pressure drom 0 to 30 psi in proper steps and note DPM reading.

5. Note the output voltage using external digital voltmeter.
6. Tabulate the result
7. Plot the graph of input pressure against output voltage

Tabulate results

S.No	Input pressure (Dial gauge reading) (psi)	DPM reading	Output Voltage (Volt)

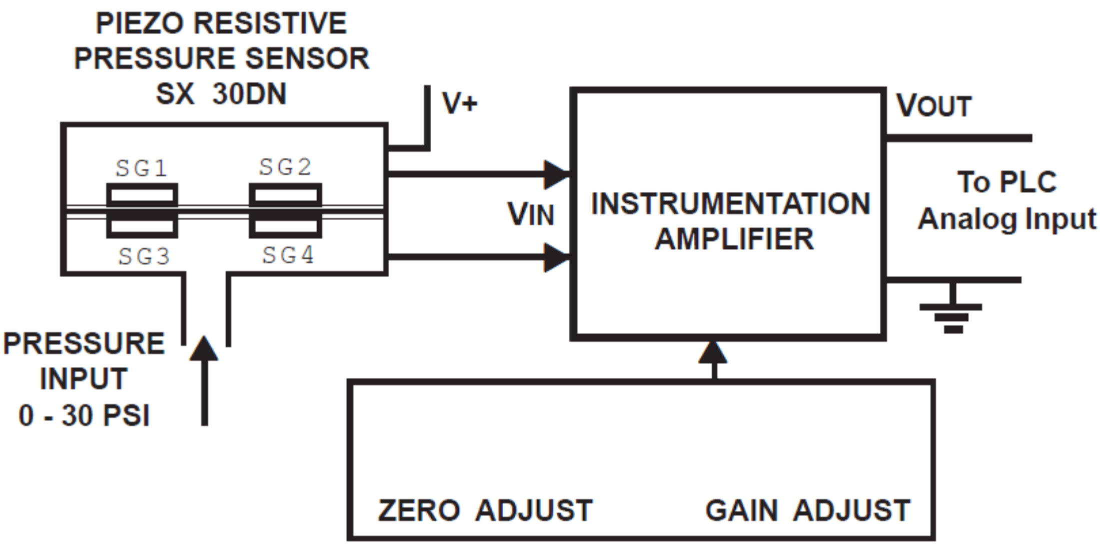


Figure.1 Pressure transducer

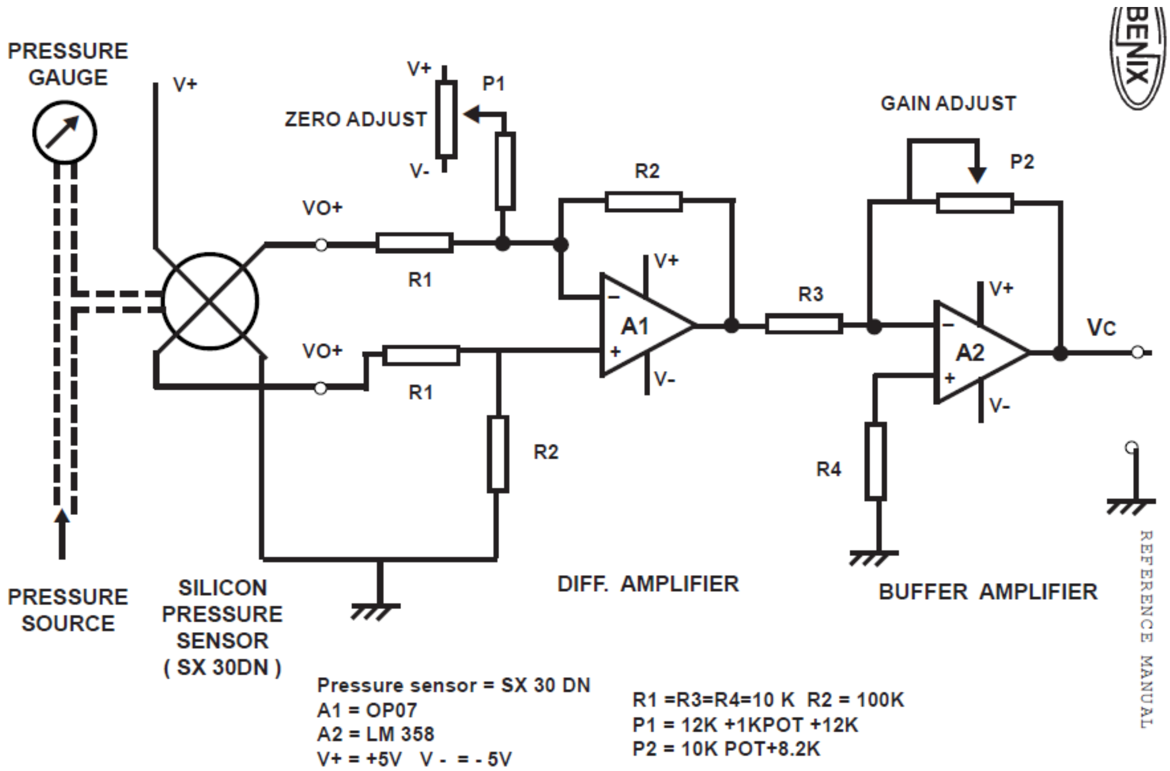


Figure.2 Pressure measurement trainer kit

Results: Pressure measurement is completed using pressure transducer, results and graphs are plotted

Experiment Title:

Temperature measurement using RTD and interfacing with DAS

Aim: Measurement of temperature using RTD and interfacing the available data with data acquisition system.

Apparatus: RTD sensor, RTD trainer, DAS, patch cords and computer

Theory: Metallic materials are basically structured molecules having free electrons. These free electrons in metal gives rise to conductivity to metals. When heated these free electrons collide with each other & lattice structure creating resistance to free motion of electrons & hence resistance of metal increases with increase in temp.

The range of temp over which this phenomenon occurs depends on temp coefficient of resistance, chemical inertness & its crystal structure. In general the resistivity of material increases with increase in temp (positive coefficient of temp). Where as in other type of material (some conducting materials) resistance decrease with increase in temp.

Temeperature measurement using resistance thermometry is most accurate having good repeatability & hence reliable. We can achive an accuracy of 0.0001k. Whereas at high temp accuracy is about 0.01K & In the range of 1200 K accuracy is 0.1K. Major disadvantage is its large size requirement of sophisticated instrumentation. Within small range of temp, temp-coefficient is constant & resistance at temp. 'T 'is given by

$$R_t = R_o\,[1 + \alpha\,(T - T_o)]$$

$$= R_o\,(1 + \alpha\, t)$$

Where R_o = Resistance at temp T_o

α = Temp coefficient of material

t = Temp differance $(T - T_o)$

$$\text{Temp. Coefficient}, \quad \alpha = \frac{R2 - R1}{R1\,T2 - R2\,T1}$$

Where R1 & R2 are resistance at temp. T1 & T2 respectively, depends on material, its purity & heat treatment.

Among the base material, copper has highest temp. Coefficient & good linearity & its resistivity is low & hence rarely used for this purpose .Temp. Sensors made from Nickel are good for temp range 1000 to 4500 K. Platinum resistance element is the best element as it gives very good accuracy and reproducibility. It is used as international standard for temp. measurement.

Calibration:

1. Make power on to the unit.
2. Connect 100 ohm resistance at point A (Junction of resistance R1 and R2).
3. Adjust zero adjust potmeter to read 0 on DPM.
4. Connect 138.5 ohm resistance at point A (Junction of resistance R1 and R2).
5. Adjust gain adjust pot meter to read 100 on DPM.
6. Repeat step 2 to 5 till we get optimum settings of zero adjust and gain adjust potmeter.

Measurement of temperature using RTD:

1. Plug in RTD pin ,in RTD socket.
2. Connect RTD at point A (Junction of resistance R1 and R2).
3. Put the RTD sensor & mercury themometer in water bath.
4. Connect water heater power cord (A.C.mains power for heater) to the output socket of control realy circult . (provided on right side of the trainer unit.)
5. Fill the water bath 3/4th by water (Water must be above heater coil).
6. Make power on to the unit.
7. Place TEMP / SP selector swith on set point position (S P)and adjust set point to 400 C by adjusting set point potmeter.
8. Change the selector switch to TEMP position.
9. Note the temp.of mercury thermometer and that read by DPM.
10. Also note the output voltage at the output of opamp A2 (Vout). (Set point must be above the actual temp. of water to observe control action.)
11. Tabulate the result.

S. No.	Temperature (^{0}C)	DPM Reading	Vout (Volt)

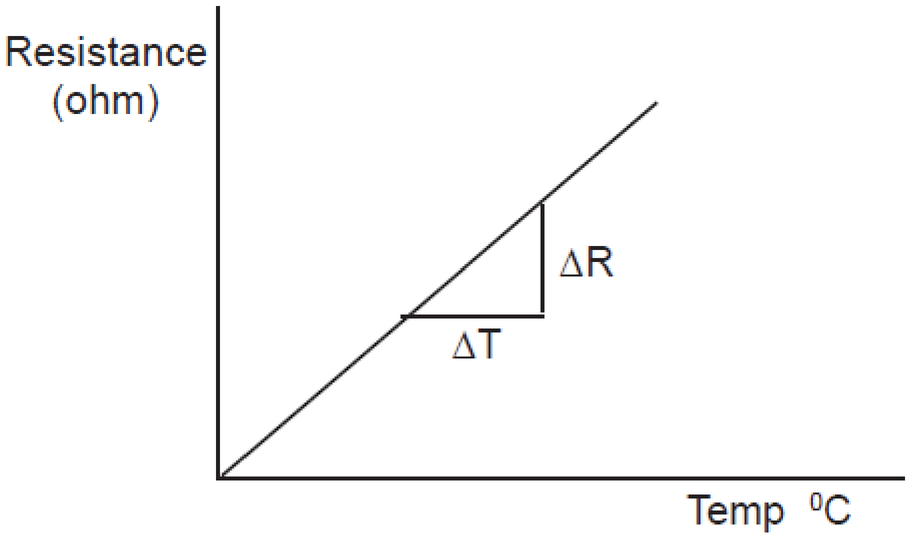
Note that heater supply remains on till temp. of water is lower than the set point temp. The moment water temp . crosses the set point (higher side) heater supply is switched OFF.

Resistance Measurement of RTD:

1. Put the RTD and thermometer in water bath.
2. Make water heater ON.

3. Note the temp. of water bath by mercury thermometer and resistance of RTD between upper tip and middle contact of jack pin of RTD.
4. Measure resistance at different temperature at an interval of 50 C and tabulate the result.
5. Plot the graph of temperature against resistance of RTD.

S.No.	Temperature	Resistance



Results: Temperature is found out using RTD and obtained data is interfaced with computer using DAS.

Experiment Title:

Temperature measurement using Thermistor and interfacing with DAS

Aim: Measurement of temperature using Thermistor and interfacing the available data with data acquisition system.

Apparatus: Thermistor sensor, Thermistor trainer, DAS, patch cords and computer

Theory: Thermistors are essentially semiconductor devices which behave as thermal resistors having a high negative temperature coefficient of resistance. The sensors are made of sintered ceramics, usually from mixtures of oxides of iron, manganese, nickel, cobalt, and copper in the form of beads or discs. The resistance value at the ambient temperature may range from 100 ohms to 100 Kohms. The variation of resistance with temperature is non - linear, decreasing with temperature. Being a semiconductor device, each probe will have its own characteristic temperature coefficient and as such requires calibration. However, there are selected types available with very close tolerances and probe assemblies that are directly interchangeable. The usable range for measurement is normally between 170 to 570 K.
The resistance RT of a thermistor at a temperature (T) can be expressed by the equation

$$R_T = a \,.\, e^{b/t}$$

Where a and b are constants determined by the structure material, the variation in resistance with respect to temperature for temperatures T1 and T2.

$$R_{T1} = R_{T2}\, e^{b(1/T1 - 1/T2)}$$

Where R_{T1} and R_{T2} are resistances measured at temperatures T_1 and T_2 respectively.
If T2 , b and RT2 are known , T1 can be computed from the measured value of RT1. By differentiating Eqn, the expression for the temperature coefficient can be written as

$$\alpha = \frac{1}{R_T}\,\frac{dR}{dT} = -\frac{b}{T^2}$$

The resistance temperature behavior is usually specified by the ratio of the resistance at 0 0 C to the resistance at 50 0 C. As temperature sensors, thermistors normally operate as externally heated devices, wherein the changes in ambient or contact temperatures can be directly converted to corresponding changes in voltage or current. They are well - suited for precision temperature measurement, temperature control, and temperature compensation, because of their very large change in resistance with temperature. The resolution obtainable is higher than that of other types of temperature transducers. They are widely used for measurements in the range 170 to 470 K. A typical 2000 - ohm thermistor with a temperature coefficient of 4 %/ oC at 25 0 C will exhibit a change of 80 ohms / 0C change in temperature, as compared to only 70ohm / 0 C of a platinum resistance sensor with the same basic resistance . Because of its smaller size, the device is ideally suited for measuring temperature distributions or gradients. The measurement of the change in resistance is carried out with a standard Wheatstone bridge network.

Temperature Measurement using Thermistor:

Calibration:

1. Connect thermistor probe at input of signal conditioner circuit.
2. Connect Vout socket of thermistor circuit to TEMP socket of controller.
3. Make power on to the unit.
4. Put thermistor probe & thermometer (0 - 100 0) in water at lowest possible temperature say 15 0 C temp.
5. Adjust zero adjust pot to read DPM 15 0 C temp.
6. Take water at higher temperature say 400 C and put thermistor probe and thermometer in water.
7. Adjust gain adjust pot to read DPM 40 0 c.
8. Repeat steps 3 and 4 till to get optimum setting of zero adjust & Gain adjust potmeter.

Temperature Measurement:

1. Put thermometer & thermistor probe in water bath.
2. Take water at 0 0 C temperature or as minimum as possible (say 10 0C)
3. Connect thermistor sensor at input socket (for Thermistor) provided panel.
4. Connect Vout socket of thermistor circuit to TEMP socket of controller.
5. Make power on to the unit.
6. Connect water heater power cord (A.C.mains power for heater) to the output socket of control relay circuit. (Provided on right side of the trainer unit.)
7. Place TEMP / SP selector switch on set point position (SP) and adjust set point to 400 C by adjusting set point potmeter. (Set point must be set above the actual temp. of water to observe control action.)
8. Change the selector switch to TEMP position (to read temperature).

9. As the temp of water increases, note the thermometer reading & DPM reading at proper intervals.
10. Note that heater supply remains on till temp. of water is lower than the set point temp. The moment water temp. Crosses the set point (higher side) heater supply is switched OFF. (Heater supply is indicated by LED on the panel)

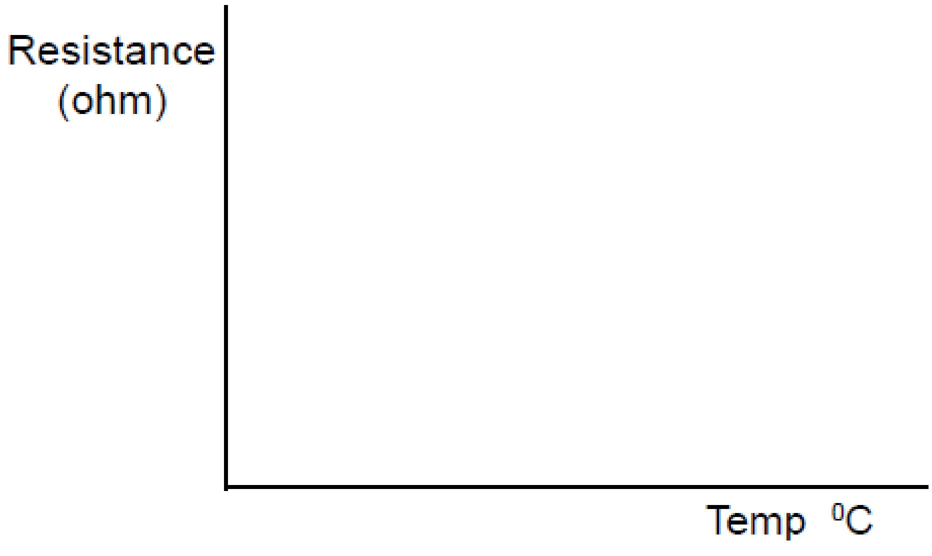
S.No.	Thermometer Reading (^{0}C)	DPM Reading (Volt)

Resistance Vs Temp Characteristics of thermistor:

a. Put thermometer & thermistor probe in water bath.
b. Take water at 0 ºC temperature or as minimum as possible (say 10 ◦C)
c. Measure the resistance of Thermistor using Digital Multimeter at upper tips of thermistor probe.
d. Make water heater on from mains supply.
e. Do not make power on to the unit.
f. As the temp of water increases, note the thermometer reading & corresponding resistance of thermistor at proper intervals. Tabulate the result.

S.No.	Thermometer Temp (^{0}C)	Resistance of thermistor (ohm)

Plot the graph of temperature against resistance of Thermistor.



Results: Temperature is found out using thermistor and obtained data is interfaced with computer using DAS.

Experiment Title:

Strain Measurement with load cell and interfacing with DAS

Aim: Measurement of load and interfacing the available data with data acquisition system.

Apparatus: Strain gauge trainer, DAS, patch cords and computer

Theory: The load cell is an electromechanical sensor employed to measure static and dynamic forces. The device can be designed to handle a wide range of operating forces with high level of reliability, and hence it is one of the most popular transducer in industrial measurements. The load cell derives its output from the deformation of an elastic member having high tensile strength. The elastic member is made of homogeneous materials, preferably steel alloys, manufactured to very close tolerances. The basic design parameters include size and shape, material density and modulus of elasticity, strain sensitivity, deflection, and dynamic response.

Cantilever beam:

A convenient configuration that is in wide use, particularly for loads up to 10 Kg is the cantilever beam, the arrangement of which is illustrated in fig. On the application of a force F at the end of the cantilever, a bending moment proportional to the force is developed in the beam. Strain gauges are attached to the top and bottom surfaces of the beam near the fixed end to sense the stresses so developed. With the direction of force as shown, tensile strains developed on the top surface are sensed by gauges R1& R3 while compressive strains are developed at the bottom surface are sensed by gauges R2 & R4. The maximum deflection due to load will occur at the free end of the beam, while maximum strain will developed at the fixed end. Thus, either the deflection δ or strain ε can be measured as a function of the applied force F. The relationship, for these quantities can be expressed as

$$\varepsilon = \frac{6 F l}{E b t^2} \quad (\text{at the fixed end})$$

$$\delta = \frac{4 F l^3}{E b t^3} \quad (\text{at the free end})$$

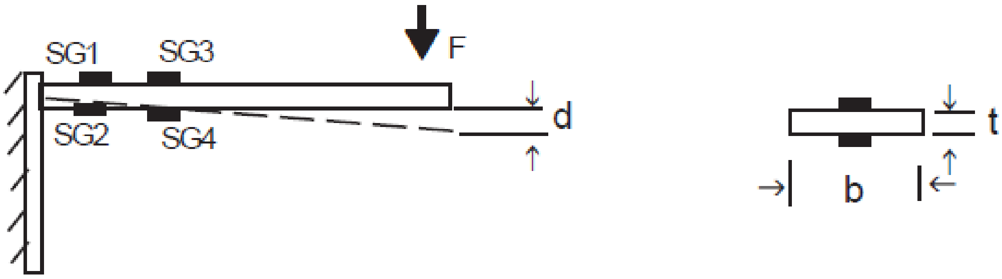


Fig : Cantilever Beam Type Load Cell

Experimental setup:

1. Cantilever beam with four strain gauges is mounted on stand i.e. its one end is firmly pivoted at base and another end is free.
2. Pan is hanged at free end of Cantilever beam.
   Supply voltage: +/- 5.0 volt
   Typical Load: 2 Kg
   Maximum Load: 50 % extra of optimum load
   Output voltage: 0.5 mV /Kg
3. Strain gauges of Cantilever beam is to be connected to control and display unit using eight pin connector cord.
4. Control and display unit.
   + /- 5.0 volt stabilised power supply is connected to Wheatstone bridge at Point A an B of bridge.
   Zero adjust (Ten turn) potentiometer is connected to bridge as shown in figure to Adjust tare weight. (Output voltage is to be adjusted zero for no weight in pan)
   Output of the bridge from point C and D (Vo1 and Vo2) acts as an input to Instrumentation amplifier (Internally connected).
5. Gain adjust potmeter of instrumentation amplifier is to be used for adjusting the required output voltage for given load.

   Procedure:

   A) FULL BRIDGE:

   - Wheatstone bridge is to be configure using strain gauge SG1 and SG2 & SG3 and SG4 as shown in figure.(Make connections using patch cord) (SG1, SG3 is in tension and SG2 & SG4 is in compression.)

- The output voltage of the bridge is internally connected to the operational amplifier OP07 in differential mode.
- The output of the OP07 is amplified and conditioned properly using opamp 741. The final output is displayed on digital milli voltmeter

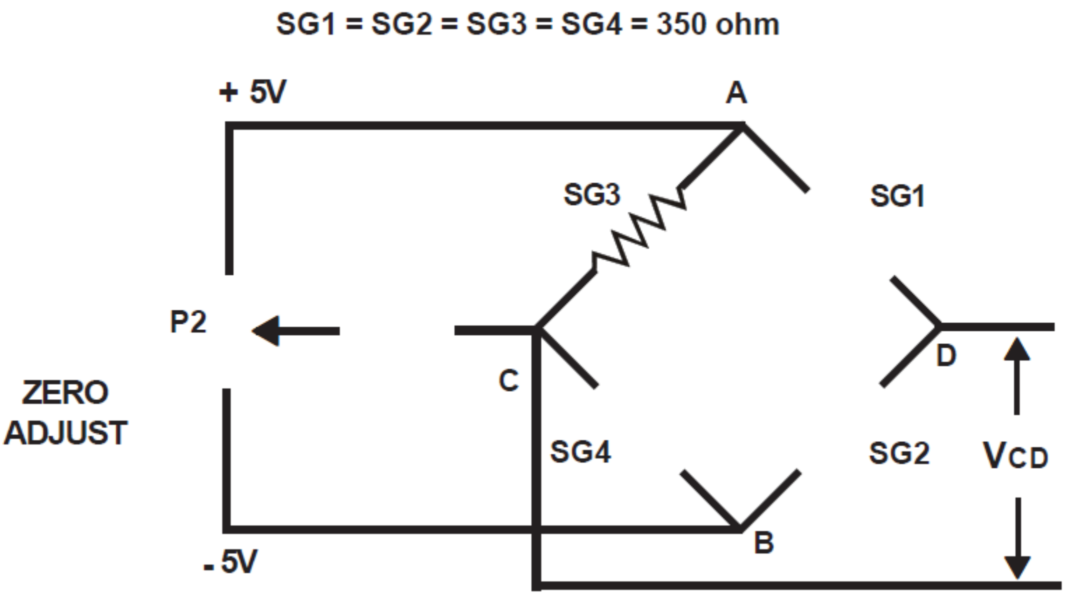
1. Connect the 8-pin (sensor) connector cord to the control and display unit at 8 pin socket.
2. Make power on to the unit. Wait for some time to stabilise the system.

Calibration:

3. Do not keep any weight in pan and and let it become stable. Adjust zero adjust pometer to get zero output voltage as displayed on digital panel meter (DPM).
4. Put 1.0 Kg weight on pan and adjust gain adjust potmeter to get 20 µstrain on DPM. Take out all dead weight and check for zero on display. If it is changed adjust again zero adjust potmeter to get it zero.

Measurement:

5. Put the dead weight in steps of say 0.2Kg (upto 2.0 Kg) and every time note th output. Tabulate the result.
6. Now take out weights in steps of 0.2 Kg and note the reading every time. Tabulate the result.



DC Wheat Stone Bridge

Calculation of strain at fixed end in cantilever beam:

$$\text{Strain} = \frac{6 \times F \times L}{E \times b \times t^2}$$

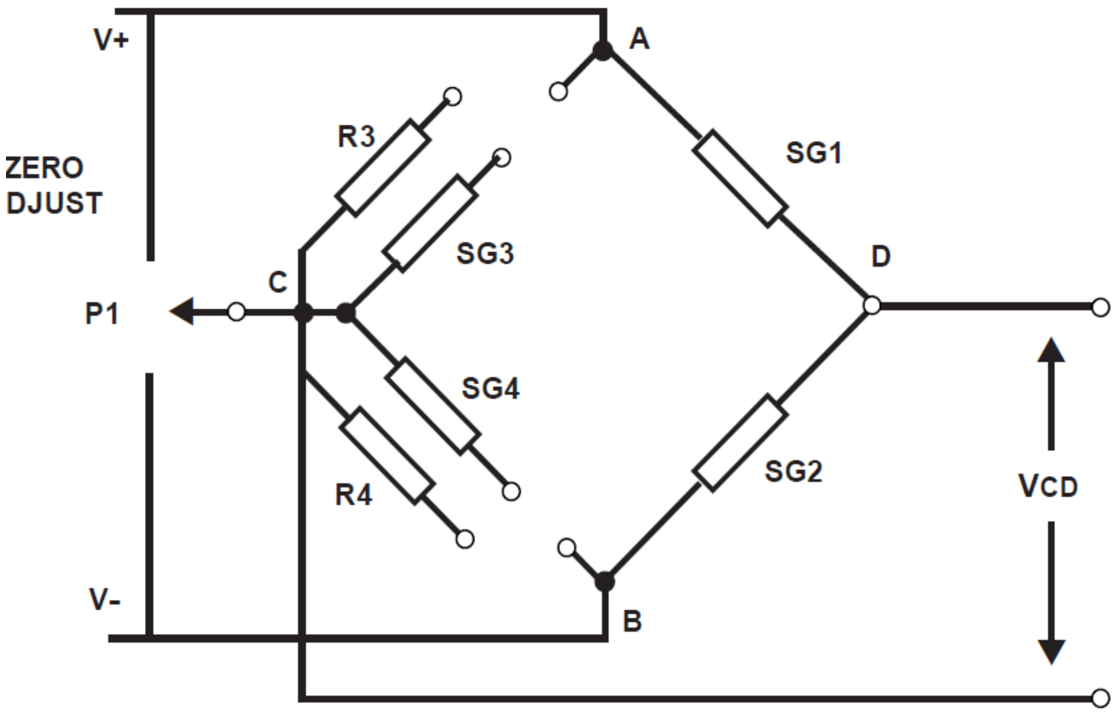
where Length L = 12.8 cm
Breadth b = 2.8cm
Thickness t = 2.2 cm
Moduliu of elasticity E = 2.8 X 10^5 Kg/cm2
Force F = Applied force.

For example , for force of 1 Kg strain = $\frac{6 \times 1 \times 12.8}{1.3 \times 10^6 \times 2.8 \times (2.2)^2}$ microstrain

= 20 microstarin

Observation Table :

S.No.	F (Kg)	Strain (calculated)	Output Voltage	DPM Reading



DC Wheatstone Bridge

Results: Strain is calculated using load cell and obtained data is interfaced with computer using DAS

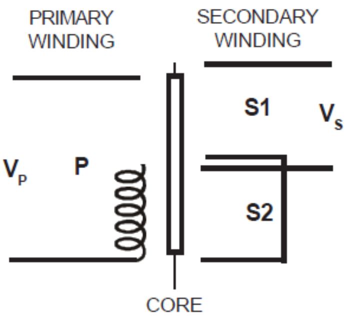
Experiment Title:
Displacement Measurement Using LVDT and Interfacing with DAS

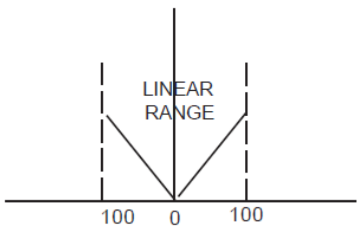
Theory: Displacement is the vector representing a change in position of a body or a point with respect to a reference. It may be linear or rotational motion, expressed in absolute or relative terms. Many of the modern scientific and industrial observations need a very accurate measurement of this parameter. Being a fundamental quantity, the basic sensing device is widely adapted with suitable linkages for the measurement of many derived quantities, such as force, stress, pressure, velocity, and acceleration. The magnitude of measurement ranges from a few microns to a few centimetres in the case of linear displacement and a few seconds to 3600 in the case of angular displacement. A majority of displacement transducers sense the static or dynamic displacement by means of a sensing shaft or similar links mechanically coupled to the point or body whose motion is to be measured. Such attachment of both linear and angular transducers are usually of simple mechanical configurations, but the coupling must be primarily designed to avoid any slippage after it is fastened and thereby keep the back-lash minimum. For linear displacement measurements. The common types employed are the threaded clevis, and bearing couplings.

Linear variable differential transformer (lvdt): Linear variable differential transformer type of transducers find a number of applications in both measurement and control system. The extremely fine resolution, high accuracy, and good stability make the device particularly suitable as a short-stroke, position-measuring device .Since a number of physical quantities, such as pressure, load, and acceleration can be measured in terms of mechanical deflection, LVDT forms the basic sensing element in all such measurement .The LVDT device is widely used as the basic element in extensometers, electronic comparators, thickness-measuring units, and level indicators. Some of the other important applications are in numerically controlled machines and creep-testing machines.

Construction & Working:-

The basic construction of the differential transformer, is as shown in figure.





The linear variable differential transformer consists of a primary coil & two identical secondary coils, axially-spaced and wound on a cylindrical-coil former, with a rod shaped magnetic core positioned centrally inside the coil assembly providing a preferred path for the magnetic flux linking the coils. The displacement to be measured is transferred to the magnetic core through suitable linkages. When the primary coil is energized with an ACcarrier wave signal, voltages are induced in each secondary section, the exact value depending upon the position of the magnetic core with respect to the centre of the coil assembly. If the core is symmetrically placed (Electrically) with respect to the two secondary coil equal voltages are induced in the two coils. When these two output are connected in phase opposition, the magnitude of the resultant voltage tends to a zero value. Such a balance point is termed 'the null position'. In practice, a small residual voltage is always present at a null position due to the presence of the harmonics in the excitation signal and stray capacitance coupling between the primary and secondary winding.

When the core is now displaced from the null position the induced voltage in the secondary towards which the core has moved increases while that in other secondary decreases. This results in a differential voltage output from the transformer. The signal output eo in relation to the other characteristics of the coil is given by,

$$e_o = \frac{16.\pi^3 .\ f.\ Ip.np.ns}{10^9\ \ln(ro/ri)} \quad \frac{2bx}{3w}\left(1 - x^2/2b^2\right)$$

Where
f = excitation signal frequency,
ip = primary current,
np = number of turns in primary,

ns = number of turns in secondary,
ns = width of primary coil,
b = width of primary coil,
w = width of the secondary coil,
x = core displacement,
ro = outer radius of the coil, and
ri = inner radius of the coil

With proper design of coils, the magnitude of the output signal is made to vary linearly with mechanical displacement of the core on both sides with respect to the null position. While the magnitude of the output voltages are ideally the same for the equal core displacements on either side of the null, the phase difference between the output and input voltages changes by 1800 when the core moves through the null position. In actual measurement, this phase changeover is measured with a phase-sensitive detector.

The sensitivity is proportional to the frequency f and the primary current Ip, and for best linearity $x < b$. However, larger Ip produces core saturation and an increase in the temperature of the coil, & hence results in larger harmonics at null position, making adjustment difficult. An increase in frequency produces a greater effect of the stray capacitance, and in turn a large null voltage. In practice, the design is optimized for the lowest null voltage, highest linearity, and appropriate size.

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The Advantages of the LVDT type of displacement transducer-

(|) Mechanical-

1. Simplicity of design & ease of fabrication and installation.
2. Wide range of displacement.
3. Frictionless movement of core and hence infinite resolution.
4. Rugged construction.
5. Negligible operating force.
6. Ability to operate even at higher temperatures.

(||) Electrical-

1. Output voltage is a linear and continous function of mechanical displacement.
2. High sensitivity.
3. Low output impedance.
4. Ablity to operate over a wide range of carrier frequencies, infinite resolution in output and very low cross sensitivity.

PROCEDURE:

Switch on power to the unit.

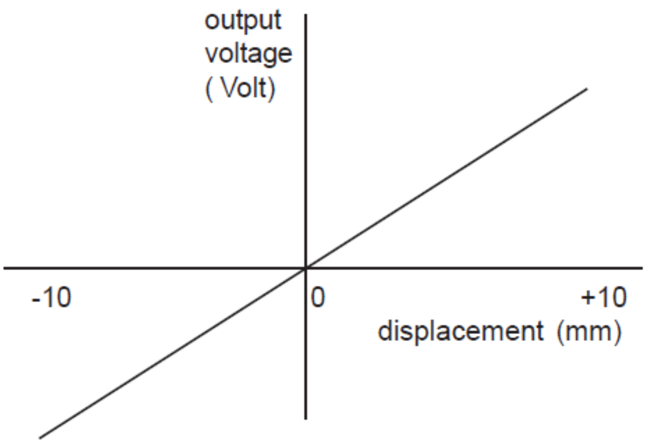
1. Connect LVDT coil to the signal conditioning circuit as under.
2. Connect P1& P2 of coil at AC excitation points P1 &P2 (points A1& A2 of coil are internally shorted.)
3. Connect B1 & B2 of coil to B1 & B2 points of signal conditioning circuit.
4. Set core for Null position
5. Move core from Null to extreme left and observe the displacement.
6. Bring core back to Null position & move from null to extreme right & observe the displacement
7. Adjust Zero adjust pot for zero reading on DPM for null position of core.
8. Set core form 10 mm position (left) and adjust gain adjust pot for -10.0 reading on DPM.
9. Move the core in proper steps to either right or left & Note the DPM reading.

Tabulate the results.

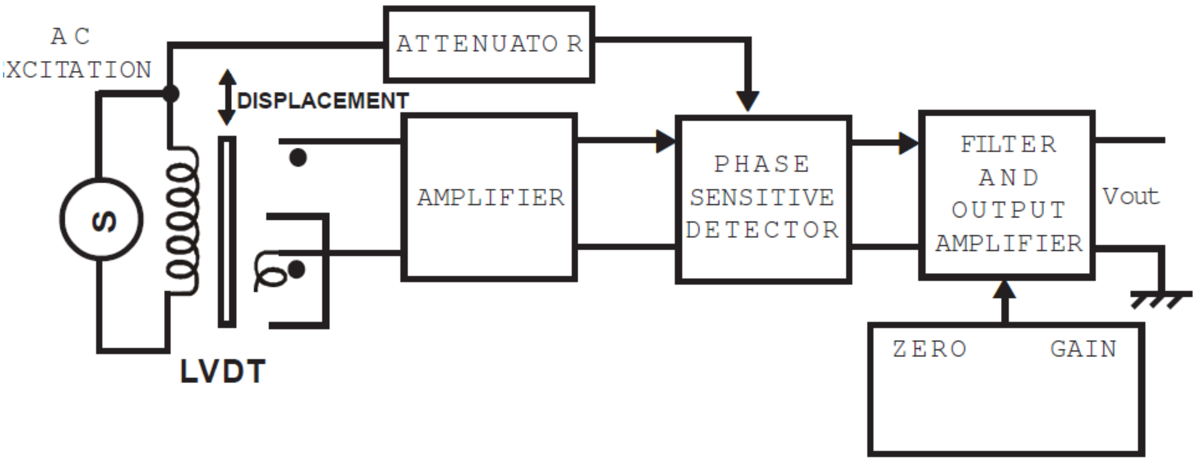
S.No.	Core Displacement (mm)	Output Voltage (Volt)
1	-10	
2	-8	
3	-6	
4	-4	
5	-2	
6	0	
7	+2	
8	+4	
9	+6	
10	+8	
11	+10	

Plot the graph of output voltage against core displacement.

From the graph note the Linear range of LVDT.



Circuit Diagram



Results: Displacement is measured using LVDT.

AUTOMOTIVE CHASSIS LABORATORY MANUAL

(19PC2AE01)

LIST OF EXPERIMENTS

1. Dismantling, inspection and assembling of clutch
2. Dismantling, inspection and assembling of sliding mesh gear box
3. Dismantling, inspection and assembling of constant mesh gear box
4. Dismantling, inspection and assembling of synchromesh gear box
5. Dismantling, inspection and assembling of automatic gear box
6. Dismantling, inspection and assembling of transaxle
7. Dismantling, inspection and assembling of transfer case
8. Dismantling, inspection and assembling of differential unit
9. Dismantling, inspection and assembling of brake system
10. Dismantling, inspection and assembling of suspension system
11. Dismantling, inspection and assembling of steering gear box
12. Dismantling, inspection and assembling of front and rear axle

Experiment No - 01

Dismantling, Inspection, and Assembling of Clutch

Aim:

To dismantling, inspection and assembling of clutch.

Equipment &Tools:

Clutches and toolbox

Theory:

In an automobile clutch, the flywheel is connected to the engine, and the clutch plate is connected to the transmission. When your foot is off the pedal, the springs push the pressure plate against the clutch disc, which in turn presses against the flywheel. This locks the engine to the transmission input shaft, making them spin at the same speed. The amount of force the clutch can hold depends on the friction between the clutch plate and the flywheel, and how much force the spring puts on the pressure plate.

Purpose:

1. The purpose of the clutch is to allow the driver to couple or decouple the engine and transmission.
2. When clutch is in engaged position, the engine power flows to the transmission through it
3. When gears are to be changed while vehicle is running, the clutch permits temporary decoupling of engine and wheels so that gears can be shifted.

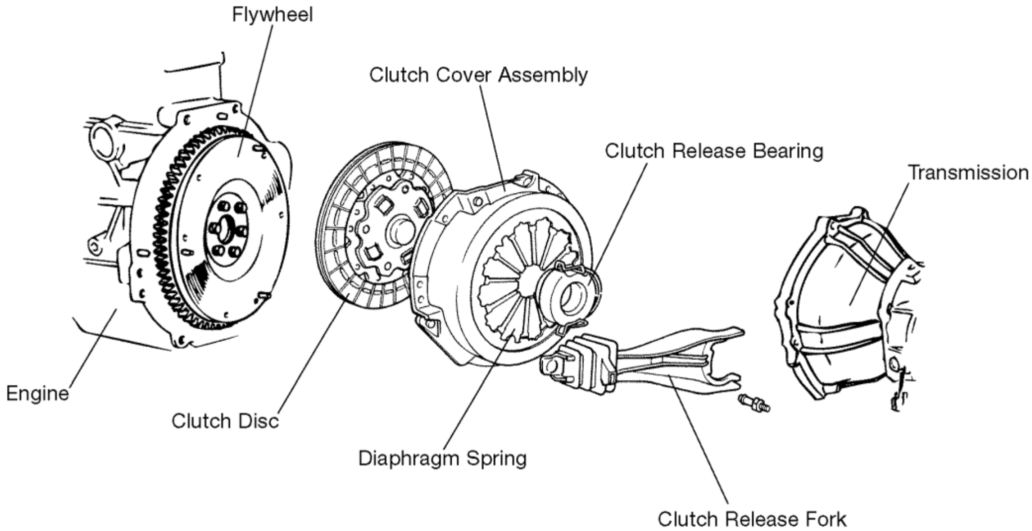
Principle:

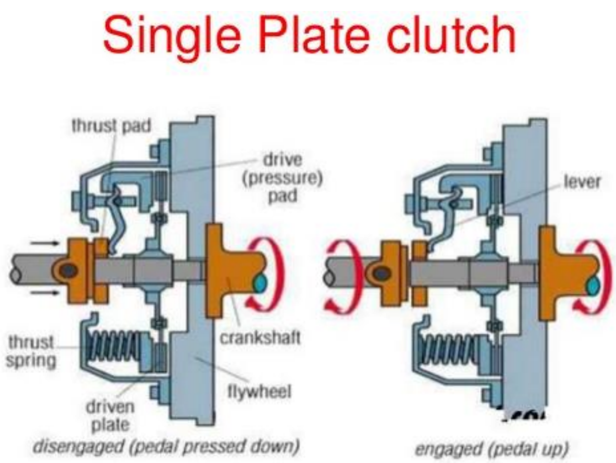
It operates on the principle of friction. When two surfaces are brought in contact and are held against each other due to friction between them, they can be used to transmit power. If one is rotated, then other also rotates. One surface is connected to engine and other to the transmission system of automobile. Thus, clutch is nothing but a combination of two friction surfaces.

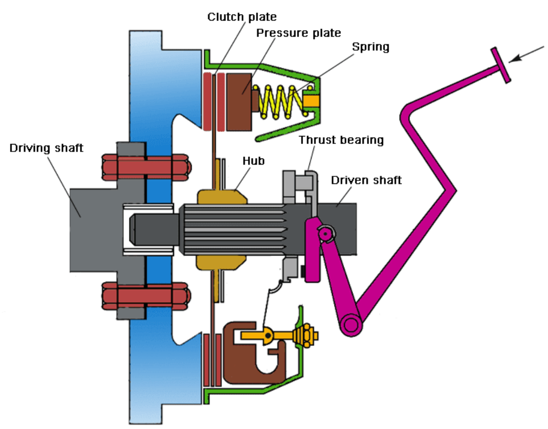
Requirements:

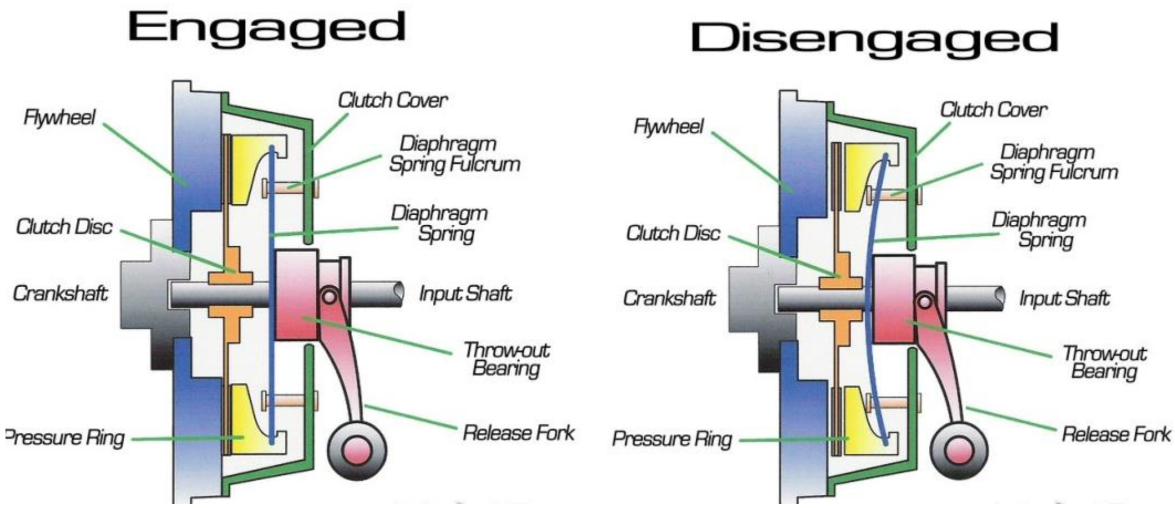
1. It should ensure smooth engagement without grab or clatter.
2. It should have the clutch with two-fold moment of inertia.
3. It should prevent gear clatter due to piston vibration caused by engine crank shaft.
4. The effort required to disengage should be minimum.
5. It must be cost effective.

6. It must be easy to maintain and adjust.

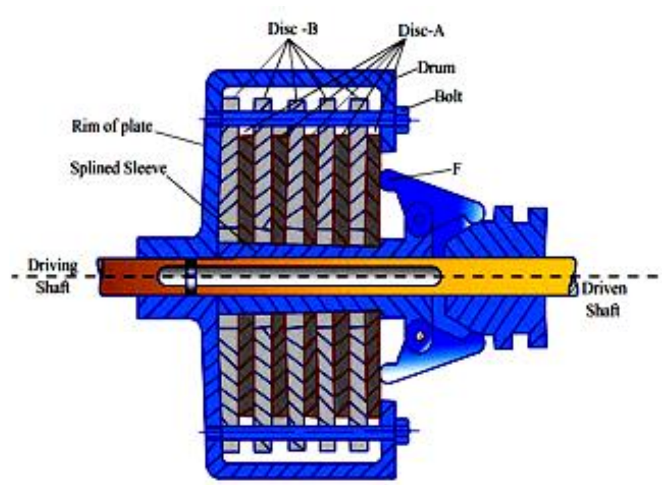








Multi-plate clutch



Procedure:

Dismantling: Given- Single plate clutch assembly:

1. Mark the pressure plate and clutch cover position with respect to each other.
2. Place the clutch assembly on the clutch drive aligning the slot on the clutch finger with the thrust and seal on the pressure plate.
3. Compress the spring cups by clutch.
4. Loosen the mounting seat screw of the rotating plate on the retaining plate so removed.
5. Loosen the mounting seat screw of the clutch finger brackets and eccentric Pins.

Inspection:

1. Visually check the fly wheel, ring gear and pressure for crankshaft.
2. Check the flatness of friction faces of the pressure plate with straight edge.

3. If flatness is not found within the specific limit without the pressure plate and fly wheel can ground so not ground below the minimum specific thickness.
4. Check the free length and tension of pressure spring.
5. Check the pressure plate tension usually for any damage. Replace the clutch plate if any torsion spring found damaged.
6. Measure the thickness of clutch lever. Release if thickness of clutch lever is less than minimum specified.

Assembling:

1. Place the clutch fingers bush in the clutch fingers.
2. Fit the clutch bracket with eccentric pin.
3. Hand tighter the mounting set screw of clutch bracket.
4. Align the marks of clutch plate and pressure plate and place the clutch over the pressure plate.
5. Compress the spring with clutch finger.
6. Place the pressure pad on the pressure plate and tighten the pad mounting set screws.
7. Release the load from the spring and remove clutch cover assembly from the clutch jig.
8. Place the withdrawn plate, retaining plate on the clutch jig finger; tighten mounting set screws of the withdrawn plate.

Calculations

Outer diameter of Clutch plate

Trails	**Main Scale Reading (MSR)**	**VR**	**LC (mm)**	**D = MSR + (VC*LC) in mm**
1				
2				
3				
			Average	

Inner diameter of Clutch plate

Trails	Main Scale Reading (MSR)	VR	LC (mm)	D = MSR + (VC*LC) in mm
1				
2				
3				
			Average	

Thickness of Clutch plate

Trails	Main Scale Reading (MSR)	VR	LC (mm)	D = MSR + (VC*LC) in mm
1				
2				
3				
			Average	

Observation table

S. No	Part name	Quantity
1		
2		
3		
4		
5		
6		
7		

Result:

Thus, the given clutch assembly is dismantled, inspected, and assembled.

Experiment No - 2

Dismantling, Inspecting and Assembling of Sliding Mesh Gear Box and Finding out the Gear Ratios

Aim:

To dismantle, inspect and assemble the given sliding mesh gear box and find out the gear ratios

Tools:

Gear box and toolbox

Theory:

An automobile requires high torque when climbing hills and when starting, even though they are performed at low speeds. On other hand, when running at high speeds on level roads, high torque is not required because of momentum. So, requirement of a device is occur, which can change the vehicle's torque and its speed according to road condition or when the driver need. This device is known as transmission box.

Main functions:

1. Provide the torque needed to move the vehicle under a variety of road and load conditions. It does this by changing the gear ratio between the engine crankshaft and vehicle drive wheels.
2. Be shifted into reverse so the vehicle can move backward.
3. Be shifted into neutral for starting the engine.

Major components:

1. Counter shaft:

Counter shaft is a shaft which connects with the clutch shaft directly. It contains the gear which connects it to the clutch shaft as well as the main shaft. It may be runs at the engine speed or at lower than engine speed according to gear ratio. It is having fixed gears

2. Main shaft:

It carries power form the counter shaft by use of gears and according to the gear ratio, it runs at different speed and torque compares to counter shaft. One end of this shaft is connecting with the universal shaft.

3. Gears:

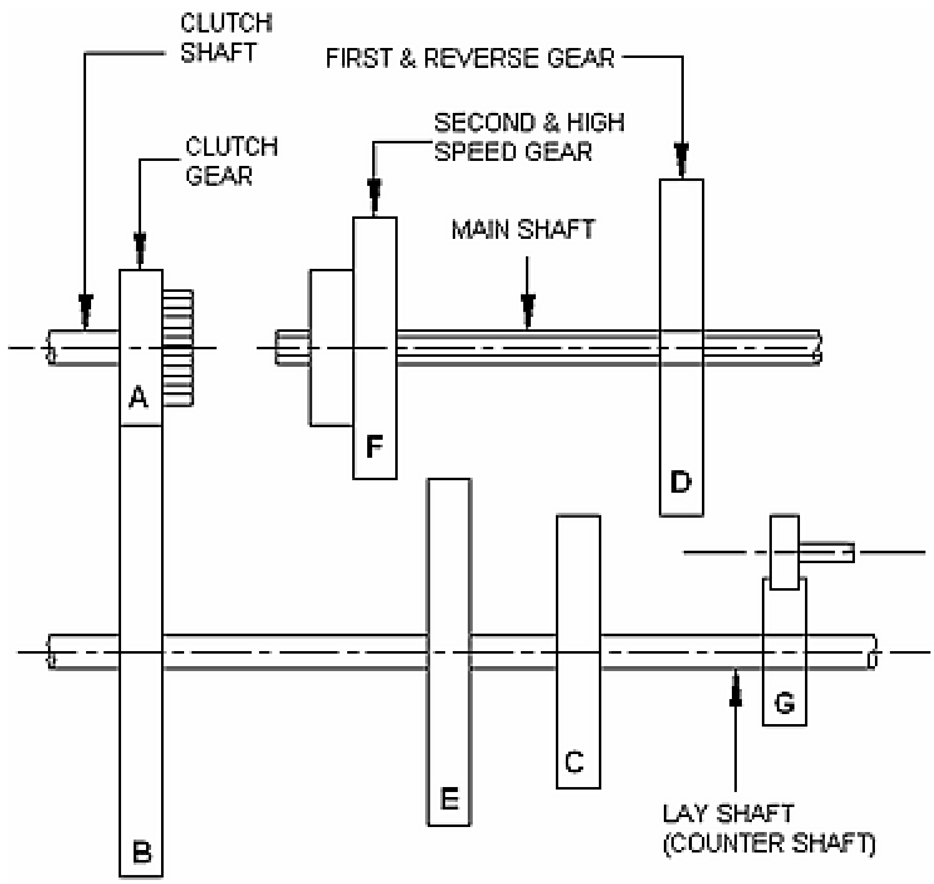
Gears are used to transmit the power form one shaft to another. They are most useful component of transmission box because the variation is torque of counter shaft and main shaft is dependent on the gear ratio. The gear ratio is the ratio of the driven gear teeth to the driving gear teeth. If gear ratio is large than one, the main shaft revolves at lower speed than the counter shaft and the torque of the main shaft is higher than the counter shaft. On other hand if the gear ratio is less than one, than the main shaft revolves at higher speed than the counter shaft and the torque of the main shaft is lower than the counter shaft. A small car gear box contains four speed gear ratio and one reverse gear ratio.

4. Bearings:

Whenever the rotary motion, bearings are required to support the revolving part and reduce the friction. In the gear box both counter and main shaft are supported by the bearing.

Working of gear box:

In a gear box, the counter shaft is meshed to the clutch shaft with a use of a couple of gear. So, the counter shaft is always in running condition. When the counter shaft is brought in contact with the main shaft by use of meshing gears, the main shaft start to rotate according to the gear ratio. When want to change the gear ratio, simply press the clutch pedal which disconnect the counter shaft with engine and connect the main shaft with counter shaft by another gear ratio by use of gearshift lever. In a gear box, the gear teeth and other moving metal must not touch. They must be continuously separated by a thin film of lubricant. This prevents excessive wear and early failure.



Sliding Mesh Gear Box

FIND OUT THE GEAR RATIO

To find out gear ratio using formula:

$$\text{Gear ratio} = \frac{\text{No.of teeth in driven gear}}{\text{No.of teeth in driving gear}}$$

1 ST

Procedure:

1. Disconnect clutch assembly.
2. Drain gear box trolley oil in a clean container.
3. Locate the gear box trolley under the gear box and unscrew clutch housing unit.
4. Check for natural position of selectors spindles, after remove selector casing unit.
5. Remove rear flange from main shaft.

6. Remove clutch shaft, ball bearing, main shaft, counter shaft, pinion wheel and roller bearings from casing.
7. Clean all parts in kerosene.
8. For calculating the gear ratios, count number teeth on 1^{st} gear, reverse gear, 2^{nd} gear, 3rd gear, etc. and pinion wheel.
9. Assemble counter shaft assembly.
10. Assemble main shaft, assembly.
11. Fit the 1st gear, reverse gear, 2nd gear, 3rd gear, etc., pinion wheel, and thrust washer.
12. To check the individual gears end play measure the height difference between the bush and the gear.
13. Check for free engagement of gears.
14. Check for free rotation of I, Reverse, II, III, etc., gear wheel.
15. Fit the clutch shaft and ball bearing.
16. Fit the flange, and selector mechanism to clutch assembly, gear box casing.
17. Fill lubricating oil. Check lubricating required level.
18. Check for any oil leakage, noise and smooth running.
19. Fit the vehicle, Connect to Battery terminals.
20. Check for proper gear engagement for different in running condition.

Observation Table

S. No	Part name	Quantity	Remarks
1	**Gear a**	**1**	**Numbre of teeth**
2			
3			
4			
5			
6			
7			

Gearbox troubleshoot

1. **Symptom:** Meshing jumps out of gear
   Possible faults:
   (i) Gear linkage worn or not adjusted correctly
   (ii) Worn selector forks
   (iii) Detent not working
   (iv) Weak synchromesh units
   (v) Worn bearings
   (vi) Misalignment

2. **Symptom:** Generates noise when changing gear
   Possible fault:
   (i) Worn-out synchromesh device

3. **Symptom:** Whining noise
   Possible fault:
   (i) Worn-out bearings

4. **Symptom:** Difficulty in changing gear
   Possible faults:
   (i) Clutch out of adjustment
   (ii) Selector mechanism fault
   (iii) Worn-out or jammed part in selector mechanism
   (iv) Lack of lubrication

5. **Symptom:** Noisy in a particular gear
   Possible faults:
   (i) Damaged gear
   (ii) Worn bearing
   (iii) Excessive clearance between gears and shafts
   (iv) Worn synchromesh device
   (v) Lack of lubrication
   (vi) Misalignments

6. **Symptom:** Noisy in neutral position
   Possible faults:
   (i) Worn input shaft bearings
   (ii) Lack of lubricating oil
   (iii) Worn clutch release bearing

7. **Symptom:** Vibration
   Possible faults:
   (i) Lack of lubrication
   (ii) Worn bearings
   (iii) Mountings loose

8. **Symptom:** Oil leakage
Possible faults:
(i) Gaskets leakage
(ii) Worn seals
(iii) Incorrect lubricant
(iv) Cracked case

9. **Symptom:** Gear clash when shifting
Possible faults:
(i) Worn synchromesh
(ii) Lack of lubrication
(iii) High engine idle speed
(iv) Worn bearing

Result:

Thus, the given gear box is dismantled, inspected and reassembled and also found the gear ratios.

1st Gear ratio = $(T_B/T_A)*(T_D/T_C)$

2nd Gear ratio = $(T_B/T_A)*(T_F/T_E)$

3rd Gear ratio = $(T_B/T_A)*(T_A/T_F)$

Reverse Gear ratio = $(T_B/T_A)*(T_I/T_G)*(T_D/T_I)$

Experiment No - 3

Dismantling, Inspecting and Assembling of Constant Mesh Gear Box and Finding out the Gear Ratios

Aim:

To dismantle, inspect and assemble the given constant mesh gear box and find out the gear ratios

Tools:

Gear box and toolbox

Theory:

An automobile requires high torque when climbing hills and when starting, even though they are performed at low speeds. On other hand, when running at high speeds on level roads, high torque is not required because of momentum. So, requirement of a device is occur, which can change the vehicle’s torque and its speed according to road condition or when the driver need. This device is known as transmission box.

Main functions:

1. Provide the torque needed to move the vehicle under a variety of road and load conditions. It does this by changing the gear ratio between the engine crankshaft and vehicle drive wheels.
2. Be shifted into reverse so the vehicle can move backward.
3. Be shifted into neutral for starting the engine.

Major components:

1. Counter shaft:

Counter shaft is a shaft which connects with the clutch shaft directly. It contains the gear which connects it to the clutch shaft as well as the main shaft. It may be runs at the engine speed or at lower than engine speed according to gear ratio. It is having fixed gears

2. Main shaft:

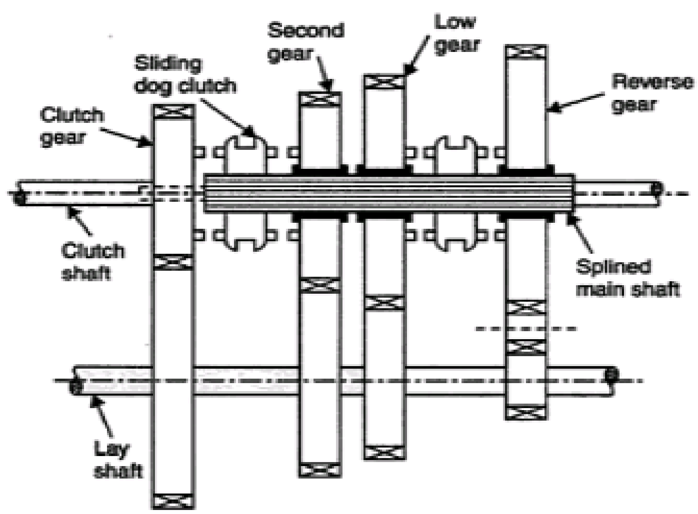
It carries power form the counter shaft by use of gears and according to the gear ratio, it runs at different speed and torque compares to counter shaft. One end of this shaft is connects with the universal shaft.

3. Gears:

Gears are used to transmit the power form one shaft to another. They are most useful component of transmission box because the variation is torque of counter shaft and main shaft is depend on the gear ratio. The gear ratio is the ratio of the driven gear teeth to the driving gear teeth. If gear ratio is large than one, the main shaft revolves at lower speed than the counter shaft and the torque of the main shaft is higher than the counter shaft. On other hand if the gear ratio is less than one, than the main shaft revolves at higher speed than the counter shaft and the torque of the main shaft is lower than the counter shaft. A small car gear box contains four speed gear ratio and one reverse gear ratio.

4. Bearings:

Whenever the rotary motion, bearings are required to support the revolving part and reduce the friction. In the gear box both counter and main shaft are supported by the bearing.



Constant Mesh Gear Box

Working of gear box:

In a gear box, the counter shaft is meshed to the clutch shaft with a use of a couple of gear. So the counter shaft is always in running condition. When the counter shaft is bring in contact with the main shaft by use of meshing gears, the main shaft start to rotate according to the gear ratio. When want to change the gear ratio, simply press the clutch pedal which disconnect the counter shaft with engine and connect the main shaft with counter shaft by another gear ratio by use of gearshift lever. In a gear box, the gear teeth and other moving metal must not touch. They must be continuously separated by a thin film of lubricant. This prevents excessive wear and early failure. Therefor a gearbox runs partially filled with lubricant oil.

FIND OUT THE GEAR RATIO

To find out gear ratio using formula:

$$\text{Gear ratio} = \frac{\text{No.of teeth in driven gear}}{\text{No.of teeth in driving gear}}$$

Procedure:

1. Disconnect clutch assembly.
2. Drain gear box trolley oil in a clean container.
3. Locate the gear box trolley under the gear box and unscrew clutch housing unit.
4. Check for natural position of selectors spindles, after remove selector casing unit.
5. Remove rear flange from main shaft.
6. Remove clutch shaft, ball bearing, main shaft, counter shaft, pinion wheel and roller bearings from casing.
7. Clean all parts in kerosene.
8. For calculating the gear ratios, count number teeth on 1st gear, reverse gear, 2nd gear, 3rd gear, etc. and pinion wheel.
9. Assemble counter shaft assembly.
10. Assemble main shaft, assembly.
11. Fit the 1st gear, reverse gear, 2nd gear, 3rd gear, etc., pinion wheel, and thrust washer.
12. To check the individual gears end play measure the height difference between the bush and the gear.
13. Check for free engagement of gears.
14. Check for free rotation of I, Reverse, II, III, etc., gear wheel.
15. Fit the clutch shaft and ball bearing.

16. Fit the flange, and selector mechanism to clutch assembly, gear box casing.

17. Fill lubricating oil. Check lubricating required level.

18. Check for any oil leakage, noise and smooth running.

19. Check for proper gear engagement for different in running condition.

Gearbox troubleshoot

1. **Symptom:** Meshing jumps out of gear
   Possible faults:
   (i) Gear linkage worn or not adjusted correctly
   (ii) Worn selector forks
   (iii) Detent not working
   (iv) Weak synchromesh units
   (v) Worn bearings
   (vi) Misalignment

2. **Symptom:** Generates noise when changing gear
   Possible fault:
   (i) Worn-out synchromesh device

3. **Symptom:** Whining noise
   Possible fault:
   (i) Worn-out bearings

4. **Symptom:** Difficulty in changing gear
   Possible faults:
   (i) Clutch out of adjustment
   (ii) Selector mechanism fault
   (iii) Worn-out or jammed part in selector mechanism
   (iv) Lack of lubrication

5. **Symptom:** Noisy in a particular gear
   Possible faults:
   (i) Damaged gear
   (ii) Worn bearing
   (iii) Excessive clearance between gears and shafts
   (iv) Worn synchromesh device
   (v) Lack of lubrication
   (vi) Misalignments

6. **Symptom:** Noisy in neutral position
   Possible faults:
   (i) Worn input shaft bearings
   (ii) Lack of lubricating oil
   (iii) Worn clutch release bearing

7. **Symptom:** Vibration
   Possible faults:
   (i) Lack of lubrication
   (ii) Worn bearings
   (iii) Mountings loose

8. **Symptom:** Oil leakage
Possible faults:
(i) Gaskets leakage
(ii) Worn seals
(iii) Incorrect lubricant
(iv) Cracked case

9. **Symptom:** Gear clash when shifting
Possible faults:
(i) Worn synchromesh
(ii) Lack of lubrication
(iii) High engine idle speed
(iv) Worn bearing

Result:

Thus, the given gear box is dismantled, inspected, and reassembled and found the gear ratios.

1st Gear ratio =

2nd Gear ratio =

3rd Gear ratio =

4th Gear ratio =

Experiment – 4

Dismantling, Inspecting and Assembling of Synchro Mesh Gear Box and Finding out the Gear Ratios

Aim:

To dismantle, inspect and assemble the given synchro mesh gear box and find out the gear ratios

Tools:

Gear box and toolbox

Theory:

An automobile requires high torque when climbing hills and when starting, even though they are performed at low speeds. On other hand, when running at high speeds on level roads, high torque is not required because of momentum. So, requirement of a device is occurred, which can change the vehicle's torque and its speed according to road condition or when the driver need. This device is known as transmission box.

Main functions:

1. Provide the torque needed to move the vehicle under a variety of road and load conditions. It does this by changing the gear ratio between the engine crankshaft and vehicle drive wheels.
2. Be shifted into reverse so the vehicle can move backward.
3. Be shifted into neutral for starting the engine.

Major components:

1. Counter shaft:

Counter shaft is a shaft which connects with the clutch shaft directly. It contains the gear which connects it to the clutch shaft as well as the main shaft. It may be runs at the engine speed or at lower than engine speed according to gear ratio. It is having fixed gears

2. Main shaft:

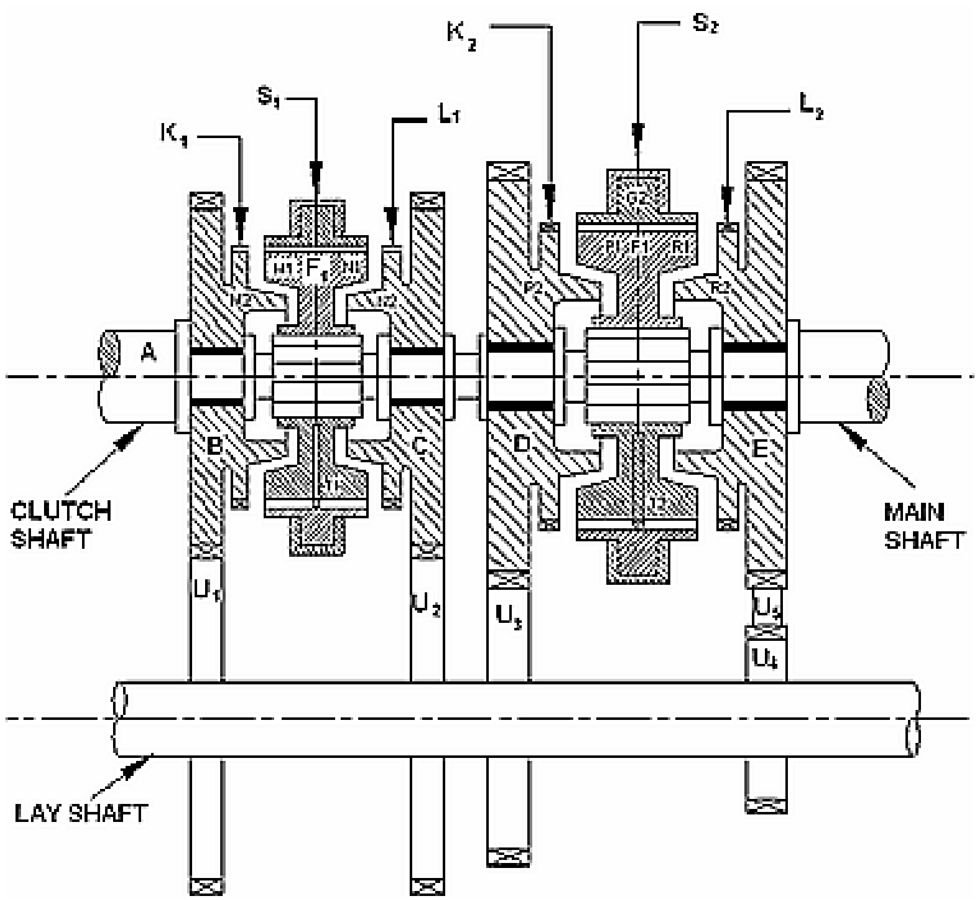
It carries power form the counter shaft by use of gears and according to the gear ratio, it runs at different speed and torque compares to counter shaft. One end of this shaft is connects with the universal shaft.

3. Gears:

Gears are used to transmit the power form one shaft to another. They are most useful component of transmission box because the variation is torque of counter shaft and main shaft is depend on the gear ratio. The gear ratio is the ratio of the driven gear teeth to the driving gear teeth. If gear ratio is large than one, the main shaft revolves at lower speed than the counter shaft and the torque of the main shaft is higher than the counter shaft. On other hand if the gear ratio is less than one, than the main shaft revolves at higher speed than the counter shaft and the torque of the main shaft is lower than the counter shaft. A small car gear box contains four speed gear ratio and one reverse gear ratio.

4. Bearings:

Whenever the rotary motion, bearings are required to support the revolving part and reduce the friction. In the gear box both counter and main shaft are supported by the bearing.



Synchro Mesh Gear Box

A- Clutch shaft

B - Clutch shaft gear wheel

C, D&E - Main shaft gear wheel

U1, U2,U3 & U4 – Lay shaft gear wheel

U5 - Idler gear wheel

S1 & S2 - Synchromesh Unit

K1, K2, L1 & L2 Synchro Ring

Working of gear box:

In a gear box, the counter shaft is meshed to the clutch shaft with a use of a couple of gear. So the counter shaft is always in running condition. When the counter shaft is bring in contact with the main shaft by use of meshing gears, the main shaft start to rotate according to the gear ratio. When want to change the gear ratio, simply press the clutch pedal which disconnect the counter shaft with engine and connect the main shaft with counter shaft by another gear ratio by use of gearshift lever. In a gear box, the gear teeth and other moving metal must not touch. They must be continuously separated by a thin film of lubricant. This prevents excessive wear and early failure. Therefor a gearbox runs partially filled with lubricant oil.

FIND OUT THE GEAR RATIO

To find out gear ratio using formula:

$$\text{Gear ratio} = \frac{\text{No.of teeth in driven gear}}{\text{No.of teeth in driving gear}}$$

Procedure:

1. Disconnect battery terminals.
2. Remove front and rear propeller shaft bolts and remove propeller shaft to the chassis frame.
3. Disconnect clutch assembly.
4. Disconnect speedometer cable reverse indicator switch wiring connections.
5. Drain gear box trolley oil in a clean container.

6. Locate the gear box trolley under the gear box and unscrew clutch housing unit.
7. Check for natural position of selectors spindles, after remove selector casing unit.
8. Remove rear flange from main shaft.
9. Remove clutch shaft, ball bearing, main shaft, counter shaft, pinion wheel and roller bearings from casing.
10. Clean all parts in kerosene.
11. For calculating the gear ratios, count number teeth on 1st gear, reverse gear, 2nd gear, 3rd gear, etc. and pinion wheel.
12. Assemble counter shaft assembly.
13. Assemble main shaft, assembly.
14. Fit the 1st gear, reverse gear, 2nd gear, 3rd gear, etc., pinion wheel, and thrust washer.
15. To check the individual gears end play, measure the height difference between the bush and the gear.
16. Check for free engagement of gears.
17. Check for free rotation of I, Reverse, II, III, etc., gear wheel.
18. Fit the clutch shaft and ball bearing.
19. Fit the flange, and selector mechanism to clutch assembly, gear box casing.
20. Fill lubricating oil. Check lubricating required level.
21. Check for any oil leakage, noise and smooth running.
22. Fit the vehicle, Connect to Battery terminals.
23. Check for proper gear engagement for different in running condition.

Gearbox troubleshoot

1. **Symptom:** Meshing jumps out of gear
   Possible faults:
   (i) Gear linkage worn or not adjusted correctly
   (ii) Worn selector forks
   (iii) Detent not working
   (iv) Weak synchromesh units
   (v) Worn bearings
   (vi) Misalignment

2. **Symptom:** Generates noise when changing gear
   Possible fault:
   (i) Worn-out synchromesh device

3. **Symptom:** Whining noise
   Possible fault:
   (i) Worn-out bearings

4. **Symptom:** Difficulty in changing gear
   Possible faults:
   (i) Clutch out of adjustment
   (ii) Selector mechanism fault
   (iii) Worn-out or jammed part in selector mechanism
   (iv) Lack of lubrication

5. **Symptom:** Noisy in a particular gear
   Possible faults:
   (i) Damaged gear
   (ii) Worn bearing
   (iii) Excessive clearance between gears and shafts
   (iv) Worn synchromesh device
   (v) Lack of lubrication
   (vi) Misalignments

6. **Symptom:** Noisy in neutral position
   Possible faults:
   (i) Worn input shaft bearings
   (ii) Lack of lubricating oil
   (iii) Worn clutch release bearing

7. **Symptom:** Vibration
   Possible faults:
   (i) Lack of lubrication
   (ii) Worn bearings
   (iii) Mountings loose

8. **Symptom:** Oil leakage
   Possible faults:
   (i) Gaskets leakage
   (ii) Worn seals
   (iii) Incorrect lubricant
   (iv) Cracked case

9. **Symptom:** Gear clash when shifting
   Possible faults:
   (i) Worn synchromesh
   (ii) Lack of lubrication
   (iii) High engine idle speed
   (iv) Worn bearing

Result:

Thus, the given gear box is dismantled, inspected, and reassembled and found the gear ratios.

1st Gear ratio =

2nd Gear ratio =

3rd Gear ratio =

Reverse Gear ratio =

Experiment No 5

Dismantling, Inspection and Assembling of Automatic gear box

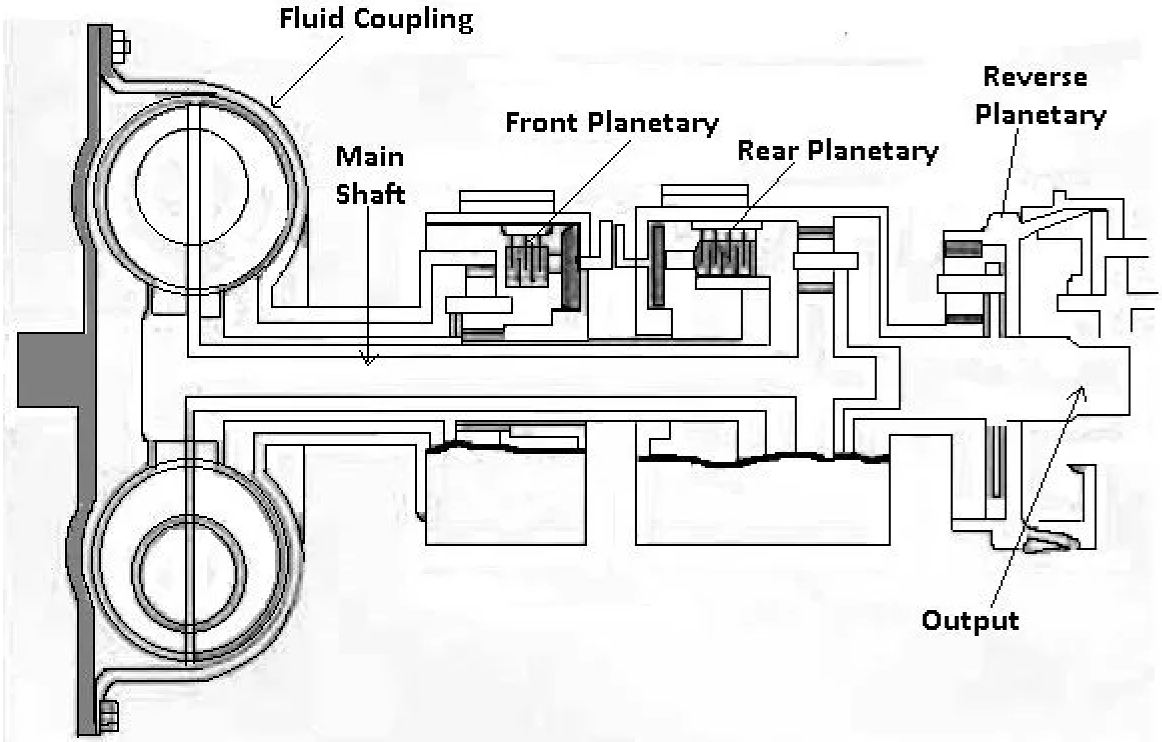
Aim: To dismantling, inspecting, and assembling of automatic gear box

Equipment and Tools: Automatic gear box, and toolbox

Theory:

An **automatic transmission** (sometimes abbreviated to **auto** or **AT**) is a multi-speed transmission used in motor vehicles that does not require any driver input to change forward gears under normal driving conditions. The most common type of automatic transmission is the hydraulic automatic, which uses a planetary gearset, hydraulic controls, and a torque converter. Other types of automatic transmissions include continuously variable transmissions (CVT), automated manual transmissions (AMT), and dual-clutch transmissions (DCT). An electronic automatic transmission (EAT) may also be called an electronically controlled transmission (ECT), or electronic automatic transaxle (EATX). The most common design of automatic transmissions is the hydraulic automatic, which typically uses planetary gearsets that are operated using hydraulics.[3][4] The transmission is connected to the engine via a torque converter (or a fluid coupling prior to the 1960s), instead of the friction clutch used by most manual transmissions. A hydraulic automatic transmission uses planetary (epicyclic) gearsets instead of the manual transmission's design of gears lined up along input, output, and intermediate shafts. To change gears, the hydraulic automatic uses a series of internal clutches or friction bands or brake packs. These devices are used to lock certain gears, thus setting which gear ratio is in use at the time.

A sprag clutch (a ratchet-like device which can freewheel and transmits torque in only one direction) is often used for routine gear shifts. The advantage of a sprag clutch is that it eliminates the sensitivity of timing a simultaneous clutch release/apply on two planetary gearsets, simply "taking up" the drivetrain load when actuated and releasing automatically when the next gear's sprag clutch assumes the torque transfer. The friction bands are often used for manually selected gears (such as low range or reverse) and operate on the planetary drum's circumference. Bands are not applied when the drive/overdrive range is selected, the torque being transmitted by the sprag clutches instead.



Automatic gear box

Procedure

1. Disconnect battery terminals.
2. Remove front and rear propeller shaft bolts and remove propeller shaft to the chassis frame.
3. Disconnect clutch assembly.
4. Disconnect speedometer cable reverse indicator switch wiring connections.
5. Drain gear box trolley oil in a clean container.
6. Locate the gear box trolley under the gear box and unscrew clutch housing unit.
7. Check for natural position of selectors spindles, after remove selector casing unit.
8. Remove rear flange from main shaft.
9. Remove clutch shaft, ball bearing, main shaft, counter shaft, pinion wheel and roller bearings from casing.
10. Clean all parts in kerosene.

11. For calculating the gear ratios, count number teeth on 1st gear, reverse gear, 2nd gear, 3rd gear, etc. and pinion wheel.
12. Assemble counter shaft assembly.
13. Assemble main shaft, assembly.
14. Fit the 1st gear, reverse gear, 2nd gear, 3rd gear, etc., pinion wheel, and thrust washer.
15. To check the individual gears end play, measure the height difference between the bush and the gear.
16. Check for free engagement of gears.
17. Check for free rotation of I, Reverse, II, III, etc., gear wheel.
18. Fit the clutch shaft and ball bearing.
19. Fit the flange, and selector mechanism to clutch assembly, gear box casing.
20. Fill lubricating oil. Check lubricating required level.
21. Check for any oil leakage, noise, and smooth running.
22. Fit the vehicle, Connect to Battery terminals.
23. Check for proper gear engagement for different in running condition

Observations

S. No	Part name	Quantity	Remarks

Result:

Thus, the given automatic gear box is dismantled, inspected, and reassembled

Experiment No 6

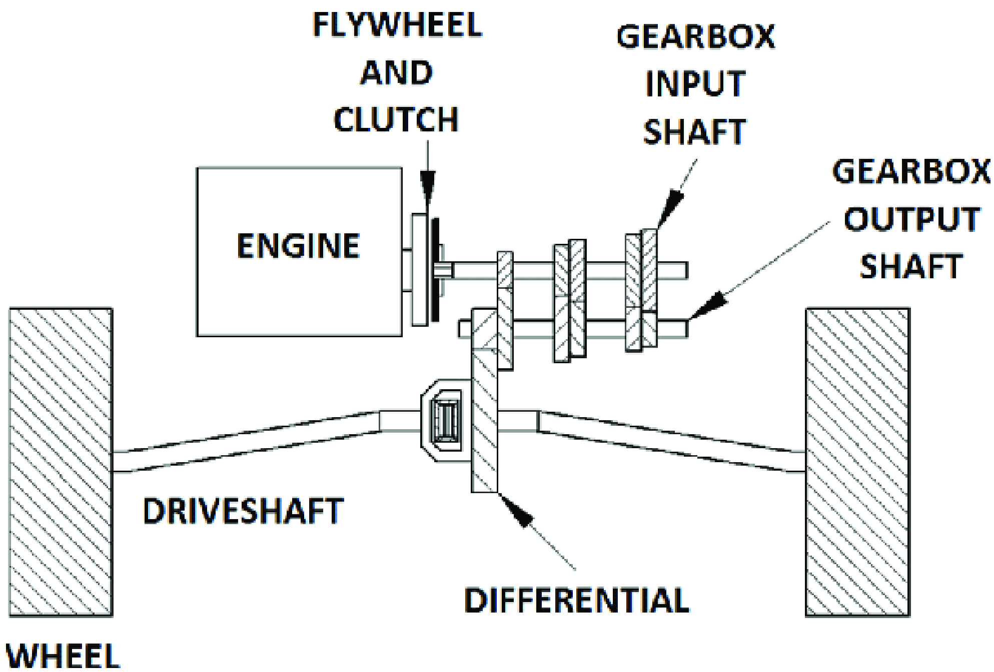
Dismantling, Inspecting and Assembling of Transaxle

Aim: To dismantling, inspecting, and assembling of Transaxle

Equipment and Tools: Transaxle, and toolbox

Theory:

A **transaxle** is a single mechanical device which combines the functions of an automobile's transmission, axle, and differential into one integrated assembly. In that way, a transaxle can drive the axles without any additional components. This is particularly useful in front-wheel-drive cars, where a CV axle can be plugged directly into the unit, although transaxles are also used in front-engine rear-wheel-drive applications. The word "transaxle" is a portmanteau of the word's "transmission" and "driven axle," which essentially describes what this component is and what it does. Specifically, it transmits power from the engine to the drive wheels via the driven axles, and it also allows the driver to change the gear ratios.



Transaxle

Types of Transaxle:

Engine and drive at same end

Transaxles are near-universal in all automobile configurations that have the engine placed at the same end of the car as the driven wheels: the front-engine/front-wheel drive; rear-engine/rear-wheel drive; and mid-engine/rear-wheel drive arrangements. Many mid- and rear engine vehicles use a transverse engine and transaxle, similar to a front-wheel-drive unit.

Front-engine, rear-wheel drive transaxle

Front-engine, rear-wheel-drive vehicles tend to have the transmission up front just after the engine, but sometimes a front-engine drives a rear-mounted transaxle. This is generally done for reasons of weight distribution and is therefore common in sports cars. Another advantage is that as the driveshaft spins at engine speed it only has to endure the torque of the engine, instead of that torque multiplied by the 1st gear ratio.

Procedure:

1. Disconnect clutch assembly.
2. Drain transaxle oil in a clean container.
3. Locate the transaxle on the table and unscrew clutch housing unit.
4. Check for the natural position of selectors spindles, after remove selector casing unit.
5. Remove rear flange from the main shaft.
6. Remove clutch shaft, ball bearing, main shaft, countershaft, pinion wheel, and roller bearings and differential unit from casing.
7. Clean all parts in kerosene.
8. For calculating the gear ratios, count number teeth on 1^{st} gear, reverse gear, 2^{nd} gear, 3rd gear, etc. and pinion wheel.
9. Calculate the final gear ratio.
10. Assemble countershaft assembly.
11. Assemble main shaft, assembly.
12. Fit the 1st gear, reverse gear, 2nd gear, 3rd gear, etc., pinion wheel, and thrust washer.
13. To check the individual gears end play, measure the height difference between the bush and the gear.
14. Check for free engagement of gears.
15. Check for free rotation of I, Reverse, II, III, etc., gear wheel.

16. Fit the clutch shaft and ball bearing.
17. Fit the flange, and selector mechanism to clutch assembly, gearbox casing.
18. Fill lubricating oil. Check lubricating required level.
19. Check for any oil leakage, noise, and smooth running.
20. Fit the vehicle, Connect to Battery terminals.
21. Check for proper gear engagement for different in running condition.

Observations

S.No	**Part name**	**Quantity**	**Remarks**

Calculations:

First gear ratio:

Second gear ratio:

Third gear ratio:

Fourth gear ratio:

Final gear ratio:

Result:

Thus, the given transaxle is dismantled, inspected, and reassembled

Experiment No 7

Dismantling, Inspecting and Assembling of Transfer case

Aim: To dismantling, inspecting, and assembling of Transfer case

Equipment and Tools: transaxle, and toolbox

Theory:

A **transfer case** is a part of the drivetrain of four-wheel-drive, all-wheel-drive, and other multiple powered axle vehicles. The transfer case transfers power from the transmission to the front and rear axles by means of drive shafts. It also synchronizes the difference between the rotation of the front and rear wheels and may contain one or more sets of low range gears for off-road use. The important functions of transfer case as follows

The transfer case receives power from the transmission and sends it to both the front and rear axles. This can be done with gears, hydraulics, or chain drive. On some vehicles, such as four-wheel-drive trucks or vehicles intended for off-road use, this feature is controlled by the driver. The driver can put the transfer case into either "two-wheel-drive" or "four-wheel-drive" mode. This is sometimes accomplished by means of a shifter, similar to that in a manual transmission. On some vehicles, this may be electronically operated by a switch instead. Some vehicles, such as all-wheel-drive sports cars, have transfer cases that are not selectable. Such a transfer case is permanently "locked" into all-wheel-drive mode.

Transfer cases that are designed to allow for normal road use synchronize the difference between the rotation of the front and rear wheels, in much the same way the differential acts on a given axle. This is necessary because the front and rear tires never turn at the same speed. Different rates of tire rotation are generally due to different tire diameters (since front and rear tires inevitably wear at different rates) and different gear ratios in the front and rear differentials since manufacturers will often have a slightly lower ratio in the front vs. the rear to help with control. If the transfer case did not make up the difference between the two different rates of rotation, binding would occur and the transfer case could become damaged. This is also why a transfer case that is not designed for on-road use will cause problems with driveline windup if driven on dry pavement.

Transfer cases designed for off-road use can mechanically lock the front and rear axles when needed (e.g. when one of the axles is on slippery surfaces or stuck in mud, whereas the other has better traction). This is the equivalent to the differential lock.

The transfer case may contain one or more sets of low range gears for off-road use. Low range gears are engaged with a shifter or electronic switch. On many transfer cases, this shifter is the same as the one that selects 2WD or 4WD operation. Low range gears allow the vehicle to drive at much slower speeds while still operating within the usable power band / RPM range of the engine. This also increases the torque available at the axles. Low-range gears are used for very inclement road conditions, towing a heavy load, driving on unimproved roads, and extreme off-road maneuvers such as rock crawling. This feature is often absent on all-wheel-drive cars. Some very large vehicles, such as heavy equipment or military trucks, may have more than one low-range gear.

Types of Transfer case:

Transfer cases used on "part-time" four-wheel-drive off-road vehicles such as trucks,rock-crawling vehicles and some military vehicles generally allow the driver to select 2WD or 4WD, as well as high or low gear ranges. Those used in sports cars and performance sedans are usually "transparent" to the driver; there is no shifter or select lever.

Gear-driven

There are two different types of internal power-transfer mechanism found in most transfer cases. Gear-driven transfer cases use sets of gears to drive either the front or both the front and rear driveshafts. These are generally strong, heavy units that are used in large trucks, but there are currently several gear drive cases in production for passenger cars

Chain-driven

Chain-driven transfer cases use a chain to drive most often only one axle but can drive both axles. Chain-driven transfer cases are quieter and lighter than gear-driven ones. They are used in vehicles such as compact trucks, full-size trucks, Jeeps and SUVs. Some off-road driving enthusiasts modify their vehicles to use gear-driven transfer cases, accepting the additional weight and noise to gain the extra strength they generally provide

Housing type

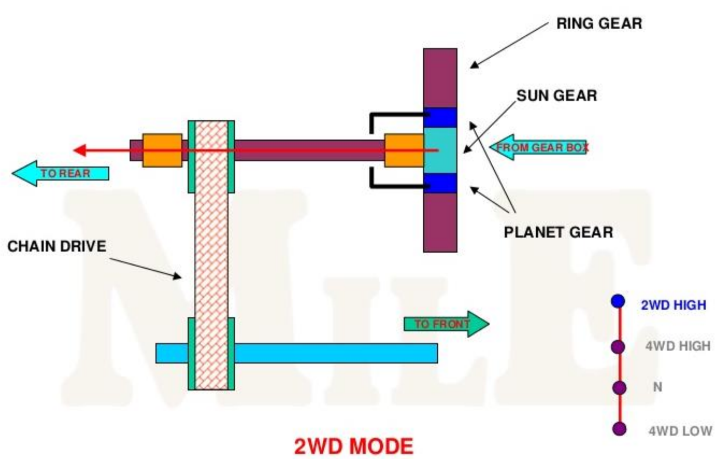
Transfer case shift type

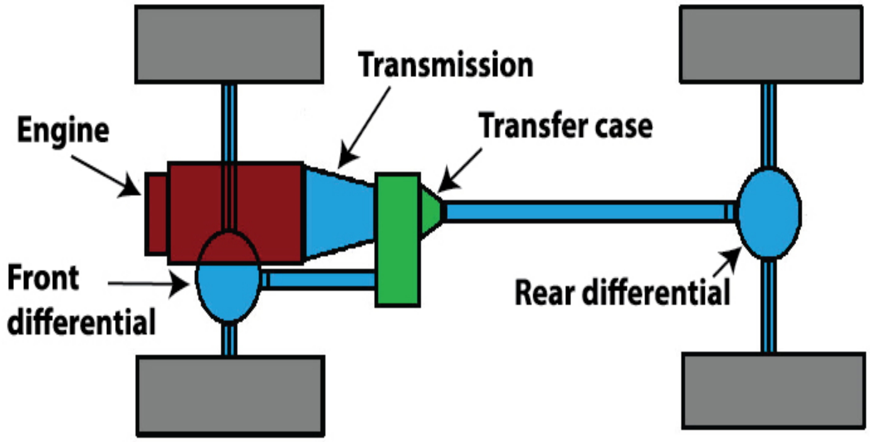
M.S.O.F.

Manual Shift On-the-Fly transfer cases have a selector lever on the driver's side floor transmission hump and may also have either two sealed automatic front axle locking hubs or two manual front axle hub selectors of "LOCK" and "UNLOCK" or "FREE". To engage the four-wheel-drive system the vehicle must be moving at a low speed. The speed at which 4x4 can be engaged depends on the vehicle. This is only for the four-wheel-drive **high** setting. To engage the four-wheel-drive **low** setting, the vehicle must be stopped, and the transmission must be shifted to neutral, then the four-wheel-drive low can be selected.

E.S.O.F.

Electronic Shift On-the-Fly (ESOF) transfer cases have a dash-mounted selector switch or buttons with front sealed automatic locking axle hubs or drive flanges. Unlike the manual transfer case, this system has a transfer case motor. To engage the four-wheel-drive system the vehicle must be moving at lower speeds. The speed at which 4x4 can be engaged depends on the vehicle. This is only for the four-wheel-drive **high** setting. To engage the four-wheel-drive **low** setting, the vehicle must be stopped, and the transmission must be shifted to neutral, then the four-wheel-drive low can be selected.





4WD MODE

Procedure

Transfer case:

1. Disconnect clutch assembly.
2. Drain transfer case trolley oil in a clean container.
3. Locate the transfer case and unscrew gearbox housing unit.
4. Check for natural position of front and rear axles, after remove 2WD and 4WD selector casing unit.
5. Remove the chain drive from the gear and pinion and roller bearings from casing.
6. Clean all parts in kerosene.
7. Assemble chain drive assembly.
8. Check for free transmission of power front and rear axle through chain drive.
9. Assemble selector mechanism, assembly.
10. Fit the gearbox assembly with screws.
11. Fit the clutch shaft and ball bearing.
12. Fill lubricating oil. Check lubricating required level.
13. Check for any oil leakage, noise and smooth running.
14. Fit the vehicle, Connect to Battery terminals.
15. Check for proper gear engagement for different in running condition.

Observations

S.No	Part name	Quantity	Remarks

Result:

Thus the given transfer case and transaxle is dismantled, inspected and reassembled

Experiment No – 08

Dismantling, Inspection and Assembling of Differential Unit

Aim:

To study, dismantle, inspect, and assemble the given Differential unit.

Tools required:

Toolbox

Function:

The differential is designed to drive a pair of wheels while allowing them to rotate at different speeds. Whenever any vehicle makes a turn, the outside wheel must travel a greater distance than the inside wheel. The drive shaft applies torque to the drive pinion gear that meshes below the center line of a crown wheel. This type of gear set is called a hypoid gear set. A vehicle's wheels rotate at different speeds, mainly When cornering, the inner wheel needs to travel a shorter distance than the outer wheel, so with no differential, the result is the inner wheel spinning and/or the outer wheel dragging, and this results in difficult and unpredictable handling, damage to tires and roads, and strain on (or possible failure of) the entire drive train. In vehicles without a differential, such as karts, both driving wheels are forced to rotate at the same speed, usually on a common axle driven by a simple chain-drive mechanism. The engine is connected to the shaft rotating at an angular velocity. The driving wheels are connected to the other two shafts, and they are equal. If the engine is running at a constant speed, the rotational speed of each driving wheel can vary, but the sum (or average) of the two wheels' speeds cannot change. An increase in the speed of one wheel must be balanced by an equal decrease in the speed of the other. (If one wheel is rotating backward, which is possible in very tight turns, its speed should be counted as negative.). The backlash is the amount of clearance between the drive pinion and the ring gear; excessive backlash could indicate excessive wear.

1. A differential is a device, usually, but not necessarily, employing gears, which is connected to the outside world by three shafts, chains, or similar, through which it transmits torque and rotation.
2. The gears or other components make the three shafts rotate.

3. It may seem illogical that the speed of one input shaft can determine the speeds of two output shafts, which are allowed to vary.

4. Logically, the number of inputs should be at least as great as the number of outputs.

5. However, the system has another constraint.

6. 6. Under normal conditions (i.e only small tyre slip), the ratio of the speeds of the two driving wheels equals the ratio of the radii of the paths around which the two wheels are rolling, which is determined by the track-width of the vehicle (the distance between the driving wheels) and the radius of the turn.

7. Thus the system does not have one input and two independent outputs.

8. It has two inputs and two outputs.

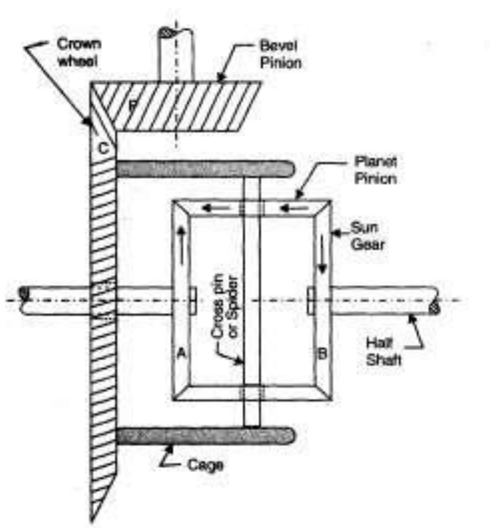
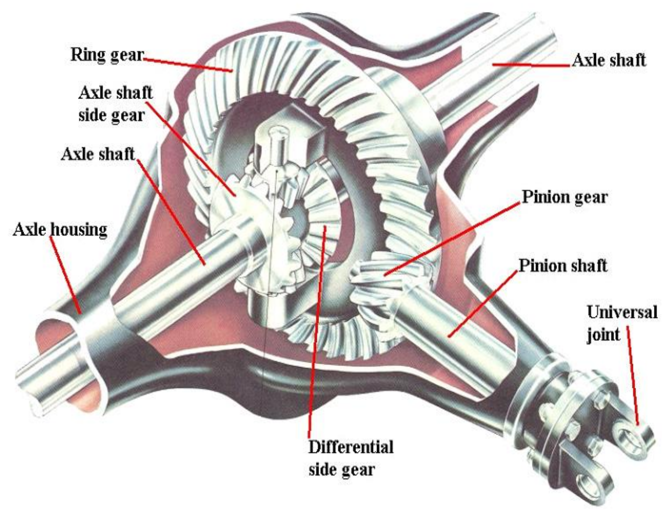
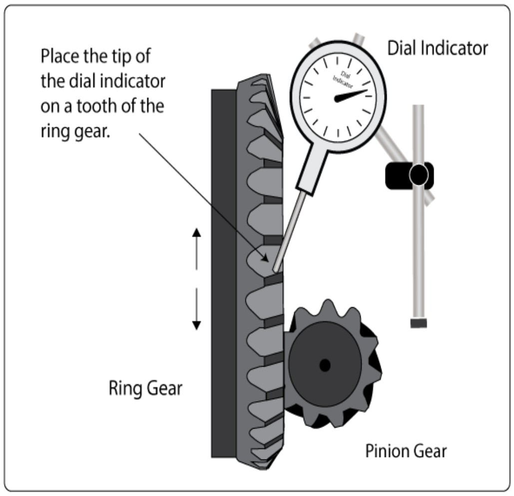
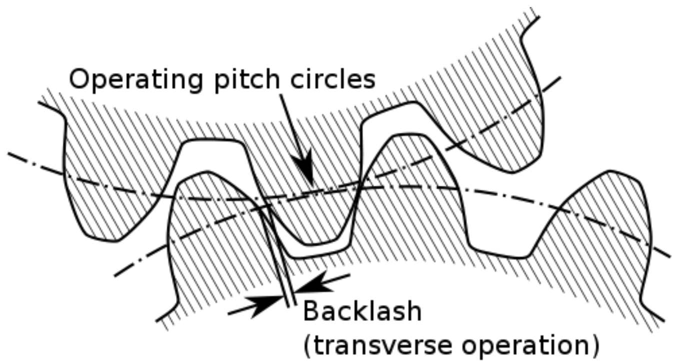


Fig. 4.3 Differential







Requirement:

The differential has three jobs:

1. To aim the engine power at the wheels.
2. To act as the final gear reduction in the vehicle, slowing the rotational speed of the transmission one final time before it hits the wheels.
3. To transmit the power to the wheels while allowing them to rotate at different speeds (This is the one that earned the differential its name).

Dismantling:

1. Remove Output shaft/drive flange
2. Pulling off Tapered roller bearing inner race
3. Remove Tapered roller bearing outer race
4. Remove Bearing body for tapered roller bearing
5. Remove Differential
6. Remove O-rings
7. Remove Adjusting ring for tapered roller bearing
8. Remove Output shaft/drive flange
9. Remove Tapered roller bearing outer race

10. Pulling off Tapered roller bearing inner race

11. Drive out Speedometer drive gear with drift Fit together with driver bushing

12. Remove small bevel gears, large bevel gears.

13. Circlip- Do not remove the circlip until after removing the drive flange as the compression spring is pre-tensioned.

Inspection:

1. Visually check the final drive gear. It is riveted onto differential housing and then machined. If differential or final drive gear is damaged, replace differential housing along with riveted final drive gear.
2. Visually check all the spare parts and replace required parts. Replace O rings always.
3. Inspect the differential for damages or wear.
4. Check the Backlash error between the gears.

Procedure to check backlash error

1. Attach the Magnetic base on the flat surface, so that the dial indicator can sit on a ring gear tooth.
2. Hold the pinion so it doesn't move and gently move the ring gear back and forth just enough to measure the backlash.
3. If you move the pinion by moving the ring gear you cannot measure the backlash error.

Assembling:

Place, position, install, press, and assemble all the spare parts as needed in the reverse order of dismantling.

Result:

Thus, the given Differential Unit is dismantled, inspected, and assembled.

Dismantling, Inspection and Assembly of brake system

Aim: To dismantle, inspect and assemble the given braking system.

Tools:

Braking system and toolbox

Theory:

A brake is an appliance used to apply frictional resistance to a moving body to stop or retard it by absorbing its kinetic energy.

Classification of brakes:

I. From construction point of view

(a) Drum brakes (b) Disc brakes

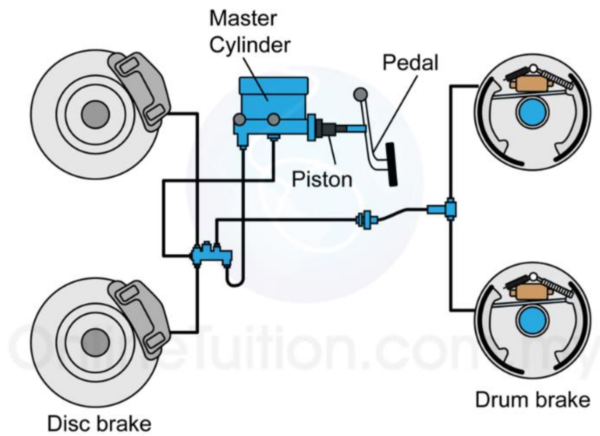
II. By method of actuation

(a) Mechanical brakes (b) Hydraulic brakes (c) Electric brakes (d) Vacuum brakes (e) Air brakes

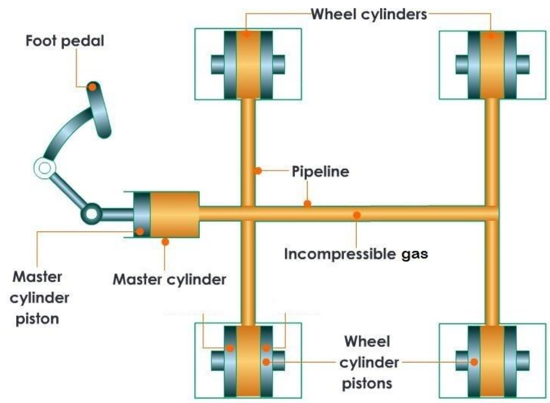
The **Hydraulic brake system** is a braking system which uses brake fluid usually includes ethylene glycol, to transmit pressure from the controlling unit, which is usually near the driver, to the actual brake mechanism, which is near the wheel of the vehicle. The most common arrangement of hydraulic brakes for passenger vehicles, motorcycles, scooters, and mopeds, consists of the following: Brake pedal or Brake lever pushrod, also called an actuating rod, reinforced hydraulic lines, rotor or a brake disc or a drum attached to a wheel Master cylinder assembly includes Piston assembly is made up of one or two pistons, a return spring, a series of gaskets or O-rings and fluid reservoir. Brake caliper assembly usually includes: One or two hollow aluminum or chrome-plated steel pistons called caliper pistons and set of thermally conductive brake pads.

A glycol-ether based brake fluid regularly loads the system or some other fluids are also used to control the transfer of force or power between the brake lever and the wheel. The automobiles generally use disc brakes on the front wheels and drum brakes on the rear wheels. The disc brakes have good stopping performance and are usually safer and more efficient than drum brakes. Many two-wheel automobiles design uses a drum brake for the rear wheel.

In Hydraulic brake system when the brake pedal or brake lever is pressed, a pushrod applies force on the piston in the master cylinder causing fluid from the brake fluid tank to run into a pressure chamber through a balancing port which results in increase in the pressure of whole hydraulic system. This forces fluid through the hydraulic lines to one or more calipers where it works upon one or two extra caliper pistons protected by one or more seated O-rings which prevent the escape of any fluid from around the piston. The brake caliper piston then applies force to the brake pads. This causes them to be pushed against the rotating rotor, and the friction between pads and rotor causes a braking torque to be generated, slowing the vehicle. Heat created from this friction is dispersed through vents and channels in rotor and through the pads themselves



which are made of heat-tolerant materials like kevlar, sintered glass. The consequent discharge of the brake pedal or brake lever lets the spring(s) within the master cylinder assembly to return that assembly piston(s) back into position. This reduces the hydraulic pressure on the caliper lets the brake piston in the caliper assembly to slide back into its lodging and the brake pads to discharge the rotor. If there is any leak in the system, at no point does any of the brake fluid enter or leave. In hydraulic brake the brake pedal is called as brake pedal or brake lever. One end of the hydraulic brake is connected to the frame of the vehicle, the other end is connected to the foot pad of the lever and a pushrod extends from a point along its length. The rod either widens to the master cylinder brakes or to the power brakes. The master cylinder is separated as two parts in cars, each of which force a separate hydraulic circuit. Every part provides force to one circuit. A front/rear split brake system utilizes one master cylinder part to pressure the front caliper pistons and the other part to pressure the rear caliper pistons.



WORKING OF PNEUMATIC BRAKE SYSTEM

Pneumatic or Air Brake System is the brake system used in automobiles such as buses, trailers, trucks, and semi-trailers. The Compressed Air Brake System is a different air brake used in trucks which contains a standard disc or drum brake using compressed air instead of hydraulic fluid. The compressed air brake system works by drawing clean air from the environment, compressing it, and hold it in high pressure tanks at around 120 PSI. Whenever the air is needed for braking, this air is directed to the functioning cylinders on brakes to activate the braking hardware and slow the vehicle. Air brakes use compressed air to increase braking forces. Design and Function: The Compressed air brake system is separated into control system and supply system. The supply system compresses, stores, and provides high pressure air to the control system and also to other air operated secondary truck systems such as gearbox shift control, clutch pedal air assistance servo, etc., Control system: The control system is separated into two service brake circuits. They are the parking brake circuit and the trailer brake circuit. These two brake circuits is again separated into front and rear wheel circuits which get compressed air from their individual tanks for more protection in case of air leak. The service brakes are applied by brake pedal air valve which controls both circuits. The parking brake is the air-controlled spring break which is applied by spring force in the spring brake cylinder and released by compressed air through the hand control valve. The trailer brake consists of a direct two-line system the supply line which is marked red and the separate control or service line which is marked blue. The supply line gets air from the main mover park brake air tank through a park brake relay valve and the control line is regulated through the trailer brake relay valve. The working signals for the relay are offered by the prime mover brake pedal air valve, trailer service brake hand control and Prime Mover Park brake hand control. Supply system: The air compressor is driven off the automobile engine by crankshaft pulley through a belt or straightly off of the engine timing gears. It is lubricated and cooled by the engine lubrication and cooling systems. The Compressed air is initially directed through a cooling coil and into an air dryer which eliminates moisture and oil impurities and contains a pressure regulator, safety valve and a little purge reservoir. The supply system is outfitted with an anti-freeze device and oil separator which is an alternative to the air dryer. The compressed air is then stored in a tank and then it is issued through a 4 - way protection valve into the front and rear brake circuit air reservoir, a parking brake reservoir, and an auxiliary air supply distribution point. The Supply system also contains many checks, pressure limiting, drain and safety valves.

Parking brake:

The parking brake holds the vehicle stationary while it is parked. Since the parking brake is independent of the service brakes, it can be used as an emergency brake if the service brakes fail. When the parking brake is operated by a hand lever, some manufacturers call it the hand brake.

Procedure:

1. First to check the height of the brake pedal. It is normally lower than the clutch pedal.
2. Start the engine, Depress the brake pedal and measure the clearance between brake pedal and floor. It should be within the specification, if less indicates the wear in rear brake shoe or air in the line.
3. If front brake is disc brake. Inspect the brake lining pad thickness, inner parts of calliper brake, Brake disc thickness.
4. Inspect the master cylinder parts for wear or damage, replace if necessary. Inspect master cylinder bore for coring or corrosion.
5. Inspect wheel cylinder parts for wear, cracks, corrosion, or damage.
6. If rear is drum brake, Inspect the brake drum for cleanliness, check wear of its braking surface, brake shoe lining thickness and spring damage or defective.
7. Normally rear brake has self- adjusting mechanism otherwise adjustment mechanism is providing in the back plate for adjust the clearance between brake shoe and drum.

Bleeding of hydraulic braking system:

1. Check the master cylinder for the fluid level in the reservoir.
2. Check and clean the bleed valve.
3. Select one of the wheel cylinders which is far away from the master cylinder,
4. Connect one end of the rubber tube to the drain nipple and the other end to the jar containing brake oil.
5. Press the brake pedal several times and open bleed valve to note whether air bubbles are escaping while keeping the pedal pressed.
6. Close the valve and release the pedal.
7. Repeat the procedure until all the air present in the system is released.
8. Remove the tube and repeat the same for the other three-wheel cylinders.
9. After the process is over, check the fluid level again and refill

Observation Table

S. No	Part name	Quantity	Remarks
1			
2			
3			
4			
5			
6			
7			

Result:

Thus the given brake system is dismantled, inspected and reassembled.

Experiment No - 10

Dismantling, Inspection and Assembly of Suspension System

Aim:

To study, dismantle, inspection and assembly of suspension system.

Tools Required:

Toolbox

Theory:

In this Mac Pherson strut type of suspension only lower wishbones are used, A strut containing shock absorber and the spring also carries the stub axle on which the wheel is mounted. The wishbone is hinged to the cross member and positions the wheel as well as resists accelerating, braking and side forces. Further the camber also does not change when the wheel moves up and down. This type of suspension commonly used on front wheel drive cars.

Leaf Springs The semi-elliptic leaf springs are almost universally used for suspension in light and heavy commercial vehicles. For cars also, these are widely used for rear suspension.

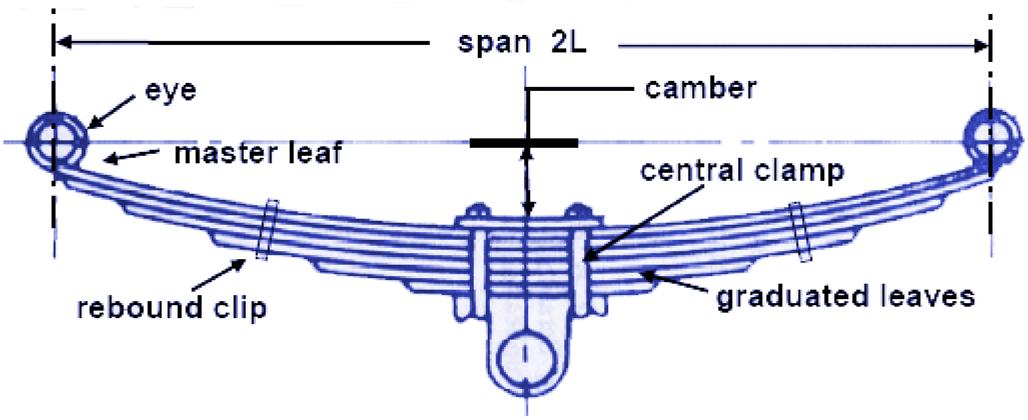
The coil springs are used mainly with independent suspension, though they have also used in the conventional rigid axle suspension as they can be well accommodated in restricted spaces. The energy stored per unit volume is almost double in the case of coil springs than the leaf springs. Coil springs do not have noise problems, nor do they have static friction causing harshness of ride as in case of leaf springs. The spring takes the shear as well as bending stresses. The coil springs, however, cannot take torque reaction and side thrust, for which alternative arrangements have to be provided. A helper coil spring is also used to provide progressive stiffness against increasing load.

Procedure:

Dismantling and assembling of Leaf Spring:

1. Jack up the vehicle using screw jack, Horse stand is placed under the axle for support.
2. The leaf spring assembly is removed from the chassis by losing the bolts at two ends and “U” bolt.
3. All Clips are removed. The spring plates are inspected separately for any breakage.
4. Due to continuous use, the spring assembly gets sagged or gets straightened.

5. Under these circumstances, the spring plate is hammered throughout the length by placing on a special fixture which will give designed cure. This operation is called re-cambering of spring.
6. Proper lubricant is applied and then all springs are assembled.
7. When the shape of spring is different from one another, the opposite spring must also be re-cambered.



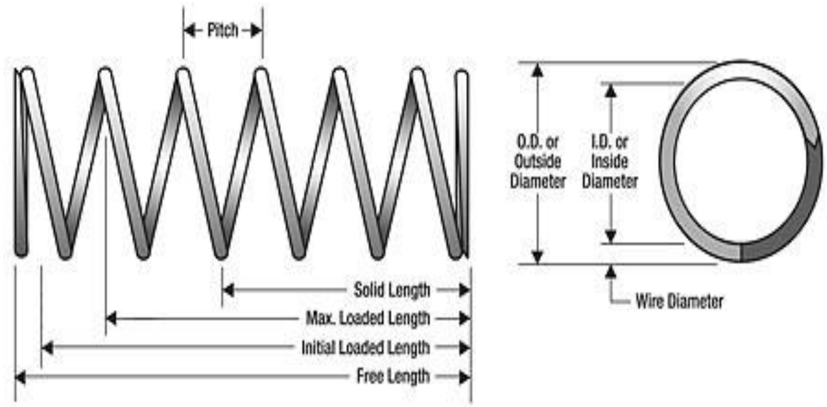
Observation and Calculations:

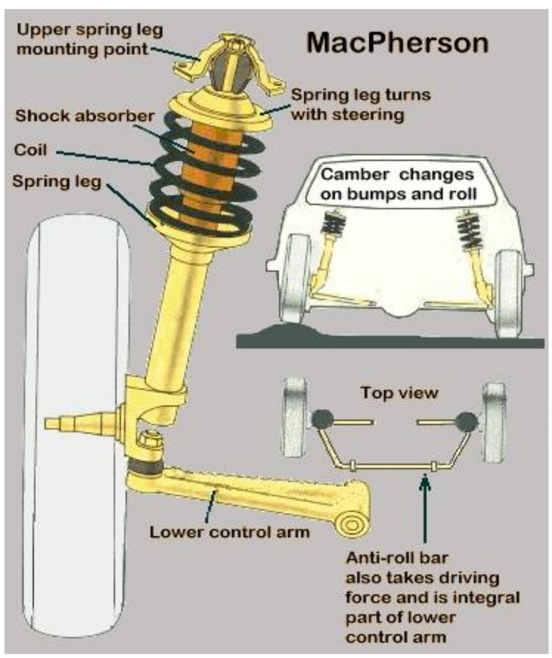
Leaf Spring No.	Leaf Spring Length (in inches)
1	
2	
3	
4	
5	
6	
7	

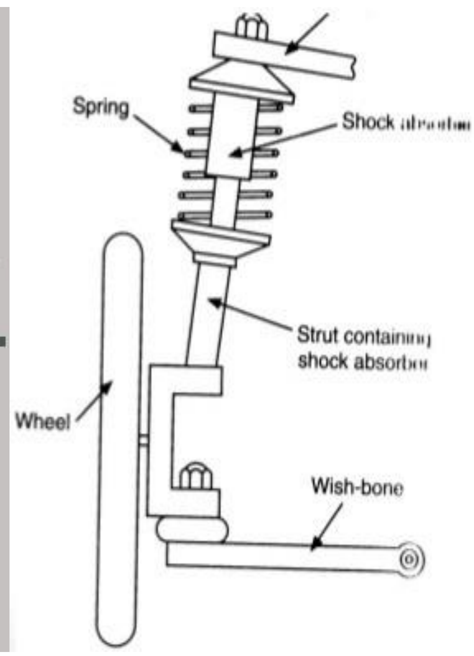
Dismantling and assembling of coil spring:

1. Jack up the vehicle. The wheels are removed.
2. The shock absorber is removed.
3. Now, the upper and lower wish bone arms are free and so, the coil spring can be removed easily.

4. The coil spring is tested on compressive load, if change in length is found, it’s deviation from the manufacture’s specification. Spring is replaced with new one.
5. Rubber pad is checked for any damage. Then refit the coil spring in vehicle.







Result:

Dismantling, inspection, and assembly of suspension system is done.

Experiment No – 11

Dismantling, Inspection and Assembling of Steering Gear box and finding out the gear ratios

Aim: To study dismantling, inspection and assembly of steering gear box and find out the gear ratios.

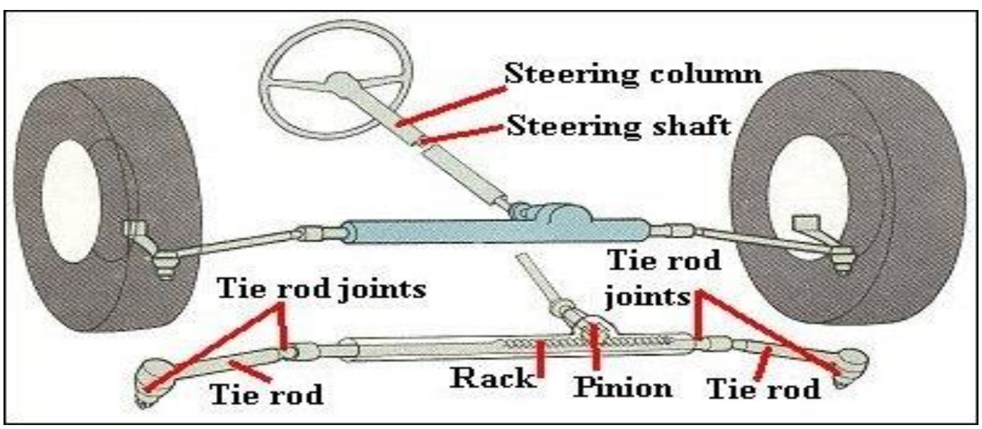
Tools Required: Steering system, toolbox.

Theory:

The main function of the steering mechanism is to steer the vehicle to the left or right as desired, according to vehicle type, its load capacity, design of the steering mechanism changes with vehicle to vehicle. There are number of steering gear boxes including Worm & Roller, Re-Circulating ball type steering mechanism, Rack & Pinion, Worm & Gear type are mainly used in Indian vehicle.

Purpose of Steering System:

The steering system allows the driver to guide the vehicle along the road and turn left or right as desired. The system includes the steering wheel, which controls the steering gear. It changes the rotary motion of the wheel into straight line motion. Manual systems were popular but now power steering has become popular. It is now installed on about 90% of the vehicles being manufactured.



Steering Gear ratio:

The steering ratio is the ratio of the number of degrees of turn of the steering wheel to the number of degrees the wheel(s) turn as a result. In motorcycles, delta tricycles and bicycles, the steering ratio is always 1:1, because the steering wheel is fixed to the front wheel. In most passenger cars, the ratio is between 12:1 and 20:1. For example, if one complete turn of the steering wheel, 360 degrees, causes the wheels to turn 24 degrees, the ratio is then 360:24 = 15:1.

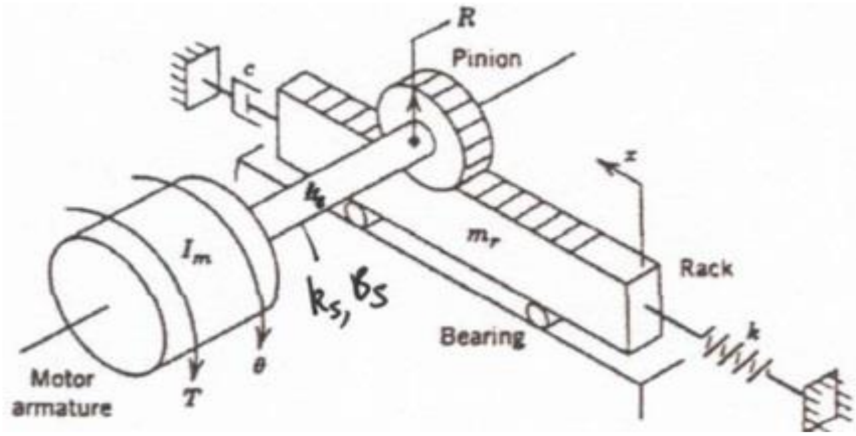
Variable-ratio steering is a system that uses different ratios on the rack in a rack and pinion steering system. At the center of the rack, the space between the teeth are smaller and the space becomes larger as the pinion moves down the rack. In the middle of the rack there is a higher ratio and the ratio becomes lower as the steering wheel is turned towards lock. This makes the steering less sensitive when the steering wheel is close to its center position and makes it harder for the driver to over steer at high speeds. As the steering wheel is turned towards lock, the wheels begin to react more to steering input.

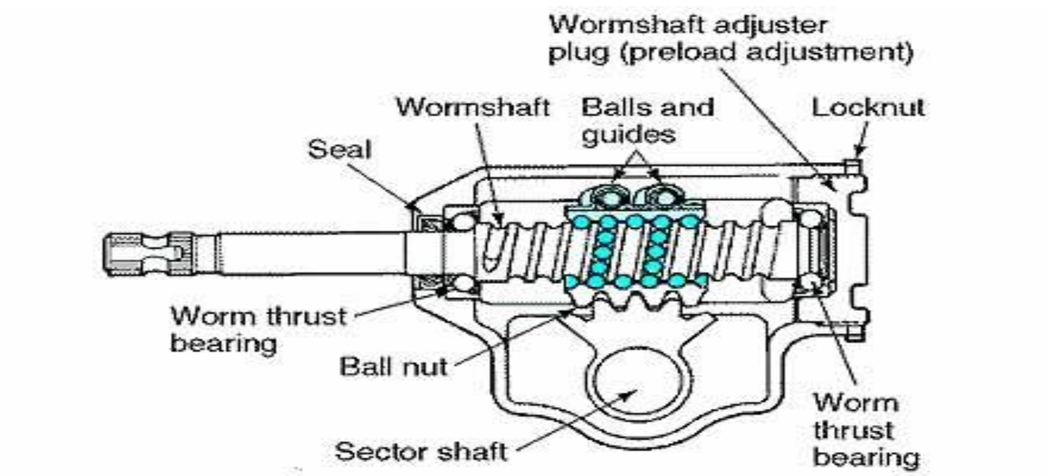
Calculating Gear Ratio:

For two standard round gears, the gear ratio is calculated by counting the number of teeth on each gear and dividing the number of teeth on the driver gear by the number of teeth on the driven gear. For example, a gear with 25 teeth drives a gear with 75 teeth. Dividing 25 by 75 gives you a ratio of 3/1, meaning that for every three rotations the driver gear makes, the larger gear turns once.

Procedure for (Rack and Pinion):

1. Dismantle the ball joint from the steering knuckle
2. Remove the dust covers and dismantle the rods
3. Dismantle the pinion
4. Pull the rack from the steering housing.





The balls are recirculated through the ball guides.

Procedure for (Recirculating ball type):

1. Loose the steering wheel nut and pull out the steering wheel with the help of steering puller.
2. Loosen the lock on the sector shaft
3. Drain all the oil from the steering gear box.
4. Remove the sector shaft at the bottom of the steering column
5. Draw out the worm shaft and nut assembly from the casing
6. Remove the lock from lock adjuster and unscrew the lash adjuster
7. If the sector shaft is worn the replace new parts and retain in position
8. Clean out face movement of worm after replacing it into the casing
9. Refit it in the reverse order.

Procedure for (Worm and Roller type):

1. Loosen the lock on sector shaft
2. Drain all the oil from steering gear box
3. Remove the sector shaft at the bottom of steering column
4. Draw out the worm shaft and nut assembly from casing
5. Remove the lock from lock adjuster and unscrew the last adjuster
6. If the sector shaft is worn out then replace new parts and retain in position
7. Clean out face movement of worm after replacing it into the casing
8. Refit it in the reverse order

Observation Table

S. No	Part name	Quantity	Remarks
1			
2			
3			
4			
5			
6			
7			

Calculations:

Steering ratio $= \frac{\text{Angle turned by steering wheel}}{\text{Angle turned by Vehicle wheel}}$

Angle turned by steering wheel = 60^0

Angle turned by vehicle wheel = 5^0

Steering Gear Ratio $= \frac{\text{No of teeth on output gear}}{\text{No of teeth on input gear}}$

No of teeth on output gear (gear) = 30

No of teeth on input gear (Warm) = 10

Steering gear ratio =

Result:

Dismantling, inspection, and assembly of steering gear box and find out the gear ratios is done.

Experiment No - 12

Dismantling Inspection, and assembling of Front and Rear axle

Aim: Dismantling, inspection and assembling of front and rear axle

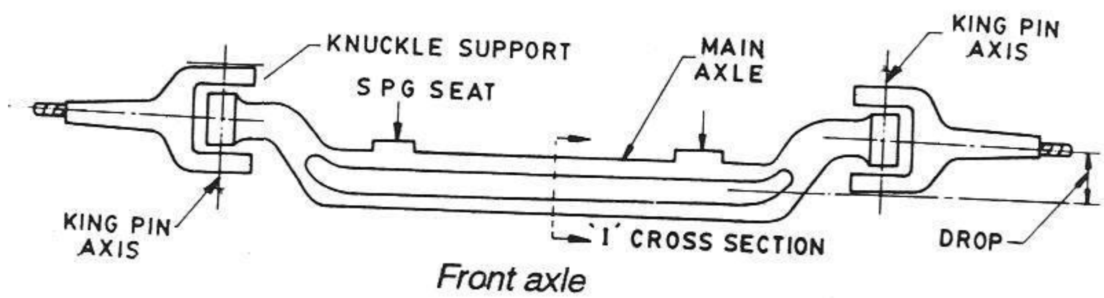
Tools: Front axle, rear axle, and toolbox.

Front axle:

The front axle is used to carry the weight of the front part of the vehicle as well as to facilitate steering and absorb shocks due to road surface variation. It must be rigid and robust in construction. It is usually steel drop forging having 0.4% carbon steel or 1 to 3% Nickel steel.

Functions of front axle:

1. It carries the hubs and the wheels.
2. It carries the weight of the front part of the vehicle.
3. It works as cushion through the spring which facilitates a comfortable ride.
4. It controls the ride through shocks absorber fitted on H. It carries the brake system.
5. It carries stub axle, king pin, Steering arm by which the vehicle steers.
6. In case of four wheel drive it also transmits power to road wheels.
7. It includes steering mechanism, braking mechanism and suspension etc.



Front axle

Procedure:

1. Remove the tyre.
2. Remove the wheel speed sensor from the steering knuckle and pull off the cable.

3. Remove the split pin from steering linkage link knuckle mounting and pull off the slot nut and detach the link from knuckle arm.
4. Remove the two knuckle-brake calliper assembly mounting blots and pull off the calliper assembly.
5. Remove the hub mounting bolt & washer and pull off the hub cover.
6. Remove the retainer ring & outer shin in the drive shaft and pull off the lock.
7. Detach the vacuum hose of locking hub from steering knuckle.
8. Remove the hub & brake disc assembly
9. Remove the hub nut & washer.
10. Remove the front disc assembly from the axle shaft.
11. Remove three-wheel bearing bolts and pull off hub assembly by using the special tool.
12. Remove two dust shield mounting bolts and pull off the dust shield.
13. Remove the split pin and nut from the steering knuckle arm and upper arm ball joint connection.
14. Remove the split pin and nut from the steering knuckle arm and lower arm ball joint connection.
15. Carefully remove the steering knuckle assembly.
16. Remove the drive shaft using the special tool.

Rear axle:

The power from differential is transmitted to rear wheel by rear axle. Depending upon the methods of supporting the rear axle and mounting the rear wheels, the rear axles are classified into three types are:

1) Semi floating type

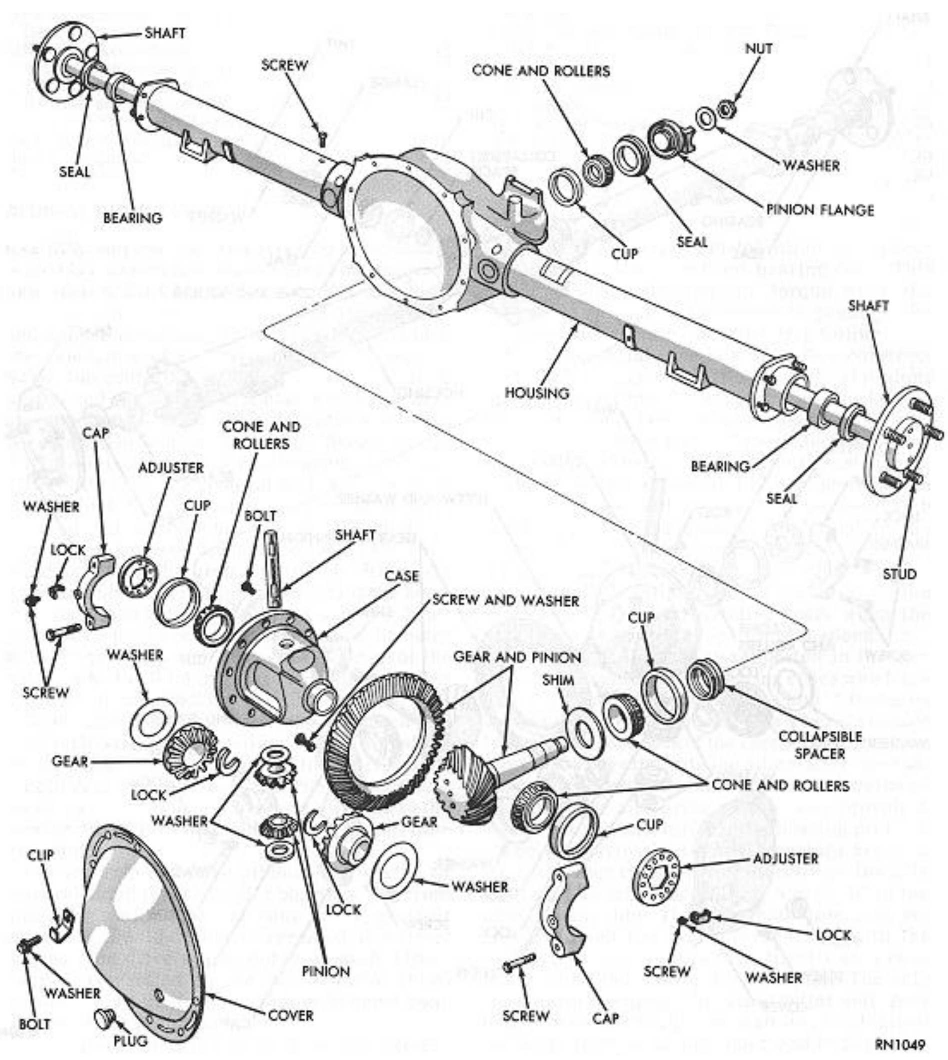
2) Three-quarter floating type

3) Full floating type

Functions of Rear Axle:

As the rear axle is suspended from the body of the vehicle by leaf springs attached to the axle housing. The rear axle performs several functions which are as under;-

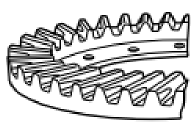
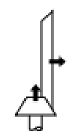
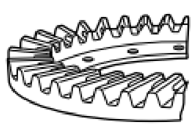
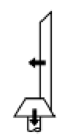
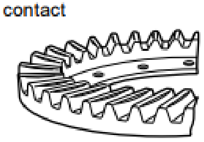
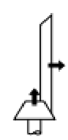
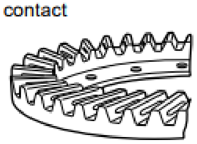
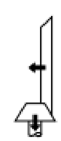
1. Changing the direction of driveshaft rotation by 90 degrees to rotate the axle shafts.
2. Providing a final speed reduction between the drive shaft and the axle shafts through the final – drive gears or differential gears.
3. Providing differential action, so that one wheel can turn at a different speed as compared to both wheel, when required,
4. Providing axle shafts or half shafts to drive the rear wheels.
5. Acting as a thrust and torque reaction member during acceleration and breaking.



Procedure:

1. Jack up car and remove rear wheels. Take out the four bolts connecting the universal ball cap to the transmission case and cover.
2. Disconnect brake rods. Remove nuts holding spring perches to rear axle housing flanges. Raise frame at the rear end, and the axle can be easily withdrawn.
3. Remove two plugs from top and bottom of ball casting and turn shaft until pin comes opposite hole, drive out pin and the joint can be pulled or forced away from the shaft and out of the housing.
4. With the universal joint disconnected, remove nuts in front end of radius rods and the nuts on studs holding drive shaft tube to rear axle housing.
5. Remove bolts which hold the two halves of differential housing together, if necessary to disassemble differential a very slight mechanical knowledge will permit one to immediately discern how to do it once it is exposed to view.
6. Care must be exercised to get every pin, bolt and keylock back in its correct position when reassembling.
7. The end of the drive shaft, to which the pinion is attached, is tapered to fit the tapered hole in the pinion, which is keyed onto the shaft, and then secured by a cotter-pinned "castle" nut.
8. Remove the castle nut and drive the pinion off.
9. The differential gears are attached to the inner ends of the rear axle shaft, they work upon the differential pinions when turning a corner, so that the axle shafts revolve independently, but when the car is moving in a straight line the differential pinions and differential gears and axle shafts move as an integral part.
10. If examine the rear axle shafts, notice that the gears are keyed on, and held in position by a ring which is in two halves and fits in a groove in the rear axle shaft.
11. To remove the differential gears, force them down on the shaft, that is, away from the end to which they are secured, drive out the two halves of ring in the grooves in shaft with screwdriver or chisel, then force the gears off the end of the shafts.

12. Disconnect rear axle, then unbolt the drive shaft assembly where it joins the rear axle housing at the differential.
13. Disconnect the radius rods and brake rods at the outer ends of the housing. Take out the bolts which hold the two halves of the rear axle housing together at the centre and remove the housing. Take the inner differential casing apart and draw the axle shaft out.
14. After replacing the axle shaft, he sure that the rear wheels are firmly wedged on at the outer end of the axle shaft and the key in proper position. It is extremely important that the rear wheels are kept tight, otherwise the constant rocking back and forth against the keyway may in time cause serious trouble.
15. If the rear axle or wheel is sprung by skidding against a curb, or other accident, it is false economy to drive the car without correcting the trouble, as tires, gears and all other parts will suffer. If the axle shaft is bent, it can, with proper facilities, be straightened, but it is best to replace it.

Tooth contact pattern	Possible cause	Remedy
1. Heel contact  A YAD3A480	Excessive backlash • Noise can be occurred	Adjust backlash (Decrease backlash) • Select proper shin to move the drive pinion toward the ring gear (toward toe)  B YAD3A490
2. Toe contact  A YAD3A500	Insufficient backlash • Tooth can be damaged or broken under heavy load	Adjust backlash (Increase backlash) • Select proper shim to move the drive pinion against the ring gear (toward heel)  B YAD3A510
3. Face contact  A YAD3A520	Excessive backlash • Drive pinion shaft is apart from the ring gear • Noise can be occurred	Adjust backlash (Increase pinion shim) • Move the drive pinion toward the ring gear (toward center of ring gear)  B YAD3A530
4. Flank contact  A YAD3A540	Insufficient backlash • Gear contacts on the low flank • Gear can be damaged or worn • Noise can be occurred	Adjust backlash (Decrease pinion shim) • Move the ring gear toward the drive pinion (toward ring gear center line)  B YAD3A550

Observation Table

S. No	Part name	Quantity	Remarks
1			
2			
3			
4			
5			
6			
7			

Calculations

The diameter of front axle =

The distance between spring supports/ suspension pads =

FIND OUT THE GEAR RATIO

To find out gear ratio using formula:

$$\text{Gear ratio} = \frac{\text{No.of teeth in driven gear}}{\text{No.of teeth in driving gear}}$$

Result:

Thus, the given front axle and rear axle assembly is dismantled, inspected, and assembled.

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY
(AUTONOMOUS)

TAMASOMA JYOTHIRGAMAYA

LABORATORY MANUAL FOR METALLURGY&MATERIALS ENGINEERING LAB

B. Tech.II Year I Sem. (Mech.&Auto.)

DEPARTMENT OF MECHANICAL ENGINEERING
Prepard by Dr
Dr.S.Shyam Sunder Rao
Professor

Experiment – 1

Preparation and study of the microstructure of metals like –Iron, Cu and Al

1. AIM:

a) To prepare the given specimen for metallographic examination.
b) To study the constructional details of Metallurgical Microscope and observe the micro structure of the prepared specimen.

2. APPARATUS AND MATERIALS REQUIRED:

Metallurgical microscope, emery belt, 1/0, 2/0, 3/0, 4/0 emery papers, lapping cloth, alumina powder, enchants, sample of metal.

3. THEORY:

The microstructure of metal decides its properties. An optical microscope is used to study the microstructure. A mirror polished surface of the metal is required for metallographic study.

4. PROCEDURE OF SPECIMEN PREPARATION:

a) Cut the specimen to the required size(small cylindrical pieces of 10 to 15mm diameter with 15mm height (or) 10mm cubes)

b) The opposite surfaces (circular faces in case of cylindrical pieces) are made flat with grinding or filling. A small chamfer should be ground on each edge for better handling. (If the sample is small it should be mounted)

c. **Belt grinding:** One of the faces of the specimen is pressed against the emery belt of the belt grinder so all the scratches on the specimen surface are unidirectional

d. **Intermediate polishing:-** The sample is to be polished on 1/0, 2/0, 3/0, 4/0 numbered emery papers with increasing fineness of the paper. While changing the polish paper, the sample is to be turned by 90^0 so that new scratches shall be exactly perpendicular to previous scratches.

e. **Disc polishing** (fine polishing):- After polishing on 4/0 paper the specimen is to be polished on disc polishing machine (Buffing machine). In the disc-polishing machine a disc is rotated by a vertical shaft. The disc is covered with velvet cloth. Alumina solution is used as abrasive. Alumina solution is sprinkled Continuously over the disc and the specimen is gently pressed against it. In case of Non-ferrous metals such as Brass, Brasso is used instead of Alumina and water. The polishing should be continued till a mirror polished surface is obtained.

f. The sample is then washed with water and dried.

g. **Etching:-** The sample is then etched with a suitable etching reagent, detailed in article 5.

h. After etching the specimen should be washed in running water and then with alcohol and then finally dried.

i. The sample is now ready for studying its microstructure under the microscope.

5. ETCHING:

Except for few cases a polished metallic surface can't reveal the various constituents (phases). Hence specimen should be etched to reveal the details of the microstructure i.e. a chemical reagent should be applied on the polished surface for a definite period of time. This reagent preferentially attacks the grain boundaries revealing them as thin lines. Thus under the microscope the gain structure of the metal becomes visible after etching i.e. grain boundary area appears dark and grains appear bright. The rate of etching not only depends on the solution employed and composition of the material but also on the uniformity of the material. A few etching reagents, their composition and their application are given below.

S.No.	Name of Etchant	Composition	Application
1	Nital a) 5% Nital b) 2% Nital	 Nitric.acid (5ml) and Abs. Methyl alcohol (95ml) Nitric acid (2ml) and Abs. Methyl alcohol (98ml)	General structure of iron and steel
2	Picral	Picric acid (4gm) and Abs ethyl alcohol (96 ml)	General structure of iron and steel
3	Marbel's reagent	Copper sulphate (4 gm), Hydrochloric acid (20ml) and water (20ml)	General structure of iron and steel
4.	Murakami's reagent	Potassium ferry cyanide, (10grms), KOH (10grms) and water (100ml).	Stainless steels
5.	Sodium hydroxide	Sodium hydroxide (10gm) and water(90ml)	Stainless steels
6.	Vilella's reagent	Hydro fluoric acid (20ml), Nitric acid (10ml) and Glycerene (30ml).	Aluminium alloys
7.	Kellers reagent	Hydro fluoric acid (1 ml), Hydro chloric acid (1.5 ml), Nitric acid(2.5 ml) and Water (95 ml).	Aluminium & its alloys
8.	Ammonium persulphate Solution	Ammonium persulphate (10gm) And Water(90ml)	Duralumin
9.	$FeCl_3$ solution	$FeCl_3$ (5gm), HCl acid (2ml) and Ethyl alcohol (96ml)	Copper and copper alloys Brass

6. METALLURGICAL MICROSCOPE:

Metallurgical microscope is used for micro and macro examination of metals. Micro examination of specimens yield valuable metallurgical information of the metal. The absolute necessity for examination arises from the fact that many microscopically observed structural characteristics of a metal such as grain size, segregation, distribution of different phases and mode of occurrence of component phases and non metallic inclusions such as slag, sulfides etc., and other heterogeneous condition (different phases) exert a powerful influence on mechanical properties of the metal. If the effect of such external characteristics on properties or the extent of their presence is known, it is possible to predict as to how metal will behave under gone by the metal. Study of structure of metals at magnifications ranging from 50X to 2000X is carried out with the aid of metallurgical microscope.

6.1 Principle:

A Metallurgical microscope is shown in fig.1.1. Metallurgical microscope differs with a biological microscope in a manner by which specimen of interest is illumination. As metals are opaque their structural constituents are studied under a reflected light. As shown in fig.1.2 a horizontal beam of light from an appropriate source is directed by means of plane glass reflectors downwards and through the microscope objective on to the specimen surface. A certain amount of this light will be reflected from the specimen surface and that reflected light, which again passes through the objective, will form an enlarged image of the illuminated area.

A microscope objective consists of a number of separate lens elements which are a compound group behave as positive and converging type lens system of an illuminated object. Specimen is placed just outside the equivalent front focus point of objective. A primary real image of greater dimension than those of object field will be formed at some distance beyond the real lens element. Objective size of primary image w.r.t object field will depend on focal length of objective and front focus point of objective. By appropriately positioning primary image w.r.t a second optical system, primary image may be further enlarged by an amount related to magnifying power of eyepiece. As separation between objective and eyepiece is fixed at same distance equivalent to mechanical tube length of microscope, primary image may be properly positioned w.r.t eye piece. By merely focusing microscope i.e. increase or decrease the distance between object plane and front lens of objective the image is located at focal point. Such precise positioning of primary image is essential in order that final image can be formed and rendered visible to observer when looking into eyepiece. If now entrance pupil of eye is made to coincide with exit pupil of eyepiece, eyepiece lens is in conjunction with cornea lens in eye will form a second real image on retina. This retrieval image will be erect, un reversed owing to the manner of response of human brain to excitation of retina. The image since it has no real existence, known as virtual image and appears to be inverted and reversed with respect to object field.

6.1.1. MAGNIFICATION:

The total magnification is the power of objective multiplied by power of eyepiece

(Power of eye piece) (Distance from eye piece to object) / Focal length of object

The magnification is marked on the side of objective.

6.2 CONSTRUCTION:

The microscope consists of a body tube (refer Fig 1.1), which carries an objective below, and an eyepiece above with plane glass vertical illuminator immediately above the objective. Incident light from a source strikes illuminator at 45^0, part of which is reflected on to the specimen. Rays after reflection pass through the eye again. Working table is secured on heavy base. The microscope has compound slide to give longitudinal and lateral movements by accurate screws having scale and verniers. Vertical movement of specimen platform is made by a screw to proper focusing. For getting perfect focusing fine adjustment of focusing can be made use of.

6.2.1. Light filters: These are used in metallurgical microscope and are essentially of three types

a. Gelatin sheets connected between two planes of clean glass
b. Solid glass filters
c. Liquid dye solution

Solid glass filters are more preferable as they are more durable. Usually light filters are used principally to render a quality of illumination. Hence filters improve degree of resolution.
A METZ - 57 model microscope is used in the laboratory.

6.2.2 Optical compilation:

Eye pieces and objectives of different magnifications are available.

Huygens eyepieces:	5X, 10X
Achromatic objectives:	5X, 10X, 45X

7. PRECAUTIONS:

a. Ensure mirror polished surface of specimen before etching.
b. Fine focusing should be done only after correct focusing has been done.
c. The glass lens should not be touched with fingers.

8. REVIEW QUESTIONS:

1. What is the use of micro structural study?
2. What is the difference among 1/0, 2/0, 3/0 and 4/0 emery papers?
3. What is lapping?
4. What are the different abrasives used in lapping?
5. Why the specimen has to be etched before micro structural study?
6. What is the etchant used for brass?
7. What is the etchant used for mild steel?
8. In a microstructure how the gain boundary area appears?
9. Why specimen is to be rotated through 90(between polishing on 1/0 and 2/0 emery papers?
10. What is etching reagent used for duralumin?
11. Why should a specimen be prepared following the set procedure before its observation under a
12. microscope?
13. Is the specimen preparation necessary at all? If so why? If not why not?
14. What is the difference between Metallurgical microscope and Biological microscope?
15. What is the magnification of the microscope?
16. xv. What are the different magnifications available in the microscope of our laboratory?
17. xvi. What are the precautions to be observed while studying, microstructure under microscope?
18. xvii. What is the use of light filters?
19. xviii. How do you calculate the magnifying power of a microscope?

Experiment – 2

Preparation and study of the microstructure of mild steels, low carbon steels &high carbon steels

1. AIM
To identify the different phases and to draw the microstructures of Plain Carbon Steels.

2. APPARATUS AND SPECIMENS:
Metallurgical Microscope, specimens of plain carbon steel of different composition (un treated)

THEORY:
3.1 Alloy:
Combination of two or more metals is called alloy. The substances that make the alloy are called its components. The metals are mixed together in required proportion when they are in molten form and then they are allowed to solidify together. After solidification the components of alloy may be in the form of solid solution, chemical compound, and mechanical mixture.
If the constituents of the alloy are completely soluble in both liquid and solid state a solid solution is formed. If constituents of the alloy are completely soluble in liquid state and completely insoluble in solid state a mechanical mixture is formed.

3.1.1 Phase:
A homogenous, physically distinct and mechanically separable part of the system under study is known as phase.

3.2 Cooling Curve:
For a Molten metal that is cooled from molten state to room temperature the graph drawn between time on X-axis and temperature on Y-axis is known as a cooling curve. A pure metal solidifies at constant temperature.

3.2. a. Cooling Curve of pure metal:
Cooling curve of pure metal is shown in fig.2.1. At ‘A’ metal is in liquid state. As metal is cooled the solidification starts at ‘B’. As metal is further cooled the temperature of metal remains constant but metal is converted from liquid state to solid state. Solidification is completed at point ‘C’. From ‘C’ to ‘D’ there is no change in the solidified metal (except fall in temperature).

3.2.b. Cooling curve of a solid solution:
If the components of the alloy are completely soluble in both liquid and solid state a solid solution is formed. Cooling curve of a solid solution is shown in fig.2.2. From ‘A’ to ‘B’ the alloy is in liquid state. Solidification starts at ‘B’ and solidification ends at ‘C’. From ‘C’ to ‘D’ there is no change is solid state of alloy. From Fig.3.2 it can be observed that a solid solution alloy is solidified over a range of temperature.

3.2.c. Cooling curve of an eutectic alloy:
Cooling curve of a binary euteotic alloy is shown in fig.2.3. From ‘A’ to ‘B’ the alloy is in liquid state. As alloy is further cooled from ‘B’ the temperature of alloy remains constant, and two solids S_1, S_2 start separating out from the liquid separately. The alloy gets completely solidified at ‘C’ and gives a mixture of

S_1 and S_2 (eutectic mixture). From 'C' to 'D' there is no change in the solidified alloy.

3.3 Cooling Curve of pure Iron:
Cooling curve of pure Iron is shown in Fig. 2.4 Depending on the temperature Iron exists in separate crystalline forms (α, γ, and δ). Above 1539^0C Iron is in liquid state. As Iron is cooled from liquid state at 1539^0C all liquid is converted to δ – Iron. As it is further cooled upto 1400^0C Iron is in the form of δ – Iron and at1400^0C all δ – Iron is converted to γ- Iron. As the Iron is still cooled from 1400^0C upto 910^0C Iron is in the form of γ- Iron and at 910^0C all γ- Iron is converted to non magnetic α- Iron. If the Iron is further cooled from 910^0C, at 768^0C non magnetic α- Iron is converted to magnetic α – Iron. If the Iron is further cooled to room temperature Iron exists as magnetic α – Iron only.

3.4 Iron – Iron Carbide equilibrium diagram:
Iron – Iron Carbide equilibrium diagram is shown in fig. 2.5.

Iron carbon alloys contain less than 2% carbon are called steels and iron carbon alloys that contains >2% Carbon are called cast irons. Steels having <0.8% Carbon, 0.8% carbon and >0.8% carbon are called Hypo eutectoid steels, eutectoid steels and Hyper eutectoid steels respectively.

3.4.1 Curie temperature (768^0C):
At Curie temperature on cooling Non-magnetic α – iron becomes magnetic.
ABCD is the liquids line and AHJECF the solidus line of the system. (i.e. the alloy will be completely in liquid state at all temperature above liquidus line and will be under solid state at all temperatures below solidus line).

3.4.2 Critical points:

The temperature at which the transformation in solid state occurs are called critical points. In hypo eutectoid steels GS (A3 line) and PS (A1 line) represents upper and lower critical points. In hyper eutectoid steels the line SE (Acm) and SK (A13) represents upper and lower critical temperatures respectively.

3.4.3 Different phases that apperar in Fe-Fe_3C diagram:
a. Ferrite (α): It is an interstitial solid solution of carbon in α – iron, maximum solubility of carbon in α – iron is 0.025% at 723oC.
b. Austnite (γ): It is an interstitial solid solution of carbon in γ – iron, maximum solubility of carbon in γ – Iron is 2% at 1130oC.
c. Cementite (Fe_3c): It is a chemical compound of iron and carbon that contains 6.67% carbon by weight.
d. Pearlite: The eutectoid mixture of Ferrite and cementite is called Pearlite.
e. Lideburite: The eutectic mixture of austenite and cementite is called Lideburite
the three horizontal lines in the diagram (HJB, ECF and PSK) indicate three isothermal reactions at fixed composition and temperature.

3.5 Slow Cooling Hypo Eutectoid steel (0.18% Carbon):
In fig 2.5 alloy 1 represents 0.18% carbon steel. Initially at X, the alloy is in completely liquid state as shown in fig 3.6a. As it is cooled when it crosses 'AB' line δ – Iron neucli start forming in liquid Iron. The Micro structure of the alloy at X_2 is shown in fig 2.6b. As alloy is further cooled, when it crosses 'BJ' line at 'J' liquid Iron and δ – Iron are combined together at constant temperature to form γ- Iron. This reaction is known as peritectic reaction.

Cooling

$$L + \delta \longrightarrow \gamma$$

(liquid) + (δ - Iron) (Austenite)

If the alloy is further cooled at X_3 the microstructure of the alloy consists of homogeneous solid solution of γ – Iron as shown in fig. 2.6c.

Upon slow cooling of alloy from X_3 nothing happens until 'A_3' line ferrite begins to form at austenite grain boundaries. The micro structure of alloy at X_4 is shown in fig.2.6d. As cooling progresses amount of ferrite increases and remaining austenite becomes richer in Carbon.

On further cooling of alloy from X_4 it crosses A_1 line (Lower critical temperature line) at X_6. The Microstructure of alloy 1 at X_5 (just above A_1line) is shown in fig 2.6e. The microstructure shows austenite (around 22%) and proeutectoid ferrite (77%).

At X_6 the Austenite gets converted into ferrite and cementite (a Mechanical mixture) at constant temperature. This is known as eutectoid reaction.

$$\text{Austenite} \xrightarrow{\text{Cooling}} \text{(Ferrite + Cementite)} \quad \text{(pearlite)}$$

The eutectoid mixture of ferrite and cementite is known as pearlite. At temperature just below X_6 the micro structure shows pearlite and proeutectoid ferrite as shown in fig.2.6f

On further cooling of the alloy to room temperature no more phase changes are observed. Hence at room temperature microstructure shows pearlite and proeutectoid ferrite.

3.6 Cooling of Eutectoid Steel (0.8% Carbon):

In Fig 2.5 alloy 2 represents 0.8% Carbon steel. Initially at X_1 the alloy is completely in liquid state as shown in fig.2.7a. On slow cooling once it crosses 'BC' line (liquidus line) γ- Iron dendrites start forming in the liquid Iron. At X_2 alloy consists of γ – Iron dendrites in liquid Iron as shown in fig.2.7b. As the cooling of alloy is continued more and more austenite is formed until it crosses 'EJ' line. At X_3 the alloy consists of uniform solid solution of γ – Iron as shown in fig 2.7c. On further cooling of alloy from X_3 no changes is observed until it crosses 'PSK' line (lower critical temperature line) at 'S'. At point 'S' all the austenite present in the alloy undergoes eutectoid reaction at constant temperature (723^0C) and gets converted into pearlite (mechanical mixture of ferrite and cementite).

$$\text{Austenite} \xrightarrow{\text{Cooling}} \text{(Ferrite + Cementite)} \quad \text{(pearlite)}$$

Just below the eutectoid temperature line ('PSK') at X_4 the alloy consists of 100% pearlite as shown in fig. 2.7d. There is no change in microstructure on cooling of the alloy from X_4 to room temperature.

3.7 Cooling of Hyper eutectoid steel (1% Carbon):

In fig.2.5 'alloy 3' represents 1% Carbon steel. Initially at $X1_1$, the alloy is completely in liquid state as shown in fig.2.8a. On slow cooling from X_1 no change is observed till 'BC' line (liquidus line) is crossed. Once 'BC' line is crossed on further cooling of alloy to X_2 austenite crystals start neucleating from liquid

Iron as shown in fig.2.8b.As cooling is continued more and more amount of austenite is formed. By the time it crosses the line ‘JE’ all liquid Iron is converted to austenite. At X_3 the alloy consists of unform solid solution of austenite as shown in fig2.8c. On slow cooling of alloy from X_3 nothing happens until ‘Acm’ line is crossed at X_4. Above X_4 austenite is an unsaturated solid solution. At X_4 austenitie is saturated with carbon. As the temperature is decreased carbon content of austenite (maximum amount of carbon that can be desolved in austenite) decreases along ‘ES’ line. So on cooling of alloy from X_4 to X_5 excess carbon is precipitated as cementite primarily along grain boundaries. The micro structure of alloy from X_5 is shown in fig.2.8d. On further cooling of alloy, once temperature of alloy crosses lower critical temperature line(‘PSK’ line) at X_7 the austenite present in the alloy undergoes eutectoid reaction and gets converted into pearlite. Just below $A_{3.1}$ line (‘SK’ line) at X_7 the microstructure of alloy shows around 96% pearlite and continuous network of cementite (around 4%) as shown fig 2.8e.

3.8 Plain Carbon Steels:

The usual composition of plain carbon steel is as follows

Carbon 0.08 to 1.7%; Mn 0.3 to 1.0%; Silicon 0.05 to 0.3%; Sulphur 0.05 % (max); Phosphorus 0.05% (max)

In plain carbon steels, carbon percentage plays a vital role in deciding the properties of steels. Depending on the carbon percentage plain carbon steels are divided into three types.

a. Low carbon steel (Mild steel) b. Medium carbon steel c. High carbon steel

The microstructure of low carbon steel (Mild steel) consists of single phase ferrite, (equi axial grains) i.e., it doesn’t respond much to the heat treatment. The properties don’t vary to any treatment given to the mild steel. It remains mild.

4. The following specimens are to be studied for their Microstructure in this exercise

a. Mild steel:

Specimen	:	Mild steel
Composition	:	Very low carbon (0.05%), remaining iron
Heat treatment	:	Nil
Etchant	:	Nital
Etching time	:	10 seconds

The structure is single phase equiaxed grains of ferrite.
Application: nuts, bolts, rivets, shafts etc.,

b. Hypo eutectoid steel:

Specimen	:	Hypo eutectoid steel
Composition	:	0.5% carbon, remaining iron
Heat treatment	:	Nil
Etchant	:	Nital
Etching	:	10 seconds

The microstructure shows ferrite and pearlite.

c. Eutectoid steel:

Specimen	:	Eutectoid steel
Composition	:	0.8% carbon, remaining iron
Heat treatment	:	Nil
Etchant	:	Nital
Etching time	:	10 seconds

The microstructure of eutectoid steel consists of 100% pearlite.

d. Hyper eutectoid steel:

Specimen	:	Hyper eutectoid steel (High carbon steel)
Composition	:	1% carbon, remaining iron
Heat treatment	:	Nil
Etchant	:	Nital
Etching time	:	10 seconds

The microstructure shows continuous network of cementite along the gain boundaries of coarse pearlite.

REVIEW QUESTIONS:

1. What is a cooling curve?
2. What is the use of equilibrium diagram?
3. What is Curie temperature?
4. What is the percentage of carbon in cememtite?
5. What are the different phases in Fe- Fe_3c equilibrium diagram?
6. How Cast iron and steel are distinguished with respect to carbon percentage?
7. What is eutectoid reaction?
8. What is eutectic reaction?
9. What is peritectic reaction?
10. What is peritectoid reaction?
11. Draw the microstructure of eutectoid steel?
12. Draw the microstructure of hypo eutectoid steel?
13. Draw the microstructure of hyper eutectoid steel?
14. What is the maximum solubility of carbon in ferrite?
15. What is the maximum solubility of carbon in Auestenite?
16. What are the properties & applications of mild steel?
17. What are the properties & applications of medium carbon steel (Hypo eutectoid steel)?
18. What are the properties & applications of Eutectoid steel?
19. What are the properties & applications of Hyper eutectoid steel?

Experiment-3

Study of the microstructure of cast iron

1. AIM:

To identify the different phases and to draw the microstructures of different cast irons.

2. APPARATUS AND SPECIMENS REQUIRED:

Metallurgical microscope, specimens of different cast irons

3. THEORY:

Cast irons are Iron carbon alloys in which carbon content varies from 2 to 6.67%. Castirons that Contain carbon percentage between 2 to 4.3% it is called Hyper eutectic cast iron.

3.1 Cooling of a Hypo eutectic cast iron(3% carbon):

Alloy 4 in fig.2.5(Iron – Iron carbide equilibrium diagram) represents Hypo eutectic castiron with 3% carbon. Initially at point X_1 the alloy is in completely liquid state as shown in fig.5.1a. As it is slowly cooled no change is observed until it crosses 'BC' line (liquidus line). After crossing 'BC' line austenite dendrites start forming from liquid iron. At X_2 the microstructure of alloy shows dendrites of proeutectoid austenite in liquid iron as shown in fig.5.1b. On further cooling of alloy when it crosses 'ECF' line (eutectic temperature line) liquid of alloy undergoes eutectic reaction at constant temperature (1130^0C) and transforms into lideburite (eutectic mixture of austenite and cementite)

$$\text{Liquid eutectic cast iron} \xrightarrow{\text{Cooling}} \text{(Austenite + Cementite)} \qquad \text{(lideburite)}$$

The microstructure of alloy at X_3 consists of dendrites of primary austenite, eutectic austenite and Cementite as shown in fig.5.1c. On further cooling of alloy there is no considerable change in microstructure except increase of cementite (This cementite is separated from austenite because of decrease of solubility of carbon in austenite as temperature is reduced).

On further cooling of alloy when 'PSK' line (eutectoid temperature line) is crossed the austenite (primary as well as eutectic) undergoes eutectoid reaction at constant temperature(723^0C) and is converted to pearlite. At X_4 the microstructure of alloy consists of dendritic areas of transformed austenite (i.e. pearlite) in the matix of transformed lideburite (pearlite+cementite) as shown in fig.5.1.d.

3.2 Cooling of Eutectic cast iron (4.3% carbon):

Alloy 5 in fig.2.5 represents eutectic castiron with 4.3% carbon. Initially at X_1 the alloy is completely in liquid state as shown in fig.5.2a. On further cooling of the alloy no change is observed until crosses 'ECF' (eutectic temperature line)at C. At 'C' liquid iron undergoes eutectic reaction at constant temperature (1130^0C) and transforms into lideburite. At X_2 the alloy consists of completely lideburite (Austenite + Cementite) as shown in fig.5.2b. On further cooling of alloy no change is observed till it crosses 'PSK' line. When alloy crosses eutectoid temperature line('PSK') eutectic austenite undergoes eutectoid reaction at 723^0C and transforms into pearlite. The microstructure of alloy at X_3 (just below 'PSK' line) consists of transformed austenite (pearlite and cementite) as shown in fig.5.2c. On further cooling of alloy to room temperature there is no change in the microstructure.

3.3 Cooling of Hyper eutectic cast iron (4.5% Carbon)

Alloy 6 in fig.2.5 represents Hyper eutectic castiron with 4.5% carbon. Initially at X_1 the alloy consists of only liquid iron as shown fig.5.3(a). On cooling of alloy no change is observed till it crosses 'CD' line. After crossing 'CD' line cementite starts nucleating from liquid iron. The microstructure of alloy at X_2 consists of proeutectic cementite dendrites in liquid iron as shown in fig.5.3b. On further cooling of alloy no change is observed till it crosses 'ECF' line (eutectic temperature line). When 'ECF' line is crossed liquid of alloy undergoes eutectic reaction at constant temperature (1130^0C) and is transformed into lideburite (eutectic mixture of austentite and cementite). The microstructure of alloy at X_3 (just below 'ECF' line) consists of eutectic austenite, cementite and proeutectic cementite as shown in fig.5.3c. On further cooling of alloy no change is observed till it crosses 'PSK' line (eutectoid temperature line). When it crosses 'PSK'line the austenite of alloy undergoes eutectoid reaction at constant temperature (723^0C) and transforms into pearlite. At X_4(just below 'PSK' line) the microstructure consists of cementite and pearlite as shown in fig.5.3d. The alloy is further cooled to room temperature there is no change in the microstructure.

3.4 The useful properties of cast iron are

i) Good fluidity(ability to fill narrow cavities in castings in liquid steel) ii) Low melting point iii) Good machinablity iv) Less dimensional changes during solidification.

Cast irons are brittle and have low tensile strength than most of the steels. Specially in the case of Grey cast iron, the graphite present will act like cracks and reduce tensile strength, toughness etc.,

Types of cast irons:

Depending on the form of carbon, cast irons are divided into

a) white cast iron b) Gray cast iron c) Malleable cast iron d) Speheroidal cast iron e) Chilled cast iron

3.5a White cast iron:

In white cast iron most of the carbon is present in combined form as cementite. This is obtained by rapidly cooling the cast iron from its molten state. These are hard and hard and wear resistant. These are used only for hard and wear resistance applicarions and also used as raw material to produce malleable iron. At room temperature microstructure of Hypi eutectic C. I consists of dendritic areas of transformed austenite in a matrix of transformed lideburite. At room temperature microstructure of eutectic cast iron consists of cementite and pearlite. At room temperature microstructure Hyper eutectic cast iron consists of cementite and pearlite. At room temperature microstructure Hypereutectic C.I consists of dendrites of primary cementite in the matrix of transformed lideburite.

3.5b Grey cast iron:

In Grey cast iron carbon is present as free graphite flakes. They contain more carbon and silicon content than white cast irons. It is a low melting alloy having good castability and good damping capacity. The tendency of carbon to form graphite flakes is due to increase in carbon and silicon content and decreasing the cooling rate. Grey cast iron receive its name from the color of a freshly made fracture. At room temperature the microstructure of Grey cast iron consists of graphite flakes and pearlite.

3.5c Malleable cast iron;

Malleable cast iron is produced by heating white cast iron to 900 to 1000^0C for about 50 hours followed by slow cooling to room temperature. On heating white cast iron, cementite structure tend to decompose into ferrite and tempered carbon. The lubrication action of graphite imparts high machinability to malleable cast iron. Malleable castings are tough, strong and shock resistant. These are used for wide range of applications such as automobile parts, railroad equipment, man hole covers etc., At room temperature the microstructure of Malleable cast iron consists of rosettes of tempered carbon graphite in the matrix of pearlite.

3.5d Speroidal graphite cast iron (Nodular cast iron or Ductile cast iron) :

Sheroidal graphite cast iron is an iron carbon alloy having a structure composed of nodules (spheroids) of graphite formed directly during the precess of solidification and embedded in matrix of steel. The formation of spherical graphite is due to addition of magnesium for hypo eutecthic cast iron and cerium for hyper eutectic cast iron. This is used for hydraulic cylinders, values cylinder heads for compressor and diesel engine etc., Due to spherodization tensile strength, ductility and toughness are improved. This cast iron combines the advantages of cast iron and steel. The graphite in spherical shape reduces stress concentration effect and hence higher strength and toughness results.

3.5e Chilled cast iron:

Chilled cast iron is produced by adjusting the composition of white cast iron and then cooling it rapidly to room temperature. Rapid cooling promotes hard, thin layer on the surface of a soft iron casting. It is used where surface hardness is important. It finds applications in making dies and rolls for crushing.

4. The Micro structure of following cast irons are studied in this exercise

4.a Grey cast iron:

Specimen	:	Grey cast iron
Composition	:	3.5% carbon 2% silicon 0.5% manganese 0.4% phosphorous 0.09% sulphur
Heat treatment	:	Nil
Etchant	:	Nital
Etching time	:	20 seconds

The micro structure shows uniformly distributed and ranbomly oriented graphite flakes in the matix of ferrite and pearlite.

Applications: These are widely used for machine bases, engine frames, cylinders and pistons of I.C engines etc.,

b. White cast iron:

Specimen	:	White cast iron
Composition	:	4% carbon 0.5% silicon 0.4% manganese 0.05% phosphorous 0.3% sulphur
Heat treatment	:	Nil
Etchant	:	Nital
Etching time	:	20 seconds

The micro structure shows dendrites of transformed austenite (pear) in the matrix of transformed Ledeberite(i.e., pearlite and cemenite). Majority of these cast irons are Hypo eutectic cast irons.

Applications: Used for wearing plates, pump linears, dies, etc., and also for production of Malleable castings.

c. Malleable cast iron:

Specimen	:	Malleable cast iron
Composition	:	4% carbon 0.5% silicon 0.4% manganese 0.1% phosphorous 0.1% sulphur
Heat treatment	:	Nil
Etchant	:	Nital
Etching time	:	20 seconds

The micro structure shows irregular nodules of tempered carbon (graphite) in the matrix of white ferrite phase, (if cooling rate is low) or pearlite phase (if cooing rate is high).

Applications: Cam shafts, Crank shafts, Axles, etc.,

d. Speheroidal graphite cast iron (Nodular cast iron or Ductile cast iron):

Specimen	:	Ductile cast iron/Nodular/Spheroidal cast iron
Composition	:	3.3% carbon 2.4% silicon 0.05% manganese small amount of Mn , phosphorous, sulphur
Heat treatment	:	Nil
Etchant	:	Nital
Etching time	:	20 seconds

The micro structure shows a typical structure. It contains nodules(spheroids) of graphite surrounded by ferrite in the matrix of pearlite.

Applications: Used for gears, punches, dies, metal working rolls, furnace doors, etc.,

5. REVIEW QUESTIONS:

1. What are the different types of cast irons?
2. What is the difference between White cast iron and Grey cast iron?
3. What are the important properties of Grey cast irons?
4. Why White cast iron has limited applications?
5. What is the structure of Malleable cast irons? Explain the heat treatment cycles used for black heart and
6. white heart malleable irons?
7. What is the additional metal added for sperodisation for Hypo and Hyper eutectic cast irons? How they
8. act?
9. What is Chilled cast iron?
10. What is the difference between Ferritic malleable, Pearlitic malleable and Pearlitic-ferritic malleable
11. casr irons?
12. Why Gray cast iron has got that name?
13. Why Gray cast iron is so brittle?
14. Explain important properties of different types of cast irons?

Experiment-4(a)

Study of the microstructure of non-ferrous alloys (Pure Metals)

1. AIM:
Determine the phases present, and draw the microstructure of Copper, Aluminium & Magnesium.

2. APPARATUS AND SPECIMENS REQUIRED:
Metallurgical microscope, specimens of Aluminum, Copper and Magnesium.

3. THEORY:

3.1 INTRODUCTION TO NON FERROUS METALS

Non ferrous metals don't contain iron as basse. A wide range of non ferrous metals are employed for various engineering applications. Most Non ferrous metals posses good corrosion resistance, formability, castablity and special electrical and magnetic properties. Important Non-ferrous metals, their melting points and crystal structures are tabulated here under.

S.No	Name	Melting point Degrees C	Crystal structure
1.	Aluminium (Al)	660	FCC
2.	Antimony (Sb)	630	Rhombohydra
3.	Bismuth (Bi)	271	Rhombohydra
4.	Cadmium (Cd)	321	CPH
5.	Chromium (Cr)	1900	BCC
6.	Copper (Cu)	1083	FCC
7.	Gold	1064	FCC
8.	Lead	327	FCC
9.	Magnesium (Mg)	650	CPH
10.	Manganese	1250	Complex cubic
11.	Nickel (Ni)	1453	FCC
12.	Silver (Ag)	961	FCC
13.	Tin (Sn)	232	Body centered tetragonal
14.	Zinc	419	CPH

The microstructure of following specimen is studied in this experiment.

a. Copper:

Specimen	:	Pure Copper
Heat treatment	:	Nil
Etchant	:	Ferric chloride solution
Etching time	:	100 seconds

The micro structure shows equi axed grains of copper.

b. Aluminum:

Specimen	:	Pure Aluminum
Heat treatment	:	Nil
Etchant	:	Ferric chloride solution
Etching time	:	60 seconds

The micro structure shows grains of Aluminum.

c. Magnesium:

Specimen	:	Magnesium
Heat treatment	:	Nil
Etchant	:	Ferric chloride solution
Etching time	:	60 seconds

The micro structure shows grains of magnesium.

5. REVIEW QUESTIONS:

1. What are the important properties of Non-Ferrous metals and alloys?
2. List out some important Non-Ferrous metals?
3. What is melting point temperature of Aluminum?
4. What is the crystal structure of Magnesium?
5. FCC metals are usually ductile and have high strain hardening tendency. Explain why?

Experiment-4(b)

Study of the microstructure of non-ferrous alloys (Alloys)

1. AIM:
Determine the phases, and draw the microstructure of some Non ferrous alloys.

2. APPARATUS AND SPECIMENS REQUIRED:
Metallurgical microscope, specimens of α – brass, α - β- brass, Gunmetal and Tin based babbit.

3. THEORY:

3.1 Brasses:
Brasses are the alloys of Copper and Zinc. From the copper-zinc equilibrium diagram
One can observe that the region of α – solid solution is quite wide extending from 0 to 38% of Zinc. If Zn percentage is more than 38% a second solid solution β is formed. With zinc content more than 50% another solid solution called gamma is found. Useful Cu-Zn alloys are those that contain less than 40% Zn.

Different brasses are Cap copper(contains 2 to 5% zinc), Gilding metals (contans 5 to 15% zinc) Cartridge brass(70% copper, 30% zinc), Admiralty brass(69% copper, 30% zinc,1% tin), Muntz metal(60% copper, 40%zinc), Naval brass(60%copper, 39% zinc, 1% tin).

3.2 Copper-Tin Alloys:-
Alloys containing principally copper and tin are called Bronzes. Bronzes posses desirable properties of strength, wear resistance and salt water corrosion resistance. From Copper-Tin equilibrium diagram, one can observe that the solubility of Tin Copper is 13.5% at 798^0C, and it increases to 15.8% at 586^0C, and remains constant up to 520^0C, decreases to 11% at 350^0C and to about 1% at room temperature. With larger proportions of Tin the hard compounds like Cu_3Sn, epsilon phase, may appear in the structure. Useful engineering alloys in this system are those containing less than 20% Tin.

General range of composition of bronzes with respect to Copper and Tin content may be divided into four groups as follows.

a. Alloys containing up to 8% Tin which are used for sheets and wires.
b. Alloys containing Tin percentage between 8 to 12, which are used for gears and other machine parts.
c. Alloys containing between 12 and 20% Tin which are used for bearing.
d. Alloys containing between 20 and 25% Tin which are used for bells.

4. The microstructure of following specimens is observed in this exercise.
a. Cartridge Brass (α Brass):

Specimen	:	Cartridge brass
Composition	:	70% Cu, 30% Zn
Heat treatment	:	Nil
Etchant	:	Ferric chloride
Etching time	:	60 seconds

The microstructure shows single phase α – solid solution of zinc in copper, grains of α – phase are polygonal and grain size is mixed.

Application: Used for cartridge cases, radiator fins, rivets etc.,

b. Muntzmetal (α - β Brass):

Specimen : Muntz metal
Composition : 60% Cu, 40% Zn
Heat treatment : Nil
Etchant : Ferric chloride
Etching time : 60 seconds

The microstructure shows two phases. White α – phases(α- solid solution of Zn in copper) is present in the matrix of dark β- phase(β-solid solution of Zinc in Copper)

Applications: Utensils, Shafts, nuts, bolts and condenser tubes.

c. Gun metal:

Specimen : Gun metal Bronze
Composition : 10% Sn, 2% Zn, Balance is Copper
Etchant : Ferric chloride
Etching time : 40 seconds

The microstructure shows heavily cored dendrites of and islands of (α+δ) eutectoid.
Applications: it is widely used for gun barrels, marine parts, valve bodies, bearing bushes etc.,

d. White metal alloys (Babbits):

babbiets are either Lead based or Tin based alloys. Both the types contain Antimony. These are mainly used as baering materials. The microstructure of Babbits consists of hard cuboids of (Sn-Sb) in a soft matrix of eutectoid. In addition to above cuboids the microstructure may consists of hard needles of CuSn and hard star shaped crystals of Cu_3Sn.

Specimen : Tin Base Babbit
Composition : 84% Sn, 7%Cu, 9%Sb
Heat treatment : Nil
Etchant : Ferric chloride solution
Etching time : 20 seconds

The microstructure shows star shaped Cu-Sn compound. Rectangular crystals of Sn-Sb compound are observed in ductile matrix of Cu- Sn- Sb ternary eutectic.
Applications: Bearings.

5. REVIEW QUESTIONS:

1. What are the important alloys of Copper & Zinc?
2. What is composition of Muntz metal?
3. What is the composition of Cartridge Brass?
4. What is a Bronze?
5. What is composition of Gun metal?
6. What are the important applications of Gun metal?
7. What is a Bell metal?
8. What is melting point of Tin?
9. What is use of Babbit metals? Explain why?
10. What is the microstructure of Tin based Babbit?

Experiment-5

Study of the microstructure of heat treated steels

1. AIM:
To identify the different phases and to draw the microstructures Heat treated plain carbon steel.

2. APPARATUS AND SPECIMENS REQUIRED:
Metallurgical microscope, Muffle Furnace, specimens of high carbon steel subjected to Annealing, Normalizing, and Hardening

THEORY:

3.1 Heat Treatment: It involves heating the metal to a suitable temperature within the solid state, maintaining the sample at the temperature for a specified period of time and cooling it to room temperature in a controlled manner.

The purpose of Heat treatment may be

- To relieve internal stresses and soften the metal for further deformation.
- To refine the grain size to improve mechanical properties.
- To alter the surface condition.
- To increase corrosion and wear resistance.

3.1.1 Different Heat Treatment processes are:
a. Annealing b. Normalizing c. Hardening d. Tempering e. Surface hardening treatments

3.2 Time Temperature and Transformation Diagram (TTT Diagram):
The TTT Diagram super imposed with different cooling rates of steel from austenitising temperatures to room temperature is shown in fig.3.1

in Fig. 3.1 V1 represents annealing (with slow cooling in the furnace)
V_2 represents Normalizing (a little faster cooling i.e in air)
Vc represents Critical cooling rate (more faster cooling in a bath of a mixture)
V_5 represents Hardening (very fast cooling – dipping the specimen in oil or water)

3.3 Annealing:
The main purpose of annealing is stress relieving so that ductility of the steel can be improved to a greater extent. The Annealing temperature range of steel is shown in fig. 3.2.
Annealing process cycle on Time-Temperature diagram is shown in fig.3.4 Annealing process consists of

a. Heating the specimen of steel to a temperature (above A_3 line in case of Hypo eutectoid steels and above A_{31} line in case of Hyper eutectoid steels).
b. Holding specimen at that temperature for a specified period of time (depending on the section thickness)
c. Then cooling the steel specimen to the room temperature in the furnace itself.
The annealed structure of hypo eutectoid steel consists of Ferrite and coarse pearlite.

3.4 Normalizing: The purpose of Normalizing is to

a. Relieve the internal stresses
b. Refine the structure and improve the machinablity

Normalizing temperature range of steels is shown in fig.3.2

Normalizing process cycle Time-Temperature diagram is shown in fig.3.5 Normalizing process consists of

a. Heating the specimen of steel to a temperature (30 to 50^0C above A3 line in case of hypoeutectoid steels and above Acm line in case of Hyper eutectoid steels.)
b. Holding the specimen at this temperature for a specified period of Time.
c. Then cooling the specimen to the room temperature in air.

Normalized Hypo eutectoid steel consists of Ferrite and fine Peralite.

3.5 Hardening: Main purpose of hardening is to improve the hardness & wear resistance of steels. Temperature range of hardening of steels is shown in fig.3.3.

a. Heating the steel specimen to a temperature (50C higher than A3 line in case of hypo eutectoid steel and around 50c higher than A3 line in case of hyper eutectoid steel)
b. Holding at that temperature for sufficient period of time.
c. Quenching in water or oil to cool the specimen of steel to room temperature

The Micro structure of hardened hyper eutectoid steel consists of fine martensite embedded with carbon network.

3.6 Tempering: Main purposes of tempering are

a. To reduce the thermal stresses
b. To Stabilize the structure of metal.
c. To reduce the hardness and brittleness.
d. To increase ductility and toughness of hardened steel specimens.

Tempering process cycle on Time – Temperature diagram is shown in fig.3.7. Tempering process consists of heating the specimen to a temperature below lower critical temperature for sufficient period of time and then slowly cooling to room temperature.

Microstructure of hardened and tempered steel consists of Ferrite and finely divided cementite.

3.7 Case hardening: For certain application hard wear resistant case and tough core is required. To get hard case and tougher core steels must be subjected to Case hardening treatment.

3.8 Case hardening methods:

Case hardening methods are broadly divided into two types

a. Methods of case hardening by altering the surface chemical composition of the components. Examples of this type are (i) carburizing (ii) Nitriding (iii) Carbonitriding
b. Methods of case hardening without altering the surface chemical composition of the components. Examples of this type are (i) Flame hardening (ii) Induction hardening.

3.9 Methods of case hardening by altering surface chemical composition of the components:

3.9.1 Carburizing: The method of increasing the carbon content on the surface of a steel is called carburizing. The process of carburizing consists of heating the steel in austenitic region in contact with a carburizing medium, holding at this temperature for a sufficient period and cooling to room temperature.

Depending on the medium used for carburizing it is classified into three types (i) Pack carburizing (ii) Gas carburizing (iii) Liuid carburizing.

3.9.1 a) Pack carburizing: The components to be carburized are packed with a carbonaceous medium (carbonaceous) medium consists of hardwood charcoal, coke and an energizer (barium carbonat) in a box and sealed with clay. The box is heated to austenitic region and then cooled to room temperature.

3.9.1 b) Gas carburizing: Here the components are heated in austenitic region in the presence of a carbonaceous gas such as methane, ehane with a carrier gas such as flue gas. These gases decompose and the carbon diffuses into steel.

3.9.1 c) Liquid Carburizing: In this method carburizing is done by immersing the steel components in a carbonaceous fused salt bath medium (bath is composed of 10% sodium cyanide, sodium carbonate and sodium chloride) at a temperature in the austenitic region for sufficient time and then cooling to room temperature.

3.9.2 Nitriding: Nitriding is accomplished by heating steel in contact with a source of atomic nitrogen (Ammonia gas) at a temperature of around 550^0C for sufficient time and they cooling to room temperature The atomic Nitrogen diffuses into steel and cambiues with iron and carbon alloying elements present in steel and form respective nitrides. These nitrides increases hardness and wear resistance of steels.

3.9.3 Carbonitriding: The components to be carbonitrided are heated in a fused salt bath or in a gaseous medium (gaseous medium contains carbunizing gases like CH_4, C_2H_6 with 5 to 10% Ammonia) to a temperature between A_1 and A_3 temperatures of steel for sufficient period of time and are then cooled to room temperature. In this process both carbon and Nitrogen are diffused into the surface of steel.

3.10 Methods of case hardening without altering the surface chemical composition of components.

3.10.1 Flame hardening: This process consists of heating the surface layer of the component to above its upper critical temperature by means of oxyacetylene flame followed by water spray quenching or immersion quenching to transform austenite to martensite.

3.10.2 Induction Hardening: This process also increases surface hardness by heating and quenching a thin surface layer of components. Here heating is done by means of an induction coil.

4. The Micro structure of following specimen are studied in this exercise:

a. High carbon steel:

Specimen	:	High carbon steel
Composition	:	1% carbon, remaining iron
Heat treatment	:	Annealing
Etchant	:	Nital
Etching time	:	10 seconds

The Annealed structure of highcarbon steel consists of continuous network of cementite and pearlite.

b.High carbon steel:

Specimen	:	High carbon steel
Composition	:	1% carbon, remaining iron
Heat treatment	:	Normalized
Etchant	:	Nital
Etching time	:	10 seconds

By normalizing the continuous network of cementite is broken. The microstructure shows cementite and pearlite.

c. High carbon steel:

Specimen	:	High carbon steel
Composition	:	1% carbon, remaining iron
Heat treatment	:	Hardened
Etchant	:	Nital
Etching time	:	10 seconds

The microstructure consists of martensite and carbon network.

d. High carbon steel:

Specimen	:	High carbon steel
Composition	:	1% carbon, remaining iron
Heat treatment	:	Hardened & Tempered
Etchant	:	Nital
Etching time	:	10 seconds

The microstructure consists of tempered martensite and epsilon carbide.

5. REVIEW QUESTIONS

1. What is the Annealing temperature range of Hypo eutectoid steels?
2. What is the Hardening temperature range of Hypo eutectoid steels?
3. Why hardened steel specimens are subjected to tempering?
4. What is the normalizing temperature range of Hyper eutectoid steels?
5. How the soaking time in furnace is decided? Mention the times required for 1 cm thickness, 5cm
6. thickness, 10 cm thickness etc?
7. Explain the properties of Hypoeutectoid, eutectoid, Hyper eutectoid steels, before and after heat
8. treatments?
9. Show Time Temperature diagram for different types of plain carbon steels?

Experiment-6

Harden ability of steels by Jominy end quench test

1. AIM:
To determine the hardenability of a given steel.

2. APPARATUS:
Jominy test apparatus, furnace, Rockwell hardness tester and a grinder.

3. THEORY;
Jominy end quench test is used to determine hardenability of steels. The process of increasing the hardness of steel is known as Hardening. Specific specimen with standard dimensions, used for the test is given in fig.8.1. The hardness of hardened bar is measured along its length.

3.1 Hardenability:
The depth up to which steel can be hardened is defined as hardenablity. A steel having high hardness need not have high hardenability. Hardenability may be defined as susceptibility to hardening by quenching. A material that has high hardenablity is said to be hardened more uniformly throughout the section that one that has lower hardenability.

M.A Gross man devised a method to decide hardenablity.

3.1.1 Critical diameter:
The size of the bar in which the zone of 50% martensite occurs at center is taken as critical diameter. This is a measure of harenablity of steel for a particular quenching medium employed.

3.1.2. Severity of Quench:
The severity of quench is indicated by heat transfer equivalent.
$H = f/k$ $f =$ Heat transfer factor of Quenching medium and the turbulence of the bath.
$k =$ Thermal conductivity of bar material.

The most rapid cooling is possible with severity of quench as infinity.

3.1.3 Ideal Critical Diameter;
The hardenbility of steel can be expressed as the diameter of bar that will form a structure composed of 50% martensite at the center when quenched with H = infinity. This diameter is defined as ideal critical diameter.

4. Description of Apparaus:
Jominy end quench apparatus is shown in fig 8.2.

The apparatus consists of a cylindrical drum. At the top of the drum provision is made for fixing the test specimen. A pipe line is connected for water flow, which can be controlled by means of a stop cock.

5. PROCEDURE:

a. Out of the given steel bar, the standard sample is to be prepared as per the dimentions shown in the fig 8.1.

b. The austenitising temperature and time for the given steel is to be determined depending on its chemical composition.

c. The furnace is setup on the required temperature and sample is kept in the furnace.

d. The sample is to be kept in the furnace for a predetermined time (based on chemical composition of steel) then it is taken out of the furnace and is kept fixed in the test apparatus.

e. The water flow is directed onto the bottom end of the sample. The water flow is adjusted such that it obtains shape of umbrella over bottom of sample.

f. T he quenching to be continued for approximately 15 minutes.

g. A flat near about 0.4 mm deep is grounded on the specimen.

h. The hardness of the sample can be determine at various points starting from the quenched end and the results are tabulated.

i. The graph is plotted with hardness values versus distance from quenched end. From the results and graph plotted the depth of hardening of the given steel sample can be determined.

The hardenability of the specimen is found by observing the structure under the microscope. As detailed Above the diameter at which the percentage of martensite is 50" indicates hardenability of material. More this diameter, high will be the hardenability. Now the important factor is the relationship between size are diameter of a steel bar quenched in an ideal quenching medium which has the same cooling rate at it centre as a given position along the surface of a jominy bar. This information is furnished in fig.8.4. Its importanceis associated with the fact that if position on the jominy bar where the structure is 50% martensite is known then the curve shown in fig.8.4 makes it possible to determine ideal critical diameter.

6. TABLE

S.No.	**Distance from quenched end**	**Hardness**

7. RESULTS:

8. CONCLUSIONS:

9. PRECAUTIONS:

1. The specimen is to be handled carefully while transferring from furnace to test apparatus.
2. Proper water flow (at high pressure) over the bottom end of specimen is to be ensured.

10. REVIEW QUESTIONS:

1. What is the difference between Hardness & Hardenability?
2. What is severity of quench?
3. What is critical diameter?
4. What is the ideal critical diameter?
5. What is the quenching medium employed in the test?
6. What are the important precautions to be observed in the test?
7. Why a flat is to be ground on the test specimen?
8. What is the equipment used to measure the hardness of specimen in the experiment?

Experiment-7

Study the microstructure of cutting tools

1.. AIM:

To identify the different phases and to draw the microstructures of cutting tools

2. APPARATUS AND SPECIMENS REQUIRED:

Metallurgical microscope, specimens of different cutting tools,

3. THEORY:

For hard and wear resistant applications(ex: Cutting tools, dies etc) the steels are subjected to hardening. After hardening hardness of the steel is increased to greater extent but the toughness of the steel is reduced markedly. In order to have high hardness with a reasonable value of toughness the hardened steel must be tempered

4. **OBSERVE THE MICROSTRUCTURE**

Cutting tool

This high carbon tap was first roll threaded and then heat treated by oil quenching from 790C. It is shown here at 200X magnification; a Nital etch was used.
The image is not terribly clear; the less decarburized metal is to the right of the bright patches of ferrite. There are more cementite particles at the right than in the middle, next to the ferrite patches.
What is wrong with this cutting tool ?
Explanation: This is a case of extreme decarburization. There is ferrite at the surface, and then a carbon gradient in the martensite formed from what had been austenite plus cementite. The decarburization occurred after the threading operation, during the austenitization. Note that there is a discontinuity in carbon content at the ferrite - prior austenite phase boundary, exactly as dictated by the iron - cementite phase diagram. The ferrite deformed severely when an attempt was made to use this tool;

High speed steel

It **has unusually high resistance to softening at temperatures up to 600C. It has what is called, *red hardness*. The steel is hardened by quenching austenite to martensite and then precipitating alloy carbides at about 550C. These alloy carbides are far more resistant to coarsening at that temperature than is cementite.**
The microstructure consists of undissolved excess carbides in a matrix of artensite. These carbides are probably the types M6C (where M is either molybdenum or tungsten) and anadium carbide (VC). If it were tempered at about 550C, the martensite would contain very finely divided M2C (M is again molybdenum or tungsten) which is the carbide responsible for the *secondary hardening* of high speed steels. The present microstructure is a good one, very fine grained. Note that the prior austenite grain boundaries are delineated by the excess carbides. Below is a summary of the types and roles of carbides in high speed steel.

5. DRAW THE STRUCTURE

6. RESULTS & DISCUSSION:

7. CONCLUSION:

9. REVIEW QUESTIONS:

1. Define cutting tool
2. Write the composition of High speed tool steel
3. What are the important heat treatments given to the tool steels?

Experiment-8

Study the microstructure of Stainless Steels

1. **AIM:**
   To identify the different phases and to draw the microstructures of stainless steel-alloy steels.

2. **APPARATUS AND SPECIMENS REQUIRED:**
   Metallurgical microscope, specimens of different Alloy steels,Stainless steel

3. **THEORY:**
   Steels are to be alloyed for improving their mechanical properties. Common alloying elements are Al, Ni, Mn, Cr, etc., however, the properties of alloy steels are not so much superior to plain carbon Steels in untreated condition. Different heat treatments are given to alloy steels to fully exploit their Properties.

3.1 Effect of Alloying Elements: Alloying elements may have one or more of the following effects.

a) Solid Solution Strengthening/Hardening: Most of the alloying elements are soluble in ferrite to some extent and form solid solutions when added to steel. Solid solutions are harder and stronger than the pure metals and hence these elements increase strength and hardness of steels.
Examples : Mn, Cr, W, Mo, V, Ti, Ni, Si, Al, Zr………

b) Formation of carbides: Some of the alloying elements combine with carbon in steel and form respective carbides. These alloy carbides are hard and increase wear and abrasion resistance of steels.
Examples: Mn, Cr, W, Mo, V, Ti, Zr, and Nb………

c) Formation of Intermediate Compounds: Some of the elements form intermediate compounds with iron e.g. Fe, Cr(sigma phase in high chromium alloys) and Fe3W2 (in tool steels).

d) Formation of inclusions: they may combine with oxygen and form oxides when added to steel.
Examples: Si, Al, Mn, Cr, V, and Ti……

e) Shifting of critical temperature and eute4ctoid carbon: the alloying element may lower or raise the transformation temperature of steel. Elements, which are austenite stabilizers like Ni, and Mn, lower the eutectoid temperature (A) while the elements, which are ferrite stabilizers, raise the above temperature.

Most of the alloying elements shift the eutectoid carbon to lower values e.g. the carbon content of Eutectoid in a 12% Cr steel is less than 0.4% as against to 0.8% in plain carbon steels.

f) Lowering of critical cooling rate: Most of the alloying elements (except Co) shift the T.T.T diagram to the right side, thus decreasing the critical cooling rate. This effect is very useful for increasing the hardenability.

g) Changes in volume during transformation: Elements may be chosen in proper proportion sp as to reduce the volume change to reduce distortions and the risk of quench cracking during hardening.

h) Other effects:

i) The transformation may become sluggish.

ii) The corrosion and oxidation resistance may increase e.g. chromium increases corrosion resistance by forming a thin film of chromium oxide on the surface. This is found in stainless steels.

iii) Creep strength may get increased due to the presence and dispersion of fine carbides.

iv) Fatigue strength may also get increased.

3.2 Classification of Alloying Elements:

With respect to relation with Carbon, alloying elements can be classified into 3 groups.

a) Carbide forming elements: They form carbides when added to steels or cast irons.

Examples: Ti, Zr, V, Nb, W, Mo, Cr, Mn……

b) Neutral Elements: Cobalt is the only element in this category, which neither forms carbides nor causes graphitization.

c) Graphitizing elements: They try to decompose the carbides into graphite, in cast irons.

Examples: Ni,Si,Cu,Al

a) Austenite stabilizers: the elements from this group raiseA_4, temperature and lower A_3temperature, thus increasing the range of stability of austenite

Examples: Mn, Ni, Cu, C, N………

b) Ferrite Stabilizers: These elem,ents lower A_4 temperature and raise A3 temperature, thus increasing the range of stability of ferrite.

Examples: Cr, W, Mo, V, Ti, Ni, Si, Al, Zr, B Nb, P……

3.3 Uses of Alloying Elements:

a) Sulphur: Sulphur combines with iron and forms iron sulphide and induces brittleness phase.

b) Phosphorus: Phosphorus dissolves in ferrite and increases its tensile strength and hardness.

c) Silicon: it is ferrite solid solution strengthener. It dissolves in ferrite increasing strength, hardness and toughness without loss of ductility. It is a strong graphitizer in cast irons.

d) Manganese: It dissolves in ferrite and increases yield strength tensile strength, toughness and hardness. It combines with Sulphur and forms MnS reducing the detrimental effect of FeS.

e) Nickel: It is ferrite solid solution strengthener. It dissolves in ferrite and increases hardness, tensile strength and toughness without decreasing ductility. It increases impact resistance of steels at low temperature i.e. it reduces ductile-brittle transition temperature.

f) Chromium:

Chromium has several functions as given below:

ii) It increases hardenability of steels.

iii) It forms carbides and increases hardness and wear resistance of steels.

iv) It increases corrosion and oxidation resistance when added in substantial amount.

Chromium has following disadvantages

i) It makes the steel susceptible to temper embrittlement.

ii) These steels are liable to form surface markings, generally referred to as chrome lines.

g) Tungsten:

It as following functions:

i) It increases hardenability.

ii) It forms carbides and increases wear and abrasion resistance.

iii) It refines the gain size and the carbides inhibit the grain coarsening.

iv) It reduces the tendency of decarburization.

h) Molybdenum:
Molybdenum has similar functions as Tungsten. However, its resistance to grain coarsening and decarburization is less as compared to Tungsten.

i) Vanadium:
The properties of vanadium containing steels are on similar lines as tungsten or/and molybdenum containing steels. However, vanadium containing steels have improved distinct properties as stated below.

i) The resistance to grain coarsening is excellent.
ii) The carbides of vanadium are extremely hard and hence, vanadium promotes secondary hardening during tempering.
iii) It effectively improves the fatigue and creep resistance.
iv) It is strong deoxidizer.

j) Titanium: It is strong carbide former it effectively inhibits grain coarsening and also acts as a grain refiner.

k) Cobalt: It is neither carbide former nor a graphitizer. It is the only element, which reduces hardenability of steels.

l) Aluminium: It is a powerful deoxidizer and hence is used for killing of steels. It is a grain refiner and also inhibitor.

m) Boron: Small additions of boron (0.001 – 0.003%) sharply increase hardenability of medium carbon steels.

4. The microstructure of following Alloy steels are studied in this exercise

a. High Speed Tool Steel: The important characteristics of Tools steels are
i) High hardness at eleveated temperatures ii) High wear resistance iii) High hardenbility iv) Good touhness.
These steels maintain high hardness up to a temperature about 550^{0}C. These are designated by T- Series.

Specimen : High speed steel

Composition : 0.7%C, 18%W, 4%Cr, 1%V

Heat treatment : Heated to a temperature of 1250-1300^{0}C, soaked at this temperature for very Short period of time. The steel is then quenched in oil to room temperature. The steel is then multiple tempered at 550^{0}C at which it shows secondary hardening.

Etchant : Nital

Etching time : 20 seconds

The microstructure consists of tempered martensite, alloy carbides and low carbon retained austenite.

Applications : Cutting tools

b. Stainless steel: these steels have high corrosion resistance

specimen : Stainless steel(Austenitic)
Composition : <0.15%C, 18%Cr, 10%Ni
Etchant : Nital
Etching time : 20 seconds

The microstructure consists of Austenitic grains. The dark regions are due to alloy carbide precipitation.
Applications: Utensils, Chemical plant equipment, Medical equipment Blades etc.,

c. High Carbon Chromium steel: These steels have very high hardenability and shows very less distortion during hardening.

Specimen : High carbon high chromium steel

Composition : 1.5%C, 12%Cr, 1%Mo

Heat treatment : Hardened and tempered

Etchant : Nital

Etching time : 20 seconds

The microstructure consists of tempered martensite. The dark area are alloy carbides.
Applications: Drawing dies, Blanking dies etc.

En36:

Specimen : En36

Composition : 015%C, 0.6%Mn, 3.35%Ni, 1.1%Cr,0.35%Si

Heat treatment : Case carburising.

Etchant : Nital

Etching time : 10 seconds

The microstructure shows a white compound layer of few microns thick at the surface and Ferrite and pearlite at the core.

Applications: These are used where a hard case and a tough core is required. Boring bits etc

5. REVIEW QUESTIONS:

i. Why alloying elements are added to steels?

1. How negative effects of sulphur in steels will be neutralized?
2. What is the composition of stain less steel?
3. What are the important characteristics of Tool steels?
4. What is the composition of H.S.S?
5. What makes High Carbon high chromium steel suitable for making dies?
6. Show the heat treatment cycles, on Time – temperature diagrams for different types of steels?
7. Compare the properties of alloy steels with and without heat treatment?

Experiment-9

Study and test the mechanical properties of Cutting tools.

1. **AIM:**
   To identify the different phases and to draw the microstructures of stainless steel-alloy steels.

2. **APPARATUS AND SPECIMENS REQUIRED:**
   Metallurgical microscope, specimens of different Alloy steels,Stainless steel

Methodology can be done as per the Ferrous materials/steels

Experiment-10

Comparing the mechanical properties through micro structure of Weld metals

1. **AIM:**
To identify the different phases and to draw the microstructures of stainless steel-alloy steels.

2. **APPARATUS AND SPECIMENS REQUIRED:**
Metallurgical microscope, specimens of different Alloy steels, Stainless steel
Welded joint-should be collected or welded
Then the process as per microstructural analysis

Methodology can be done as per the Ferrous materials/steels

Experiment-11

Study of different micro structures under various stresses

To find out the hardness of various treated and untreated steels

1. AIM:
To study the effect of heat treatment on steel specimens and to observe the microstructure. The resulting hardness also will be measured.

2. APPARATUS & MATERIALS:
Muffle furnace, Rock well hardness tester, Nital (etching reagent) and specimen polishing equipment, hardned steel specimens.

3. THEORY:
For hard and wear resistant applications(ex: Cutting tools, dies etc) the steels are subjected to hardening. After hardening hardness of the steel is increased to greater extent but the toughness of the steel is reduced markedly. In order to have high hardness with a reasonable value of toughness the hardened steel must be tempered. After tempering the toughness value will be increased without much loss of hardness. If the toughness is improved, the life of the component will be increased as it can absorb more energy of deformation before fracture takes place.

4. PROCEDURE:
i. The hardness of the given hardened steel specimens are noted.
Note: All the specimens should be hardened under same condition.
ii. The furnace is switched on and is set for low temperature tempering(around 250^0)
iii. One sample is introduced in to furnace and soaked for 30 minutes. (this time depends on the specimen thickness or diameter)
iv. The sample is taken out and cooled in air.
v. The furnace is set up for high temperature tempering(i.e. around 600^0c).
vi. Second sample is introduced in to furnace, soaked for 30 minutes and then cooled in air.
vii. The hardness of two samples is noted and compared with each other and with original hardness of the given hardened specimen.
viii. The microstructure of the samples are drawn.

5. TABLE

Sample No	temperature	Rock well hardness value	
		Before HT	After HT

6. RESULTS & DISCUSSION:

7. CONCLUSION:

8. PRECAUTIONS:

The hot specimen is to be handled carefully.
The furnace should be carefully set to appropriate tempering temperature.

9. REVIEW QUESTIONS:

1. Why specimen as to be tempered after hardening?
2. What is low temperature tempering?
3. What is medium temperature tempering?
4. What is high temperature tempering?
5. What is the microstructure of a hardened and tempered steel?
6. What are the important precautions observed in the test?
7. What is the type of furnace used and mention it’s specifications?
8. What is the cooling medium employed during hardening & during tempering?

Experiment-12

Study the different crystal structures of metals

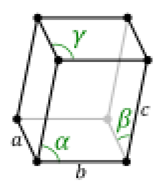
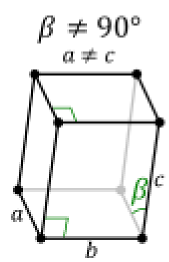
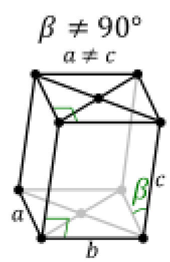
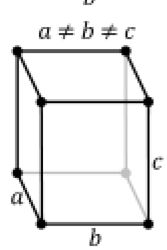
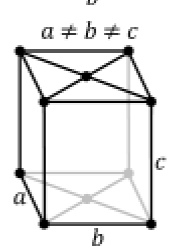
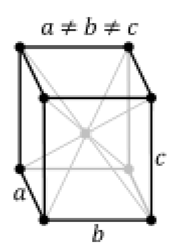
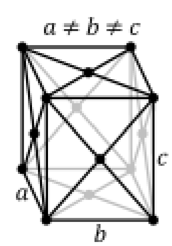
1.. AIM:
Draw the different crystal structures of metals.

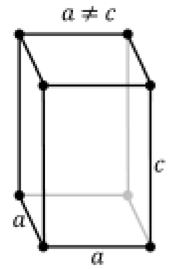
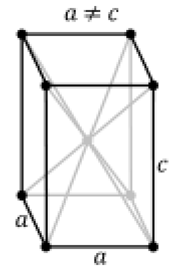
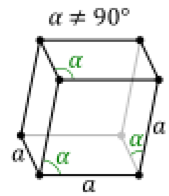
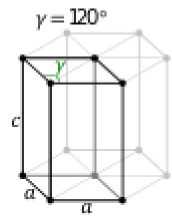
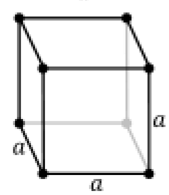
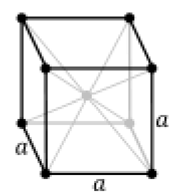
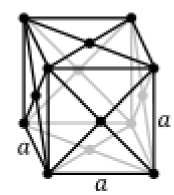
2. APPARATUS AND SPECIMENS REQUIRED:
Charts of Unit cells and Crystal structure of different metal ,FCC,BCC,HCP etc.

3. THEORY

Lattice systems

These lattice systems are grouping of crystal structures according to the axial system used to describe their lattice. Each lattice system consists of a set of three axes in a particular geometric arrangement. There are seven lattice systems. They are similar to but not quite the same as the seven crystal systems and the six crystal families

Crystal family Lattice system	symmetry	14 Bravais Lattices			
		Primitive	**Base-centered**	**Body-centered**	**Face-centered**
Triclinic	C_i				
Monoclinic	C_{2h}				
Orthorhombic	D_{2h}				

Tetragonal	D_{4h}		
Rhombohedra	D_{3d}		
hexagonal	D_{6h}		
Cubic	O_h		 

4. DRAW THE CRYSTAL STRUCTURE

5. GIVE THE EXAMPLES FOR EACH STRUCTURE

6. REVIEW QUESTIONS

1. Give example for BCC, FCC,HCP metal
2. What is packing factor?
3. What is unit cell?
4. Define crystal structure

MECHANICS OF SOLIDS LABORATORY

FOR II YEAR, I SEMESTER

Mechanical ENGINEERING

&

Automobile Engineering

LAB MANUAL

Department of Civil Engineering

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING & TECHNOLOGY

Bachupally, Nizampet (S.O.), Hyderabad – 90

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

TAMASOMA JYOTHIRGAMAYA

MECHANICS OF SOLIDS LABORATORY

For II year, I semester, B. Tech (Mechanical & Automobile Engineering Students)

LIST OF EXPERIMENTS

1. Tension test
2. Compression test
3. Rockwell Hardness test
4. Brinell Hardness test
5. Izod Impact test
6. Bending test on Cantilever beam
7. Torsion test
8. Direst Shear test
9. Test on spring
10. Charpy Impact test beam
11. Bending test on Simply supported beam
12. Compound Screw Jack
13. Study on Flywheel

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING & TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING
II B. TECH, I SEMESTER
STRENGTH OF MATERIALS LABORATORY

UNI-AXIAL TENSION TEST ON DUCTILE MATERIAL (MILD STEEL) USING 20t UTM

AIM OF THE EXPERIMENT

To determine the Modulus of Elasticity of the material of given specimen by conducting an uniaxial tension test. Also, to find (i) Yield stress, (ii) Ultimate strength, (iii) Breaking stress (Nominal and Actual).

PURPOSE

For Analyzing and Designing any structure, the material properties must be assessed. Even though highly sophisticated software's are adopted for analysis, the analysis cannot be done without the knowledge of material properties such as Young's Modulus, Rigidity Modulus, Poisson's ratio and nature of material (whether ductile or brittle).
The design of the structure cannot be taken up unless strength properties of material like yield stress, ultimate strength & % elongation etc., are known. As the specimen is going to be a tensile member, it is only amount of area of cross section that matters but not the actual distribution of area within the cross section. Hence equivalent area is sufficient in the case of ribbed bars.

APPARATUS

- 20t UTM
- Callipers
- Gauge marker
- Scale
- Extensometer

THEORY

Universal Testing Machine (U.T.M), is a machine designed to test the specimens in tension, compression, flexure and shear. The machine can be set to any range by attaching suitable weights to the dynamometer pendulum on the rear side of the control panel. The 20t UTM has the following four load ranges.

Range	Weights attached to the pendulum	Least count
0 – 2 t	A	4 kg
0 – 5 t	B	10 kg
0 – 10t	C	20 kg
0 – 20t	D	40 kg

DESIGN OF THE EXPERIMENT

1) Based on the diameter of the specimen, estimate the maximum load expected, assuming the ultimate tensile strength of the material. Accordingly select the range of testing machine by attaching suitable weights to the pendulum dynamometer.
2) Calculate the maximum length of the specimen such that the total extension of the specimen is within the capacity of the machine (Distance of travel of the cross head during testing).
3) Select proper gauge length of the extensometer, nearer to the standard gauge length.

PROCEDURE

Measure the diameter of the given mild steel rod at three sections with the help of a Vernier calliper and take the average value in the case of mild steel specimen. In the case of high tensile steel with ribs, the equivalent diameter is calculated assuming the density of 7.8 gm/cc. Mark the grip length. Now sub-divide the length between the grips into convenient equal parts. Measure each subdivision and tabulate. Calculate the gauge length using the formula, $GL = 5.64\sqrt{A_o}$, where A_o = the original area of cross section. Select the extensometer gauge length nearer to the above estimated value. Fix the extensometer somewhere near the center. Approximately estimate the ultimate strength and fix the loading range. Fix the specimen in the machine using appropriate grips, maintaining the grip length accurately. Apply the load uniformly such that the rate of increase of stress on the test piece such that it is not more than $1 kg/mm^2$ per second. Note the load from the dial of the machine on the appropriate scale and the corresponding elongation from the extensometer. This procedure of noting the elongation for each increment of load is continued till 80% of the estimated yield load. Remove extensometer. Note that the elongations from the extensometer are the elongations over the gauge length of extensometer. Now on furthering of loading, the specimen reaches the yield load indicated by stopping and/or decreasing of the load on dial of the machine. The yield load is noted. On further loading, the load reaches a maximum value called ultimate load. After reaching the ultimate load, the load pointer moves back very fast, and the specimen breaks at some load called breaking load, which is to be noted on hearing the breaking sound of the specimen. It may also be noted that there will be a neck formation on the test specimen before breaking of the specimen at a load less than the ultimate load.
In the case of high tensile steel or when the material is hardened, the specimen does not indicate a sharp yield point. In such cases, the stress strain curve is plotted beyond 0.2% strain. A straight line is drawn parallel to the initial straight line portion of the stress strain curve at 0.2% strain and intersecting the stress-strain curve. The corresponding stress is called proof stress. It is used in lieu of yield stress.

OBSERVATIONS

- Average original diameter of the given specimen (mm) :
- Original cross sectional area, A_0 (mm^2) :
- Standard Gauge Length $5.64\sqrt{A_o}$ (mm) :
- Gauge Length L_0 of extensometer (mm) :
- Least count of extensometer :

- Length of each subdivision, (before test), L (mm) :
- Final length of each subdivision, L' (mm) :
- Diameter of the specimen at the fractures section d_u (mm) :
- Area of cross section at the neck, A_u (mm^2) :

CALCULATIONS

Calculate the nominal stress and the strain over the gauge length from the extensometer readings. Draw the graph between stress and strain. This is known as nominal stress strain diagram as the original cross sectional area of the specimen is taken to calculate the stress. In the graph the slope of the straight line portion gives the young's modulus of the material of the specimen. Calculate the yield stress, ultimate strength and breaking stress taking the respective loads and original area of cross section, A_0.
Calculate the average percentage elongation from the expression:

$$\% \, elongation = \frac{L' - L}{L} \, X \, 100$$

The % elongation is to be calculated for each division. Draw a graph between % elongation and gauge length for various gauge lengths, considering equal number of sub-divisions on each side of fracture; get the % elongation over the standard length.
% reduction in cross sectional area can be calculated from the equation:

$$\% \, Reduction \, cross \, sectional \, area = \frac{A_0 - A_u}{A_u} \, X \, 100$$

Where, A_u is the area of cross section at the neck point and A_0 is the original cross section area.

Table 1: For the determination of Young's modulus of the material (1 ton = 1000kg = 10kN)

Sl. No.	Load		Extensometer Readings (mm)	Nominal Stress (N/mm²)	Strain over gauge length of extensometer
	ton	Newton			
1					
2					

Table 2: Distribution of % elongation over the length of the specimen

Sl. No of sub-division	Initial Length L, (mm)	Final Length L', (mm)	% elongation, $\frac{L'-L}{L}$ X 100
1			
2			

Table 3: For determining the % elongation over standard Gauge length

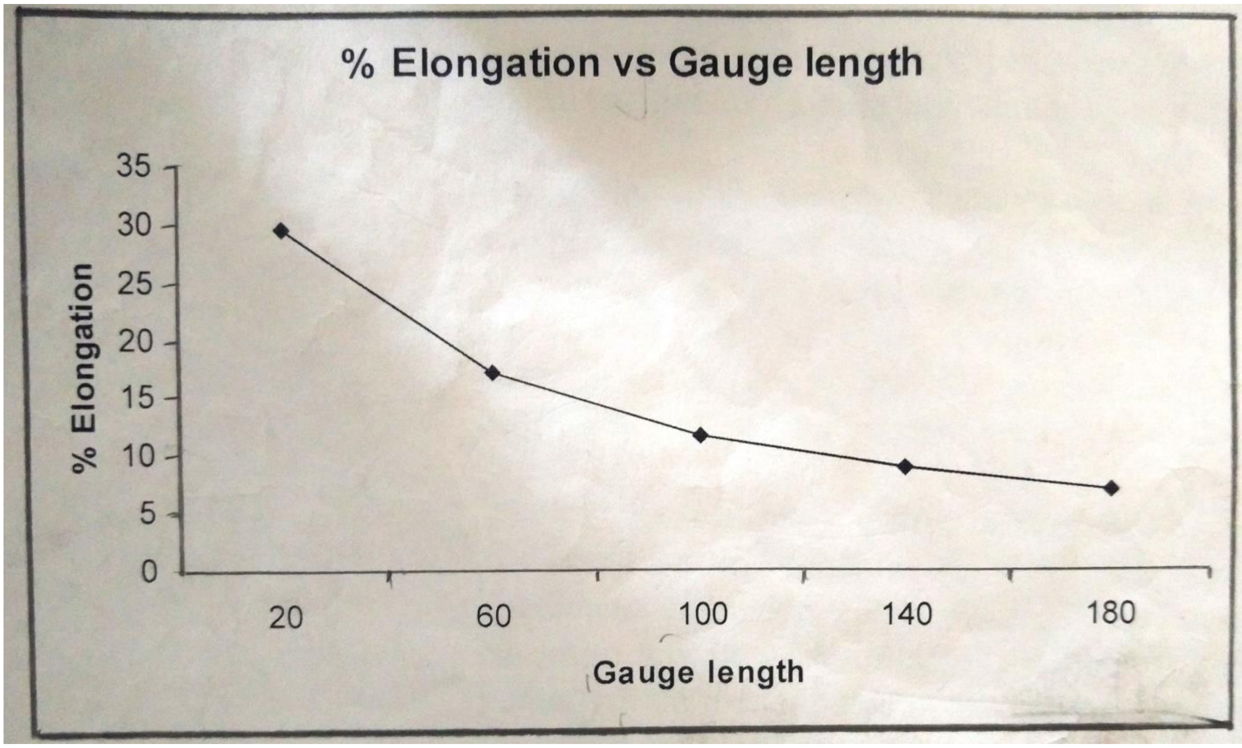
Sl. No	Gauge length		% Elongation $\frac{L'_n - L_n}{L_n}$ X 100
	Initial	Final	
1	Ln (Division of Failure)	L'n	
2	$L_n + (L_{n-1}) + (L_{n+1})$	$L'_n + (L'_{n-1}) + (L'_{n+1})$	
3	$L_n + (L_{n-1}) + (L_{n+1}) + (L_{n-2}) + (L_{n+2})$	$L'_n + (L'_{n-1}) + (L'_{n+1}) + (L'_{n-2}) + (L'_{n+2})$	
4	----------	-----------	----------

RESULTS

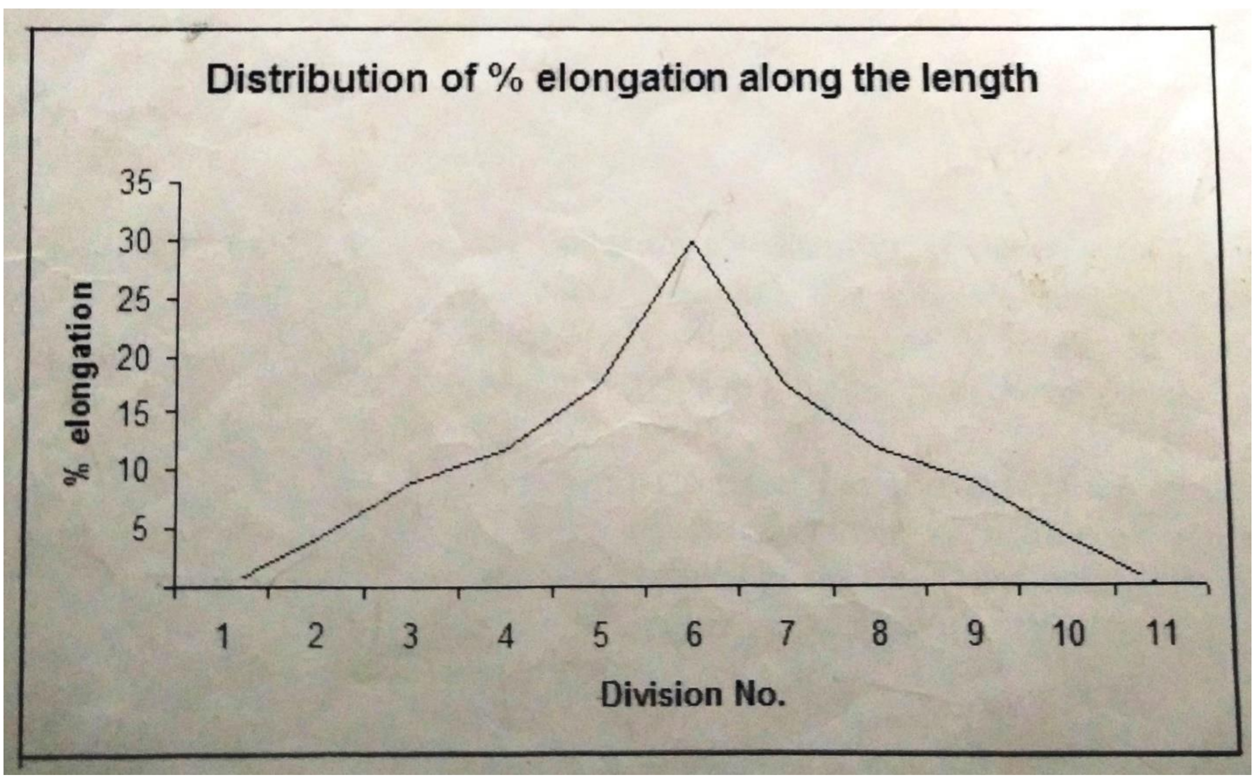
1. Young's Modulus of the material of the given specimen, $E = \frac{Stress}{Strain}$ = N/mm^2
   (Slope of the straight line portion of stress strain curve)
2. Yield stress $= \frac{\text{Yield Load}}{Original\ Area}$ = N/mm^2
3. Ultimate Tensile strength $= \frac{\text{Ultimate Load}}{Original\ Area}$ = N/mm^2
4. Breaking stress
   a. Nominal stress $= \frac{Breaking\ load}{Original\ area}$ = N/mm^2
   b. Actual stress $= \frac{Breaking\ load}{area\ of\ the\ neck}$ = N/mm^2
5. $\%\ elongation\ over\ standard\ gauge\ length = \frac{L\prime - L}{L}\ X\ 100$ =
6. $\%\ Reduction\ cross\ sectional\ area\ = \frac{A_0 - A_u}{A_u}\ X\ 100$ =

DISCUSS

1. Characteristics of fracture
2. Breaking stress (nominal) < Ultimate strength
3. Actual breaking stress > Ultimate strength
4. Concentration of % elongation near fracture plane
5. Fracture of brittle materials



Gauge length, mm (Symmetrical about the fracture plane)



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II B. TECH, I SEMESTER
STRENGTH OF MATERIALS LABORATORY

COMPRESSION TEST ON A BRICK OR CONCRETE SPECIMENS

A. WATER ABSORPTION AND COMPRESSIVE STRENGTH OF BRICK SPECIMENS

AIM

To determine the percentage of water absorption and compressive strength of brick specimens in the laboratory.

PURPOSE

Brick is the most commonly adopted basic element in buildings. Even these days bricks are used for curtain walls (non-Loading Bearing walls) and also for load bearing walls, because of simplicity in construction. Property of rate of water absorption is of utmost importance even though it is used as a non-load bearing unit. If the brick absorbs more water than the specified limit, it results in the decay of masonry or transmits dampness into the building. So the bricks to be used in construction should be tested for water absorption and compressive strength, so as to produce masonry of requisite standards.

APPARATUS

Compression testing machine

THEORY

Compression testing machine is used to find the compressive strength of brittle materials like concrete, wood, brick and glass etc.. the machine consists of a self straining frame and the pumping unit. The pumping unit is connected to straining unit by flexible pipes and cables. There are two main controls on the pumping unit, one for applying and other for releasing the load.

DESIGN OF EXPERIMENT

Select the proper range for the compression testing machine depending upon the specimen and expected ultimate compressive strength.

PROCEDURE

1. Keep three bricks in oven at 180^0C temperature for 24 hours.
2. Take the weight of the bricks (W1), after taking out of the oven and allowing to cool.
3. Soak the bricks for 24 hours in water.

4. Wipe out the moisture and weigh the brick (W2).
5. Apply cement mortar of 1:3 proportions on both the faces of each brick to obtain even and parallel faces.
6. Keep them under 90% relative humidity condition for 24 hours and then immerse in water for 2 more days.
7. The bricks are tested for compressive strength after wiping out the surface moisture and taking dimensions.

OBSERVATIONS AND CALCULATIONS

- Weight of over dried brick, W1 = (kg)
- Weight of bricks soaked in water, W2 = (kg)
- % water absorption $= \frac{W2-W1}{W1} X\ 100$ = (%)
- Dimensions of the brick
  a. Length of the brick, L (mm) =
  b. Breadth, B (mm) =
- Ultimate load = (N)
- Compressive strength of the brick $= \frac{\text{Ultimate load}}{\text{L X B}}$ = (N/mm^2)
- Results of the three specimens is averaged and reported as the resultant Water absorption & compressive strength.

DISCUSSIONS

Give the comments on the results

Table 1: % Water absorption of bricks

Sl. No.	Dimensions (mm)		W1 (kg)	W2 (kg)	% water absorption $= \frac{W2-W1}{W1} X\ 100$ (%)
	Length	Breadth			

Table 2: Compressive strength of bricks

Sl. No.	Identification marks	Weight (kg)	Ultimate load (kN)	Ultimate crushing strength of brick (N/mm^2)
1				
2				
3				

B. COMPRESSIVE STRENGTH OF CONCRETE CUBES

AIM

To determine the compressive strength of concrete by testing cube specimens.

PURPOSE

The concrete that is used in structural members must possess the required strength so that the members do their function satisfactorily. The compressive strength of concrete in the form of cube crushing strength is most important property of structural concrete. Three concrete cube specimens are cast with the concrete used in construction, in the specified manner. They will be cured as per the specifications and tested for compressive strength usually at 7 days or 28 days age.

The 28 day cube crushing strength of the concrete is one of the important characteristics useful for the design of structural members.

APPARATUS

Compression testing machine

DESIGN OF EXPERIMENT

Select the proper range for the compression testing machine depending upon the specimen and expected ultimate compressive strength.

PROCEDURE

1. Take the three cube specimens of concrete.
2. If they are completely dry, cure the cubes for 24 hours by soaking them in water.
3. Take the cubes out of water, wipe out the surface moisture and take the weight.
4. Note down the identification marks.
5. Measure the dimensions of the cube
6. Place the cube on the test platen of the machine such that the axis which was vertical during casting of the cube is placed horizontally. This is to ensure that the load is applied only on two perfect parallel planes, but not on the finished surface.
7. The cube is placed centrally over the test platen.
8. The load is applied at the standard rate and ultimate load is noted.

OBSERVATIONS AND CALCULATIONS

Table 2: Compressive strength of Concrete cubes

Sl. No.	Identification marks	Age of concrete on the day of testing (days)	Weight (kg)	Ultimate load (kN)	Cube crushing strength (N/mm^2)
1					
2					
3					

RESULTS

a. Water absorption and compressive strength of brick specimens

1. % water absorption =
2. Average ultimate compressive strength of Bricks =

b. Compressive strength of concrete cubes

1. Average Crushing strength =

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COMPRESSION TEST ON CLOSED COILED HELICAL SPRING

AIM

To determine the Modulus of Rigidity of the material and stiffness of a given closed coiled helical spring by conducting a compression test under axial load.

PURPOSE

The springs are used in automobiles (or other means of transport) or engines etc. to absorb shocks without transmitting them to the chasis for the comfort of the passengers and durabilioty of various parts of the automobile. The closed coiled helical spring are most commonly adopted. They are also used to store energy (infinite forms of strain energy) to do useful work upon release.

APPARATUS

- Loading frame with pressure gauge to measure load
- Closed coiled helical spring
- Dial gauge with magnetic base

Theory

When an axial compressive load W is applied on a closely coiled helical spring, every section of the spring wire is subjected to a twisting moment T = WR, where R is the mean radius of the coil. For a closed coiled helical spring,

a. Deflection of the closed coiled helical spring

$$\delta = \frac{64WR^3n}{Cd^4}$$

Where,

- δ = deflection of the spring in mm (compression or elongation along the axis)
- W = Load applied in N
- R = mean radius of coil in mm
- C = Rigidity modulus of the material of the spring in N/mm^2
- d = diameter of the wire of the spring in mm
- n = number of active coils in the spring (that contributes to axial deflection)

from the above expression for a given spring, Rigidity modulus (C) can be found by measuring deflection of the spring under a particular load W.

b. Stiffness of closed coiled helical spring

$$K = \frac{\text{Load (W)}}{\text{Deflection } (\delta)}$$

Where,

K = Stiffness of the spring

PROCEDURE

Measure the outer diameter of the coil and diameter of the wire with the caliper. The load is applied through a screw jack and measured with the help of a pressure gauge. The actual compression in the spring is measured with the help of a dial gauge.

Take readings at least at six load levels such that at the highest load, the coils of the spring do not touch each other. Tabulate the observations.

OBSERVATIONS

- Outer diameter of the spring coil (D) = mm
- Diameter of the spring wire (d) = mm
- Mean radius of the coil (R), $\frac{D-d}{2}$ = mm
- Number of effective turns of the spring (n) =
- Least count of the dial gauge for the measurement of deflection = mm

Table 1: Load vs deflection values for the closed coiled helical spring

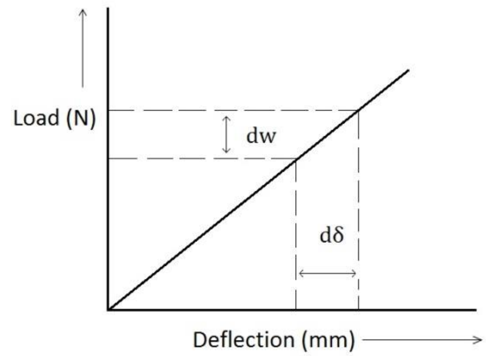
Sl. No	Load (N)	Deflection (mm)
1		
2		
3		
4		
5		
6		

CALCULATIONS

Draw the graph between Load and Deflection. Find the ratio $\left(\frac{dw}{d\delta}\right)$ the slope of the line, which will give the stiffness of the spring.

Stiffness, K = $\left(\frac{dw}{d\delta}\right)$ N/mm

Modulus of Rigidity = C = $\frac{64R^3n}{d^4} X \left(\frac{dw}{d\delta}\right)$ N/mm^2



RESULTS

1. Stiffness of the spring load required to produce unit deflection = N/mm
2. Rigidity Modulus of the material of the spring, C = N/mm^2

DISCUSSION

1. Nature of stress developed in the material.
2. Comparison of behaviour of the closed coil helical spring under tension and under compression.
3. Development of stress in spring under compression after coils touches each other.
4. Determination of young's modulus and bulk modulus assuming poisons ratio.

ROCKWELL HARDNESS TEST

AIM

To determine the Rockwell hardness number for the given specimen.

APPARATUS

- Rockwell hardness testing machine

THEORY

The Rockwell test is similar to the Brinell test in that the hardness number is found by the action of an indentor under given static loads. Various loads and indentors are used depending on the condition of test. It differs from the Brinell test in terms of the indentors used and the applied loads. The resulting indentations in the Brinell test will be smaller & shallower. The Rockwell test is applicable even to test materials having hardness beyond the scope of the Brinell test. This test is faster because it gives direct readings. It is widely used in industrial work.

The test is conducted in a specifically designed machine that applies load through a lever system and gives the hardness number directly. The indentor or penetrator may be either a hard steel ball or a diamond cone. The hardness value as read from a specifically graduated dial is an arbitrary number that is related to the depth or indentations.

Table 1: Choice of loads & indentors for various hardness tests

Major Load (kg)	60	100	150
Indentor	Diamond cone	Hard steel ball (1/16” dia)	Diamond cone
Hardness Scale	Rockwell A	Rockwell B	Rockwell C
Suitable for	Testing of case hardened steel	Annealed or hardened tempered steel. Non ferrous metals, copper alloys, soft steel, aluminum alloys	Annealed or hardened & tempered or case hardened steel

PROCEDURE

1. Set the load selector according to the material of the specimen and Rockwell scale chosen.

2. Keep the lever in position 'A'
3. Place the specimen on the testing table
4. Raise the specimen such that it will push the indentor & the small pointer moves to the red spot. The long pointer automatically stops at '0' on black scale. That means a minor load of 10kg is applied. If there is any difference, unload and check the weight on load selector and other adjustments. If the red spot is crossed, lower the specimen, select new spot on the specimen and again raise the specimen as above.
5. Turn the lever from position 'A' to 'B' slowly so that the major load is brought into action without any jerks.
6. When the long pointer of the dial gauge reaches a steady position take back the lever to 'A' position slowly releasing the major load.
7. Read the value against the long pointer. That is the direct reading of the hardness of the material of the specimen. Resulting RHN represents the difference in depth from the zero reference position as a result of the application of the major load.
8. Turn back the hand wheel and remove the specimen.
9. Repeat the procedure for two or three times on each specimen.

OBSERVATIONS

Table 2: Rockwell Hardness test

Sl. No	Material	Scale	Weights	Indentor	Rockwell Hardness number

RESULTS

- Rockwell Hardness number of brass = RHN =

DISCUSSIONS

Advantage of Rockwell Hardness Test over Brinell Hardness Test

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BRINELL HARDNESS TEST

AIM

To determine the "Brinell Hardness Number" of the given metals using the Brinell hardness testing machine.

PURPOSE

The hardness of metals is very much required to make scratch proof members or covers. The hardness of various products is necessary when they are put to use for its specific purpose of facing incidental force that may damage the finished surface of the member or part or body of the machine.

APPARATUS

- Brinell hardness testing machine
- Microscope
- Indentors
- Calibrated weights

THEORY

Hardness number is defined as the load in kilograms per square millimeter of the surface area of indentation. This number depends upon the magnitude of the load applied, material and size of the indentor. For the Brinell hardness test, the diameter of the spherical indentor and the load shall be taken from the following table:

Table 1: Brinell Hardness Test data

Test Load (P)	$30D^2$	$10D^2$	$5D^2$
Determinable range of hardness	67-500	22-315	11-158
To be used preferably on	Steel, soft iron, cast iron, malleable cast iron etc.	Copper, Brass, Bronze, Nickel, Light Metals, cast and Forging alloys, Dicasting alloys etc..	Pure Aluminum Magnesium, Zinc, Carbon etc..
Designation of Hardness Number			
a) For 10mm diameter hard steel	HB 30/10	HB 10/10	HB 5/10
b) For 5mm diameter hard steel indentor	HB 30/5	HB 10/5	HB 5/5
c) For 2.5mm diameter hard steel	HB 30/2.5	HB 10/2.5	HB 5/2.5

Brinell's Hardness Number (HB) is given by,

$$\mathrm{HB} = \frac{\text{Load on the hard steel indentor (in kg)}}{\text{Surface area of indentation in sq. mm}}$$

$$HB = \frac{2P}{\pi D(D - \sqrt{D^2 - d^2}\,)}$$

Where,
P= Load in kg
D = Diameter of the indentor (steel ball) in mm
d = diameter of indentation in mm

DESIGN

Study the material of the specimen. Select the diameter of the indentor and calculate the load values depending upon the hardness range, i.e., the nature of material using the Table. If the specimen for hardness test is very small, a hard steel ball of 1mm diameter with 1kg test force can be used. It is known as Baby Brinell's Test.

PROCEDURE

Fix the indentor in position. Attach the appropriate load to the hanger. Place the specimen on the anvil of the machine and raise the anvil by means of the elevating wheel until the indentor comes in contact with the specimen.
Push the lever and leave it to apply the full load. Release the load after steady state is reached and allowing a dweli time of 10 to 15 seconds. After releasing the load, lower the anvil by means of the hand wheel. Repeat the test at least for 3 times with the same indentor. Conduct the test for all given materials.
Making use of microscope, measure the diameter of each indentation in two perpendicular directions and in plan tabulate the observations. Calculate the hardness number of each specimen taking the average value of the diameter of indentation.

OBSERVATIONS AND CALCULATIONS

Table 2: Observations of the experiment

Material	Load (kg)	Dia. Of the indentor, D (mm)	Trial No.	Dia. of the indentation			Hardness No.
				d1	d2	$\frac{d1 + d2}{2}$	
1			1				
			2				
			3				
2			1				
			2				
			3				

RESULT

Report the result in proper format such as Brinell hardness number = HB 30/10 = _________

DISCUSSION

1. $d<D$
2. Sources of error
3. Baby Brinell test on small specimens (ball of 1mm diameter and test force of 1kgf)

IZOD IMPACT TEST ON METAL SPECIMEN

Aim

To determine the energy absorbed by the metal specimen due to impact load.

Purpose

Very often members of machines or parts of automobiles receive a lot of impact. They are supposed to be able to absorb energy without breaking when subjected to loads with impact. Thus, the properties of impact strength and toughness of the material are of importance.

Apparatus

- Impact testing machine with accessories

Principle

The principle employed in impact testing is that a specimen absorbs a certain amount of energy before it breaks. The quantity of energy thus absorbed is a characteristic of the physical nature of the material. If it is brittle, it breaks more readily, i.e., it absorbs less quantity of energy, and if tough, it needs more energy of fracture.

Theory

A swinging hammer is made to strike the specimen held firmly in a vice. The hammer breaks the specimen through its kinetic energy. The height of rise of the hammer on the other side, after breaking the specimen indicates the residual energy of the hammer. The energy actually absorbed by the material of the specimen for failure is given by the difference between initial and final energies of the hammer.

The impact strength is the energy absorbed per unit area of the cross section of the standard specimen. The impact resistance is dependent upon the material composition as well as the heat treatment process given to it. In impact tests the specimens will be under bending, when subjected to impact loading in the specified manner. The toughness is the energy absorbed by the material of the specimen per unit volume of the material under bending. Typically the impact strength is given in $N\text{-}mm/mm^2$.

Machine description

The indicating mechanism consists of a dial fixed on the front side of the stand and the indicating pointer gives directly the energy absorbed by the specimen for the rupture. The swings of the hammer can be stopped by operating the brake lever.

Specimen description

The standard specimen for the Izod test is a square rod of 10mm side. There is a 2mm deep, 45 degrees notch made at distance of 28mm from the end of the specimen.

The specimen is prepared and fixed in the machine in such a way that the hammer strikes it at a point 6mm from the top. The notch of the specimen is fixed to be in level with the anvil, and to face the pendulum. In izod impact test, the specimen is held at one end like a cantilever, the standard groove being on the tension side.

Test Procedure

1. Fix up the Izod striker.
2. Loosen the clamping screws of support and insert test specimen.
3. Align the centre line of the notch in the planes of support top, by using the setting gauge and clamp the specimen by clamping screw.
4. Touch the striker to test specimen and adjust the indicating pointer 170 Joules.
5. Adjust the point carrier in such a way that it touches the indicating pointer.
6. Lift the pendulum by hand till it gets attached in position and release the pendulum using the release lever.
7. Allow the pendulum to swing freely and break the specimen.
8. After rupture, stop pendulum on the other side slowly by operating the brake lever and note the reading on the dial.
9. That is the energy absorbed by the specimen.

OBSERVATIONS

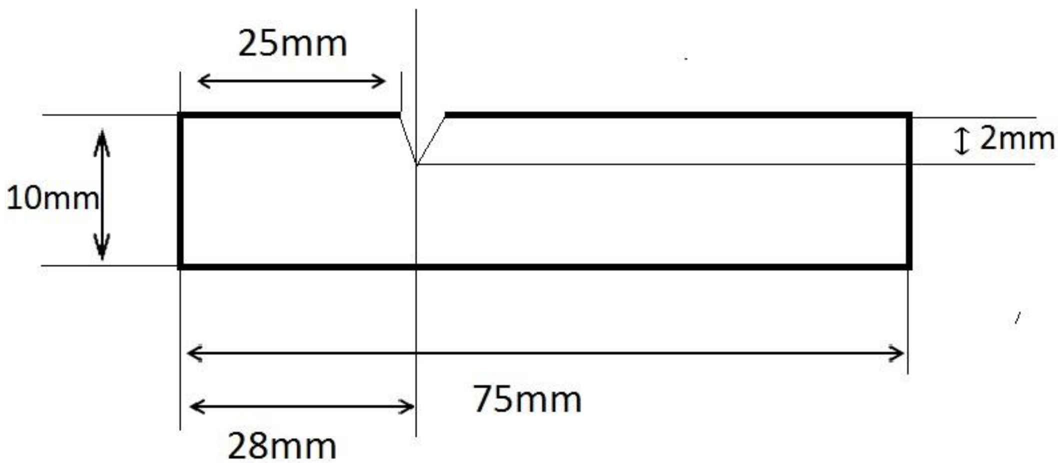
- Energy absorbed by specimen, K = Joules
- Impact strength, I = K/A = Joules/sq.mm = N.mm/mm^2
  (1 Joule = 1N/mm)
- Volume of the material under bending = mm^3
- Toughness = N.mm/mm^3

DISCUSSION

1. Principle of energy involved.
2. Positioning of the standard groove.
3. Marking of divisions on the scale.

Technical Specification

Sl. No.	Object	Izod test
1	**Pendulum**	
a	Maximum Impact energy	170 Joules
b	Angle of Drop	90^0
2	**Specimen position**	Vertical, cantilever



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BENDING TEST ON SIMPLY SUPPORTED BEAM

AIM

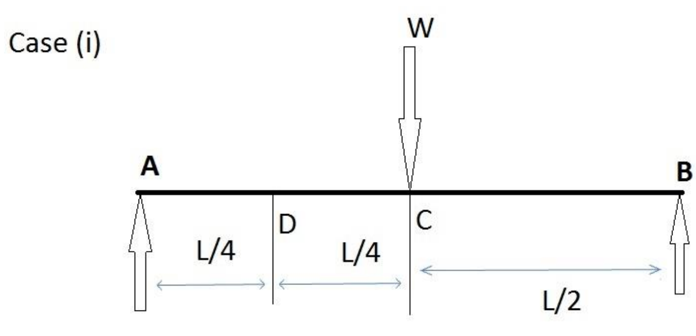
To find the young's modulus of the material of the given beam by conducting bending test on a simply supported beam using Maxwell law of reciprocal deflections.

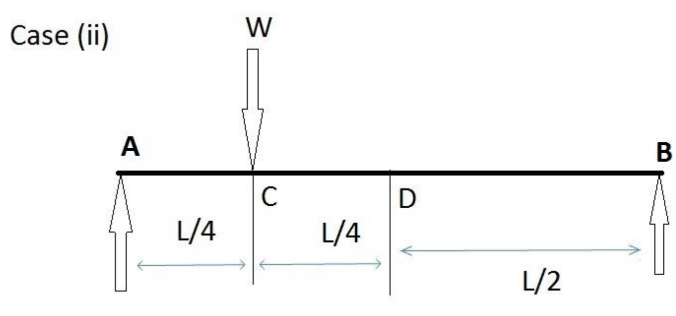
APPARATUS

- Scale
- Calipers
- Weights
- Dial gauge with magnetic base
- The supports for the beam

THEORY

Consider two cases of loading on a simply supported prismatic beam of flexural rigidity EI as shown in the following figures. The load is applied at C while the deflection is measured at D. As per Maxwell's law of reciprocal deflections, the deflections at D in both the cases must be same.





For the above two load conditions the deflection at D is given by

$$\delta = \frac{11\,WL^3}{768\,EI}$$

PROCEDURE

Measure breadth (b) and depth (d) of the beam at three sections along the span and take average values. Apply the load at C in increments and measure the corresponding deflections with the help of a dial gauge. Take precautions to keep the dial gauge in correct position to measure the desired deflection. Tabulate the deflections corresponding to various loads for each case as shown below.

OBSERVATIONS

Sl. No.	Load (g)	Deflection for case (i) Dial gauge reading			Deflection, δ1 (mm)	Deflection for case (i) Dial gauge reading			Deflection, δ2 (mm)	Avg. Deflection (mm)
		Loading	Unloading	Avg.		Loading	Unloading	Avg.		

CALCULATIONS

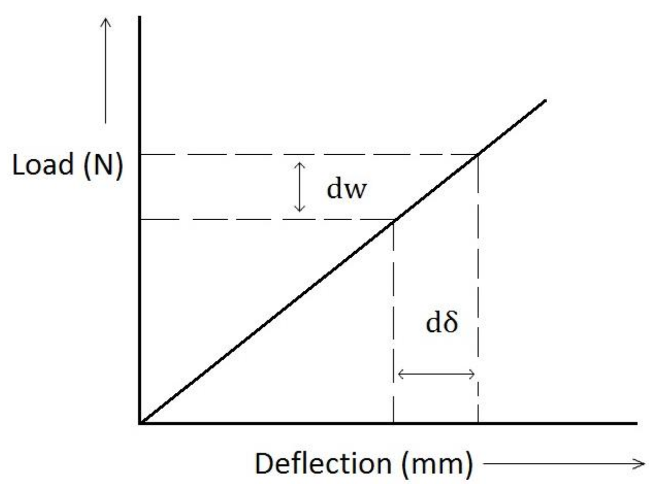
Plot the graph between load and deflection for the average of above cases.

From the graph corresponding to any two convenient points, find the value of dw/dδ ratio.

Calculate the flexural rigidity from the following expression:

$$EI = \frac{11L^3}{768}\ X\ \frac{dw}{d\delta}$$

$$E = \frac{Flexural\ rigidity}{Moment\ of\ Inertia} = \frac{EI}{I}$$



RESULTS

Report the average value of the young's modulus of material of the given beam.

DISCUSSIONS

1. Maxwell's law of reciprocal deflections
2. Instantaneous deflection
3. Creep deflection
4. Flexural rigidity

TORSION TEST ON A SPECIMEN OF DUCTILE MATERIAL

AIM

To determine the Torsional rigidity and Modulus of rigidity of the given material by conducting torsion test on the specimen.

PURPOSE

For analyzing any member subjected to twisting moment it will be required to know the torsional rigidity of the member. The torsional rigidity of a member is the product of modulus of rigidity of the material and polar moment of inertia of the cross section of the member. In the phenomena of torsion, the material of the member will be subjected to shear stress and hence it is the modulus of rigidity of the material that will influence the performance of the member.

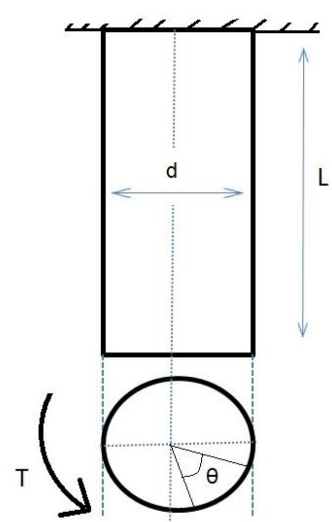
Therefore, it is essential to know the modulus of rigidity of the materials.

APPARATUS

- Torsion testing machine
- Set-up for measuring the angle of twist
- Scale
- Specimen in the form of rod of circular cross section with enlarged ends for gripping, if necessary.

THEORY

If a circular shaft or member of circular cross section is subjected to axial twisting moment as shown in the figure below,



The twist is given by the torsion formula

$$\frac{T}{J} = \frac{C\theta}{L} = \frac{\tau}{r}$$

Where,

- T = Torque applied
- J = Polar moment of inertia of the shaft = $\frac{\pi d^4}{32}$
- C = Rigidity Modulus of the material

- θ = Relative angle of twist in radians
- L = Gauge length (length of shaft over which the relative angle of twist is measured)
- τ = shear stress in the member
- r = radius of the specimen

The torsion testing machine has the following three ranges

- A – 0 – 5 kg.m : value of each division = 0.01 kg.m
- B – 0 – 10 kg.m : value of each division = 0.02 kg.m
- C – 0 – 20 kg.m : value of each division = 0.04 kg.m

The machine can be set to any range by proper adjustment after releasing the load fully.

DESIGN

1. Diameter of the specimen, d = mm

   Polar moment of Inertia, $J = \frac{\pi d^4}{32}$ = mm^4

   Length of specimen, L = mm

   Maximum twist to be reached = Radian

   Assumed modulus of rigidity = N/mm^2

   Expected Torsion, $T = \frac{CJ\theta}{L}$ = kg.mm

   Fix the range of the machine A, B or C.
2. T from the maximum shear stress point of view

$$\frac{T}{J} = \frac{\tau}{r}$$

$$T = \frac{\tau J}{r} = \frac{\tau_{allowable}\ \pi d^4}{32\frac{d}{2}}$$

$$T = \frac{\tau_{allowable}\ \pi d^3}{16}$$

   Assume $\tau_{allowable}$ and calculate $T_{Allowable}$. Fix the range.
3. Fix the range of the machine for higher T from the above two conditions.

PROCEDURE

Fix the specimen within the grips and measure the length between the grips. Measure the diameter of the specimen at three sections with the help of Vernier calipers and take the average value of weight as the case may be, or calculate the diameter.

From the expression, $= \frac{\tau_{allowable}\,J}{r}$, find the permissible torque that can be applied on the shaft for the assumed permissible shear stress. Apply the torque slowly by rotating the handle clockwise. Note the torque applied and the corresponding relative twist in degree. Repeat the experiment at suitable intervals to get 6 to 7 readings, until the permissible torque value is reached and tabulated in the table as shown below:

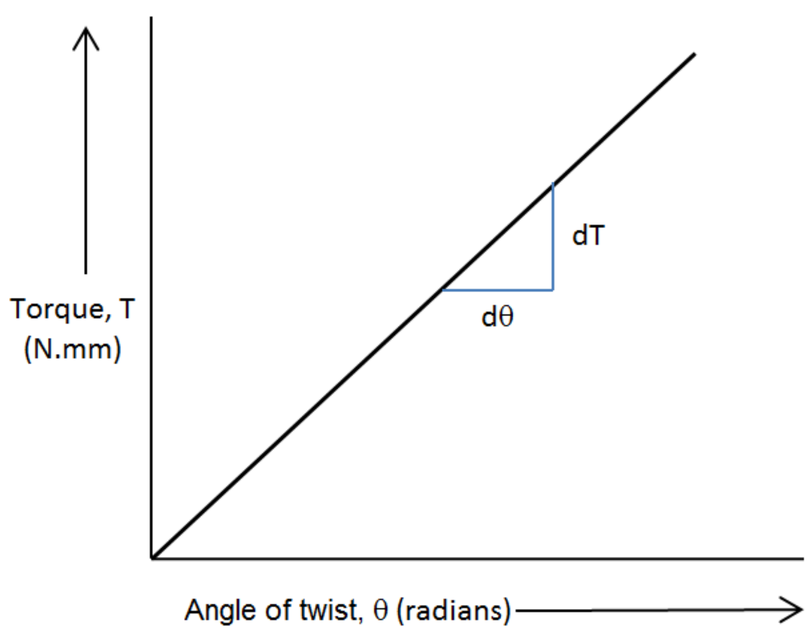
Sl. No.	Twist in degree		Relative twist in degrees	Twisting moments, T (kg.m)		Average Torque (kg.m)	Average Torque N.mm	Relative twist in Radians
	θ1	θ2	θ	Loading	Unloading			

OBSERVATIONS

- Gauge length, L = mm
- Diameter of the shaft, d = mm
- Polar moment of inertia, $J = \frac{\pi d^4}{32}$ = mm^4

CALCULATIONS

Plot the graph between the twisting moment (T) and the angle of twist. From the graph, find the slope of the line, dT/dθ and calculate the torsional rigidity.



$$CJ = L\left(\frac{dT}{d\theta}\right) \text{ and}$$

$$C = \frac{\text{Torsional rigidity}}{\text{Polar moment of inertia (J)}}$$

DISCUSSION

1. Torsional rigidity
2. Relative twist
3. Polar moment of inertia
4. Why polar moment of inertia and not moment of inertia.

DIRECT SHEAR TEST

AIM

To find the ultimate shear strength of the material of the given specimen by conducting the direct shear test using compression testing machine.

PROCEDURE

The structural members are subjected to shear stresses very often, especially rivets or bolts connecting members to other members or gusset plates will be subjected to direct shear force imposing direct shear stresses, either in double shear or single shear as the case may be. To decide the size of the rivets or to design the thickness of the gusset plates or thickness of the connecting legs of members the ultimate shear strength of the material or rivet is necessary. Hence, the determination of ultimate shear strength of the materials is of great importance. The strength of the rivet of given size in the appropriate shear can be determined. The number of rivets required in a group to support the load can be assessed knowing the strength of each rivet.

APPARATUS

- Vernier caliper
- Shear test attachment (shear shackle)

THEORY

In the direct shear test, the specimen is supported in the shear shackle, so that the bending stresses are avoided across the planes along which the shearing force is applied.

DESIGN OF EXPERIMENT

Fix the load range, knowing the size of the specimen and approximate ultimate strength in shear.

PROCEDURE

1. Measure the diameter of the specimen in two directions at three sections and take the mean.
2. The specimen is placed in the shear shackle in such a way that the specimen over hangs equally on both sides.
3. The test piece should just fit (neither tight fit nor loose fit) in the three rings. The three rings of the shear shackle should touch each other.

4. The shear shackle with the specimen is placed between the compression platens of the machine.
5. On application of load, the test piece, being in double shear, breaks into 3 pieces, failing along two cross sections.

CALCULATIONS

If d = mean diameter of rod in mm,

Cross sectional area = $\pi d^2/4$

The ultimate shear strength of the material,

$$\tau = \frac{F}{2A} \quad (N/mm^2)$$

Where, F = Ultimate load on the specimen.

RESULT

The ultimate shear strength of the material in direct shear is _________ N/mm^2

DISCUSSION

1. Discuss the difference between
   - Direct shear stress
   - Flexural shear stress
   - Torsional shear stress
   - Punching shear stress
2. The effect of shape of cross section on shear stress distribution across the depth in direct shear.

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING & TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING
II B. TECH, I SEMESTER
STRENGTH OF MATERIALS LABORATORY

CHARPY IMPACT TEST ON METAL SPECIMEN

AIM

To determine energy absorbed by the metal specimen due to impact.

APPARATUS

1. Impact testing machine
2. Test specimen

PRINCIPLE

The principle employed in impact testing procedures is that a material absorbs a certain amount of energy before it breaks. The quantity of energy thus absorbed is a characteristic of the physical nature of the material. If it is brittle, it breaks more readily, i.e. it absorbs less quantity of energy, and if tough needs more energy for fracture.

THEORY

The methods of testing in both the impact tests (Charpy & Izod) are very similar. A swinging hammer is made to strike the specimen held firmly in vice. The hammer breaks the specimen through its kinetic energy. The height of rise of the hammer on the other side indicates the residual energy of the hammer. The energy actually absorbed by the material of the specimen in order to fracture is given by the difference between initial and final energies of the hammer.

The impact resistance depends upon the material composition as well as the heat treatment process given to it. The annealed materials normally would have better toughness than the corresponding normalized or quenched specimens. Coarse grained structures would tend to have higher ductility compared to fine grained structure and consequently better toughness. Typically the impact strength is given in J/Sq.mm.

MACHINE DESCRIPTION

The indicating mechanism consists of a dial fixed on the front side of the stand and the indicating pointer gives energy absorbed by the specimen for rupture. The breaking arrangement for stopping, the swing of the pendulum after rupture consists of the breaking strip having a leather lining at the top. The brake is to be operated by the brake lever.

SPECIMEN DESCRIPTIONS

The standard specimen for the Charpy test is a square rod of 10mm side. Specimen design only differs in the shape of the notches. A U-notch or a key hole or a V-notch as in case of Izod specimen are the three commonly recommended notches for Charpy specimens.

The specimen is placed in the machine as simple beam. The notch on Charpy scale in the specimen does not face the hammer as in Izod method. But will be on tension side. The hammer head, a pointed one of 8mm radius, strikes the specimen just in the vertical axis of the notch, producing tension on notch side as earlier.

OBSERVATIONS

1. Energy absorbed is indicated on the dial after breaking the specimen.
2. Impact strength of specimen = $I = \frac{K}{A}$ J/Sq.mm.

   Where,
   K = Energy absorbed by specimen due to impact (Joules)
   A = Area of cross section of the specimen below notch before test (mm^2)

TEST PROCEDURE

1. Fix up the Charpy Izod block and the Charpy striker in their respective positions. Release the hammer from full height without the specimen. The energy absorbed is zero.
2. Place the Charpy test specimen on the supports.
3. Align the centre of the specimen notch with respect to centre of support by means of Charpy setting gauge.
4. Touch the striker to the test specimen and adjust the indicating pointer to 300 Joules on Charpy scale.
5. Adjust the pointer carrier in such a way that it touches the indicating pointer.
6. Lift the pendulum by hand till it gets latched in position and release pendulum operating the lever.
7. Allow the pendulum to swing freely and break the specimen.
8. After, rupture apply brake levers and note the reading on dial.
9. The reading against pointer is noted which indicates the energy absorbed.

OBSERVATIONS

- Energy absorbed by specimen = Joules = Nm
- Impact strength, I = $\frac{K}{A}$ = Joules/Sq.mm = N.mm/mm^2
- Toughness = N.mm/mm^2

TECHNICAL SPECIFICATIONS

Sl. No	Object	Charpy test
1	**Pendulum**	
a	Maximum impact energy	300 J
b	Angle of drop	1400
c	Effective weight of Pendulum	21.3 kg
d	Minimum Scale Graduation (Least count)	2 J
e	Swing Velocity	5.038 m/sec
2	**Specimen Position**	Horizontal

BENDING TEST ON CANTILEVER BEAM

AIM

To find the flexural rigidity of the beam and the young's modulus of the material of the given beam by conducting deflection test on a cantilever beam.

PURPOSE

The young's modulus of a material is a very vital property that decides the stiffness (or strength) of structural members against axial forces and flexure. This is exclusively the property of the material of the member irrespective of its dimensions.

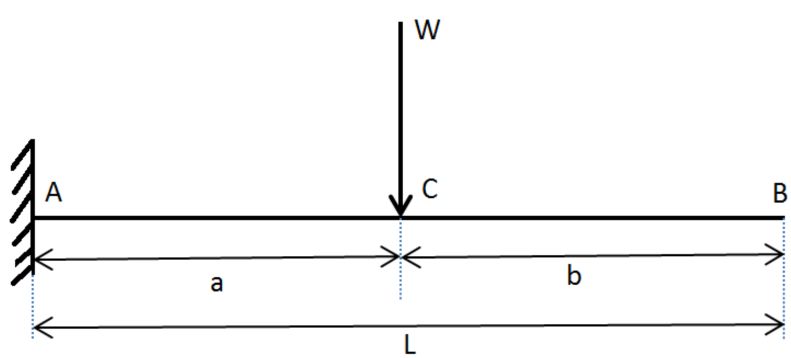
In tension test or compression test it is determined applying axial forces. It is evident that the values of young's modulus are independent of the test that is adopted. However, when the required equipment for conducting tension/compression tests are not available, the young's modulus of the material of the given specimens can be determined by conducting a bending test on the specimen. The flexural rigidity of the beam and the young's modulus of the material of the beam can be determined.

APPARATUS

- Scale
- Calipers
- Weights
- Dial gauge with magnetic base
- Set-up for supports.

THEORY

Consider the following case on a cantilever beam of uniform flexural rigidity "EI". It is loaded at C and deflection is measured at B.



DESIGN

1. Having an approximate idea of young's modulus of the material decide the dimension of beam. So that the deflection, the displacement that is required to be measured precisely, is within the measurable range of the tool, the dial gauge.
2. Decide also the span of the beam (cantilever) such that reasonable amount of deflection can be developed. If the deflection is too small the percentage error in measurement will be more.
3. Select the values of "a" and "b" conveniently and calculate the deflection at "B".

PROCEDURE

Measure breadth (b) and depth (d) of the beam at three sections with calipers and take the average values. Calculate moment of inertia about N.A.
Apply the load at "C" of span as shown in fig. in six increments, measure the corresponding deflections at the section "B" for each load value.
Take precautions to keep the dial gauge in correct position to measure the vertical deflections.
Tabulate the deflections corresponding to various loads.

OBSERVATIONS

- Average breadth of the beam, b = mm
- Average depth of the beam, d = mm
- Moment of Inertia (I) = $\frac{bd^3}{12}$ = mm^4
- L.C. of dial gauge =
- Material of beam =

Sl. No.	Loading	Dial gauge readings			Deflection
		Loading	Unloading	Average	

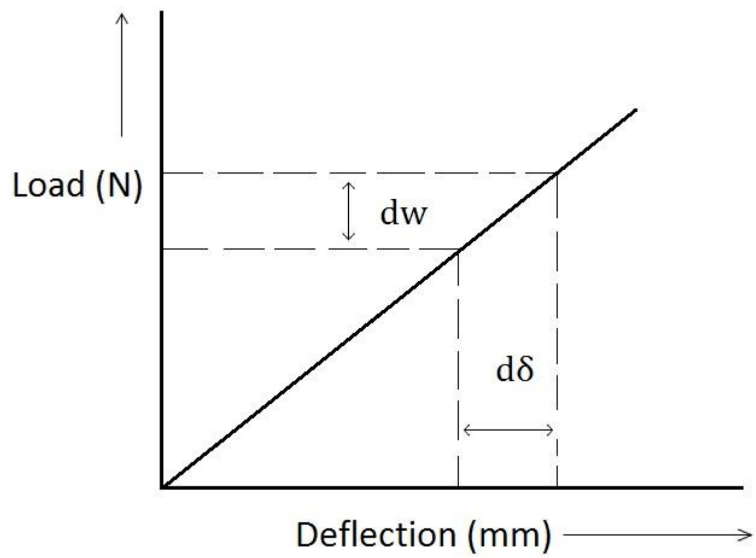
CALCULATIONS

Plot a graph between loading & average deflection in mm. Determine the slope of the line, dw/dδ.

Calculate EI, the flexural rigidity of the beam from the equation,

$$\Delta = \frac{W}{EI}\left\{\frac{a^3}{3} + \frac{a^2 b}{2}\right\}$$

$$E = \frac{\text{Flexural rigidity}}{I}$$



RESULT

Report the average value of the flexural rigidity of the beam and young's modulus of material.

DISCUSSIONS

1. Main sources of error
2. Elastic curve.

BENDING TEST ON CONTINUOUS BEAM

AIM

To find the flexural rigidity of the beam and young's modulus of the material of the given beam by conducting bending test on a two span continuous beam.

PURPOSE

When long spans are to be bridged, intermediate supports will be provided in addition to the end supports to bring down maximum shear force and maximum bending moment in the members.

Since the length of the member is divided into number of shorter spans. The members however become statically indeterminate externally. The displacements such as deflections will become very small. Hence, continuous beam will be stiffer and make the construction economical.

APPARATUS

- Scale
- Callipers
- Weights
- Dial gauge with magnetic base
- The supports for the beam

THEORY

Consider the following loading case of a two span continuous beam of uniform flexural rigidity EI. It is loaded at the centre of each span by two equal concentrated loads one on each span and the deflection is measures at $1/4^{th}$ of the span from the end supports.

The deflection at the points D and H of the beam for the above loading conditions is given by,

$$\delta = \frac{43\, W\, L^3}{6144\, EI}$$

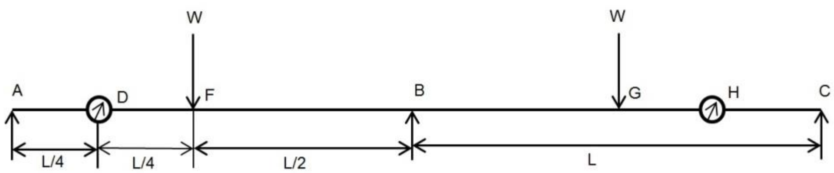
DESIGN

To make the analysis simple, consider a continuous beam of two equal spans with two concentrated loads symmetrically applied on the two spans (at F and G) as shown. Due to this symmetrical loading the deflections at the two symmetrical points (at D & H) will be equal.

Using theorem of three moments the support reaction can be determined. Adopting successive integration method or otherwise, the deflection at D and H can be calculated to be,

$$\delta = \frac{43\, W\, L^3}{6144\, EI},$$

Where, w is each of the loads and L is each of the spans as shown below.



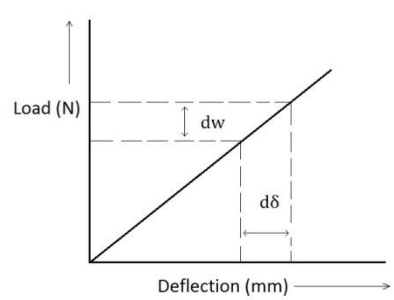
PROCEDURE

1. Measure breadth (b) and depth (d) of the beam at three sections with caliper and take average values.
2. Apply equal loads at half of each span (at F & G) as shown in the figure in six increments. Measure the corresponding deflections at L/4 from the end supports (at D & H) where L is the length of each span with the help of dial gauges.
3. Take precautions to keep dial gauges in correct position to measure vertical deflections.
4. The deflections corresponding to various loads are tabulated.
5. Draw a graph between load and deflection (W Vs. δ).
6. Calculate the flexural rigidity EI from the equation,
   $\mathrm{EI} = \frac{43\ \mathrm{L}^3}{6144}\left(\frac{\mathrm{dw}}{\mathrm{d}\delta}\right)$
7. Report the results of values of flexural rigidity of the beam and the value of young's modulus of the material of the beam.

OBSERVATIONS

Sl. No.	Load (g)	Dial Gauge Readings					Deflection (mm)
		Dial gauge 1		Dial gauge 2		Average	
		Loading	unloading	Loading	Unloading		

CALCULATIONS



- Length of beam, L (mm) =
- Breadth of the beam, b (mm) =
- Depth of the beam =
- Moment of Inertia of beam , I = $\frac{bd^3}{12}$ (mm⁴)
  =

- Flexural rigidity, EI = $\frac{43\ L^3}{6144}\left(\frac{dw}{d\delta}\right)$, (N/mm^6) =
- Young's modulus of the material, E = $\frac{Flexural\ rigidity\ (EI)}{Moment\ of\ Inertia\ (I)}$ (N/mm^2) =

RESULTS

Report the values of flexural rigidity and the young's modulus of the given specimen.

MANUFACTURING TECHNOLOGY LABORATORY MANUAL

Laboratory code: 19PC1ME02

AUTOMOBILE ENGINEERING DEPARTMENT
VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECGNOLOGY, HYDERABAD

Experiment 1 (Foundry/ Casting)

PATTERN MAKING

1. AIM: To make stepped pulley, split pattern as per the given dimensions of a component.

2. Material -size of the pattern:

Raw Material used: Teak wood: 145 x 60 x 60 mm

Pattern Dimensions: (Diameter x length)

a) D1=50mm and L1=40mm (*ϕ 50 x 40 mm)*
b) D2=40mm and L2=50mm (*ϕ 40 x 50 mm)*
c) D3=30mm and L3=40mm (*ϕ 30 x 40 mm)*

3. Theory:

Pattern is replica of the part to be cast and is used to prepare the mould cavity. It is the physical model of the casting used to make the mould. Made of either wood or metal. -The mould is made by packing some readily formed aggregate material, such as moulding sand, surrounding the pattern. When the pattern is withdrawn, its imprint provides the mould cavity. This cavity is filled with metal to become the casting. - If the casting is to be hollow, additional patterns called 'cores', are used to form these cavities. Patternmaking is the art of designing patterns. It is the first and most essential part of the casting process. There is much more to patternmaking than making an exact replica of the shape you want to cast—the patternmaker must account for the mold type and casting metal characteristics. These allowances are built into the pattern:

Draft allowance: The pattern needs to be removed from each mold it shapes without breaking or distorting it. The draft is a taper that facilitates pattern removal. The exact angle of the taper depends on the complexity of the pattern, the mold type, and surface type.

Shrinkage allowance: Like all materials, metal contracts as it cools. If the pattern were made in the exact dimensions specified for the end-product, the casting would be smaller than required. Shrinkage allowance compensates for the amount that a metal will shrink during cooling. The precise allowance depends on the metal being cast.

Distortion allowance: Patterns may be intentionally distorted to compensate for expected cooling distortion.

Machining allowance: Some castings are finished by machining. The patterns for machine-finished castings intentionally include excess material to compensate for material that will be lost in the finishing stage.

All patterns need a gating system

Every pattern includes a gating system that delivers liquid metal to the mold cavity. The gating system also regulates the speed that the metal enters the mold—too fast, and the turbulent liquid metal can erode the mold; too slow, and it may cool before completely filling out the cavity.

The system includes several interconnected parts:

Pouring cup: Liquid metal is poured directly into the pouring cup/basin. It helps separate slag from metal, reduces turbulence, and helps maintain the correct flow rate.

Sprue & runner: Metal flows from the pouring cup into the tapered sprue, then through the runner, which in turn feeds into the gates.

Gate(s): Metal flows through the gates to fill the mold cavity. Small gates are used for castings that solidify slowly, while larger gates are used for castings that solidify rapidly. The gates need to be placed carefully to promote directional solidification.

Riser: The riser is a reservoir that prevents shrinkage cavities. For a riser to work properly, it needs to cool more slowly than the casting.

Gated patterns incorporate the gating system into the main pattern body. Alternatively, the gating system can be added by hand cutting or with separate pattern pieces.

There are different pattern types

Patterns come in many materials, including wood, metal, plastics, and wax. The pattern material is chosen based on the casting volume and process used. Wood and metal patterns are usually used with sand casting, while wax is rarely used for anything but investment casting.

Patterns vary in complexity, depending on the size, shape, and number of resulting castings required. There are many types of patterns in use in foundries today; some of the more common ones include the following:

Loose patterns: Normally produced in wood, these are single representations of the casting needed to be produced, and are used only when a few castings are needed as productivity associated with more complex patterns is likely not an issue. When molding with loose patterns, the feeding system for the casting (gates, risers, etc.) is normally cut into the sand by hand. Some loose patterns may be split into two halves to facilitate molding.

Gated patterns: Often more complex than loose patterns, gated, or “mounted,” patterns are generally mounted to incorporate a gating and running system along with the pattern to facilitate productivity (by eliminating hand cutting and other molding steps), and to enhance reproducibility of the molds, which improves the overall quality of the castings.

Match-plate patterns

Although these are commonly produced in wood, these patterns are also often cast with the cope (top) and drag (bottom) portions of the pattern mounted on opposite sides of a plate to speed up the molding process. Gating systems are normally embedded into the match plate as well, along with fixtures/fittings used to mount these patterns onto special types of molding machines. These patterns are generally employed where large production volumes warrant the additional, higher cost of creating such patterns, and where production consistency is extremely important.

Investment casting dies: Lost-wax impressions are the actual patterns that are used to make molds in investment casting foundries. But where do these impressions come from? Investment casting dies are used to produce the wax patterns that will eventually form the lost-wax casting molds. As each wax pattern is destroyed in the lost-wax casting process, one is needed for each casting that is made, and these wax patterns are produced in dies. The dies are often complex metal tools with at least two parts, where the interior cavity is machined to take the shape of the desired wax pattern. Wax gets injected into these dies, and, after cooling, the die is separated and the one-piece wax pattern is extracted. As with sand molding, metal cores and other pieces can be assembled into these investment casting dies to form interior cavities and other complex parts of the desired casting.

4. TOOLS AND EQUIPMENTS:

a) Cross cut chisel
b) Round chisel
c) Outer callipers
d) Firmer chisel
e) Making chisel
f) Groove chisel
g) Steel rule
h) Wood turning lathe machine
i) Vernier height gauge
j) V-Block
k) Saw
l) Bench vice

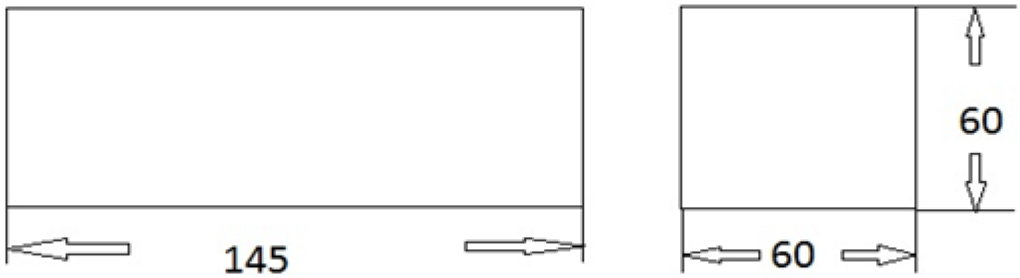
5. PROCEDURE:

1. Fix the given wood piece between the either ends of the head-stock and tail-stock.
2. Using the round chisel, turn down the given piece into cylindrical shape.
3. According to the given dimensions, use appropriate chisels to obtain required dimensions & to get required pattern.

6. PRECAUTIONS:

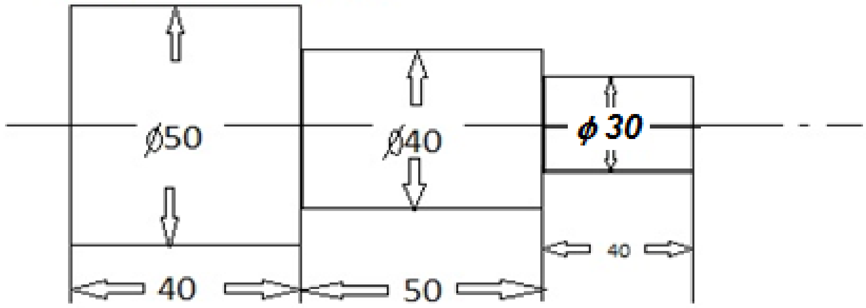
1. Wear apron and shoes.
2. Maintain proper turning angle with gauge.
3. Be alert, to avoid accidents.

6. RESULT: The required stepped pulley, pattern is made of wood using the wood turning lathe machine.



Wooden piece before making pattern

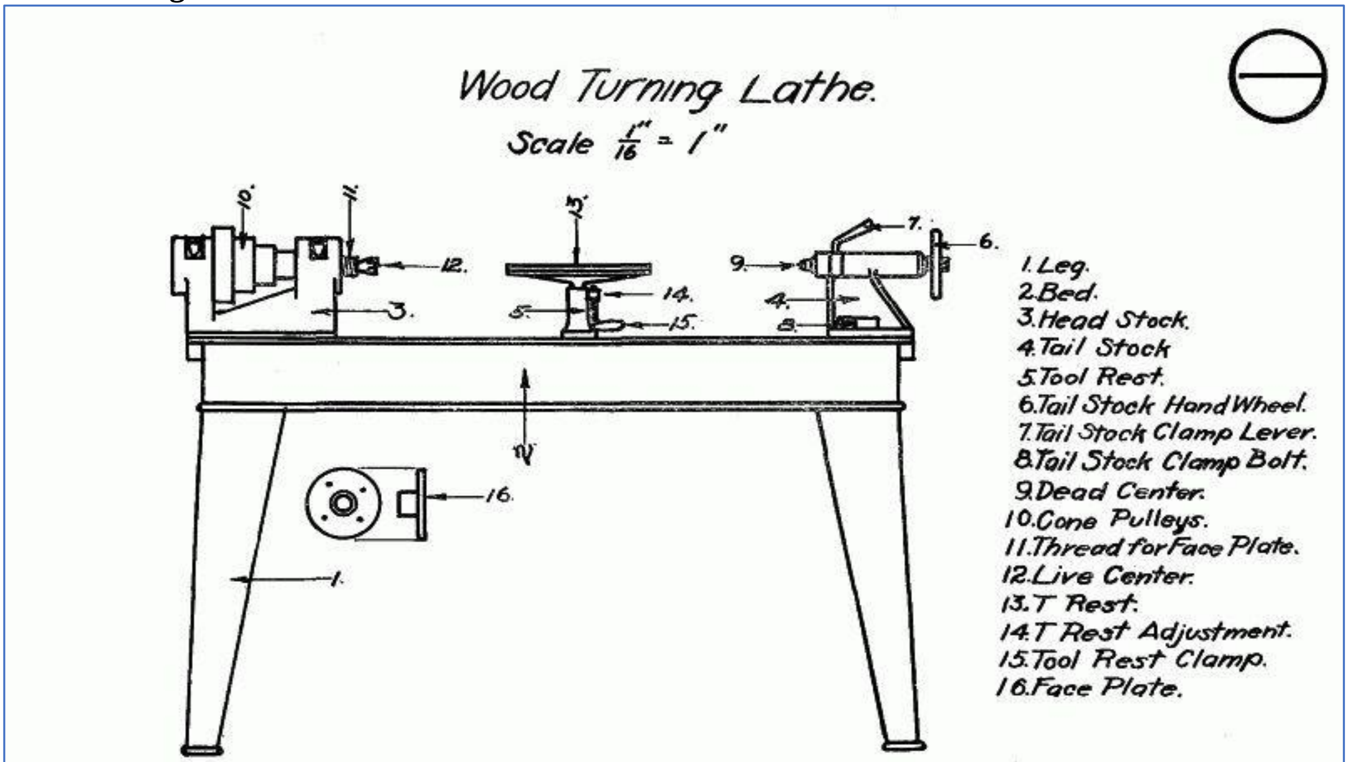
(All Dimensions are in mm)



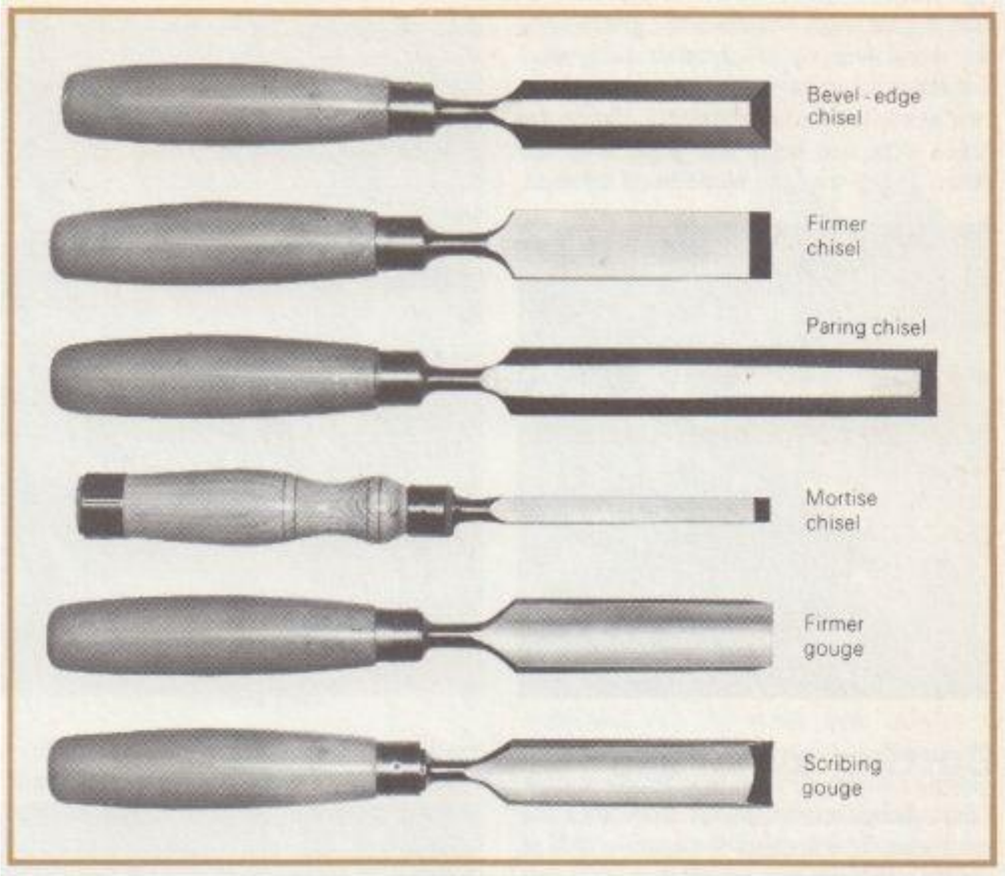
Wooden Pattern- Stepped Pulley

(All Dimensions are in mm)

Wood Turning Lathe:



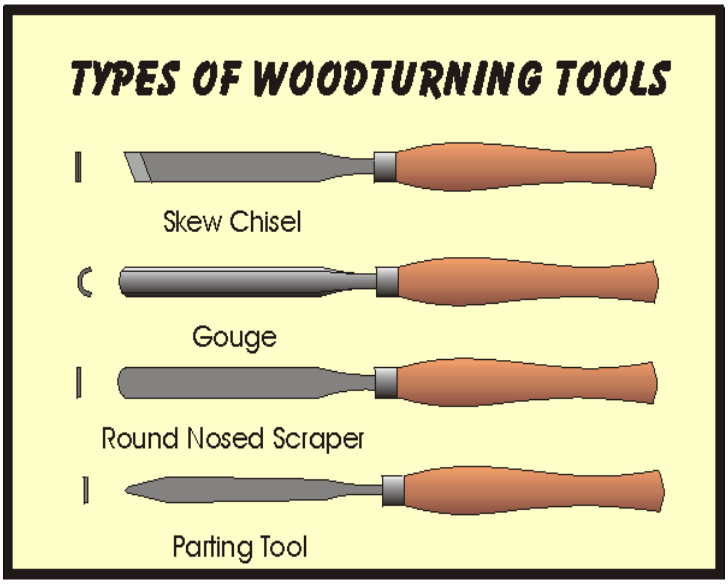
Tools Used in Pattern Making (shaping):

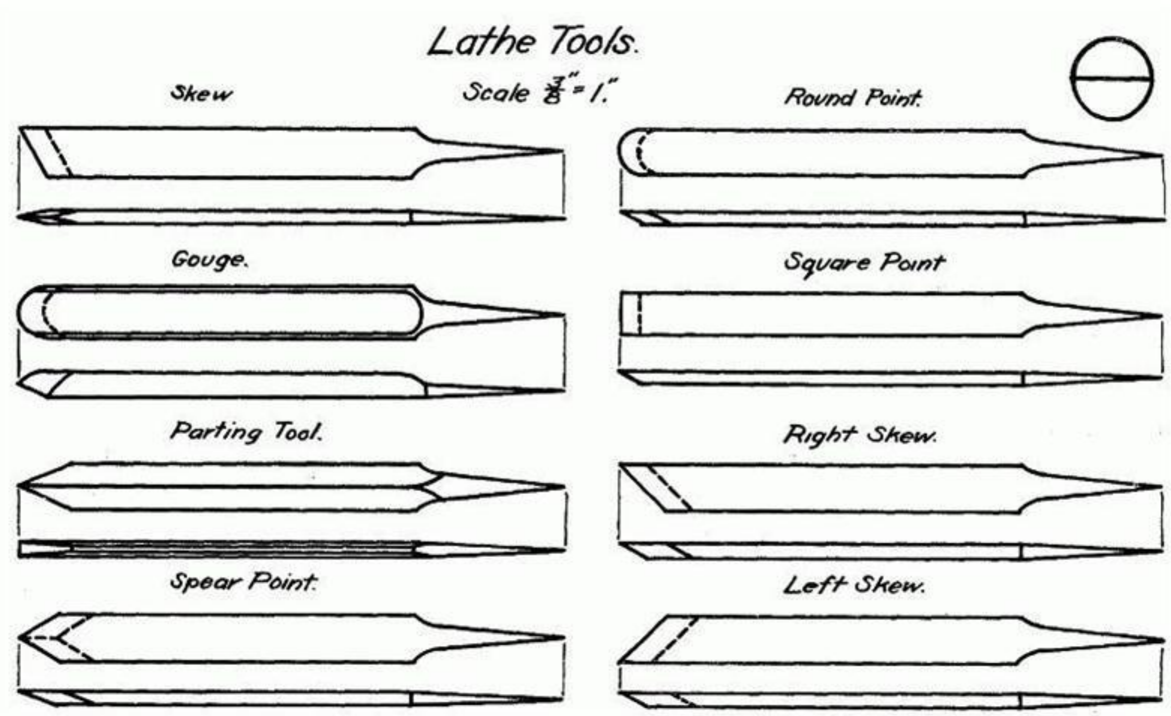


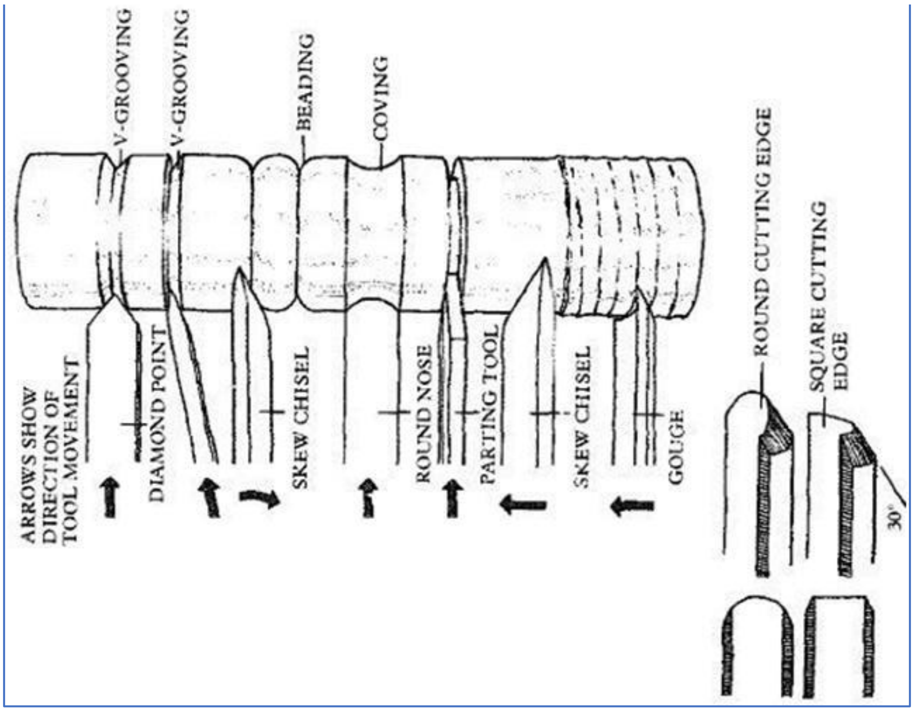
Scale

Calliper

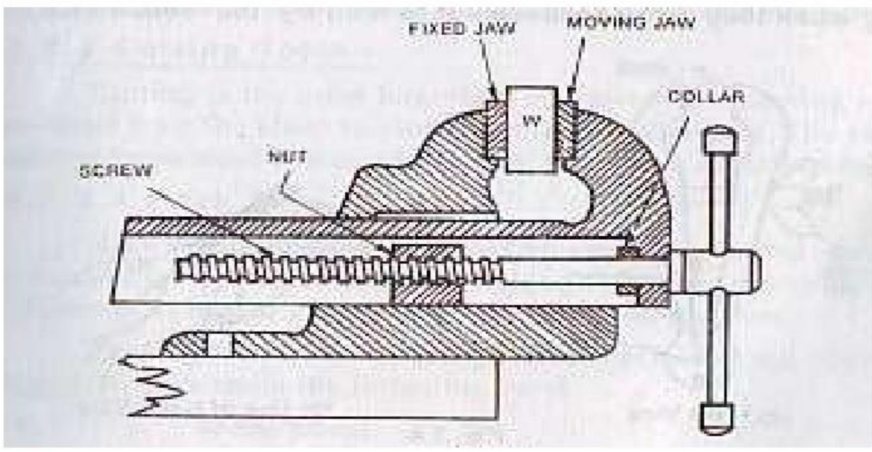

Wood turning Lathe


TYPES OF WOODTURNING TOOLS
Skew Chisel
Gouge
Round Nosed Scraper
Parting Tool


Lathe Tools.
Scale 3/8" = 1."
Skew
Round Point
Gouge.
Square Point
Parting Tool.
Right Skew.
Spear Point
Left Skew.



CROSS SECTION OF BENCH VICE



Experiment 2 (Foundry/ Casting)

MOULD MAKING

1. AIM: To prepare a mould using a dumbbell pattern

2. TOOLS AND MATERIALS REQUIRED:

a) Strike-off bar
b) Shovel
c) Moulding sand
d) Gate cutter
e) Draw spike
f) Vent rod
g) (Cope & drag) moulding boxes
h) Rammer
i) Two piece dumbell pattern

3. PROCEDURE:

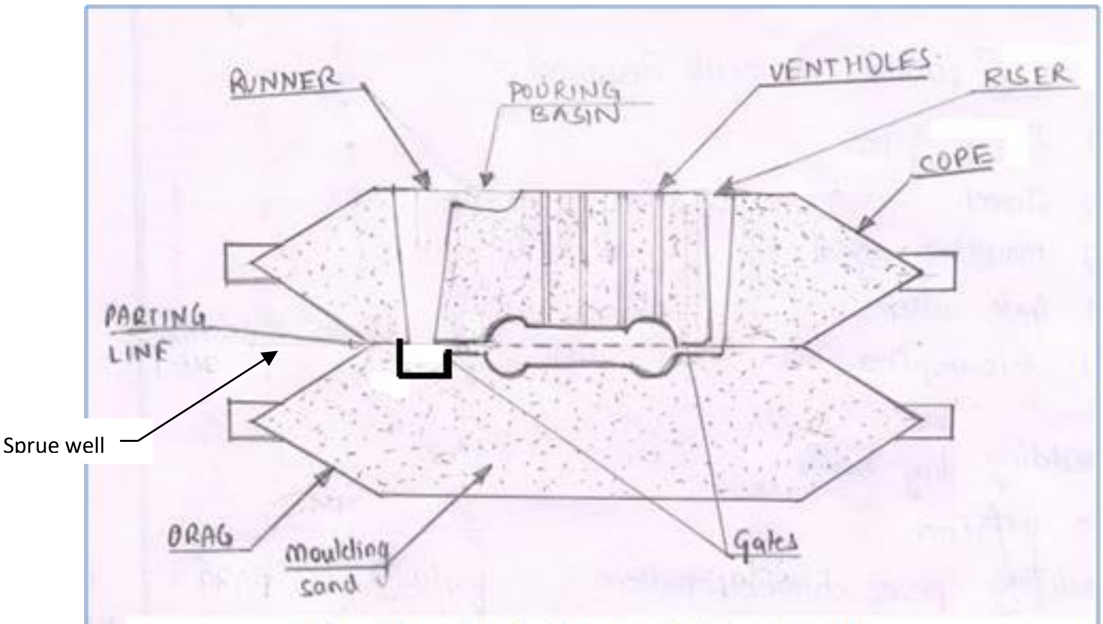
a) Take a drag and place one piece of dumbell at the centre of the drag and sprinkle the dry sand around it. Take some moulding sand with the help of shovel and add some water and mix the sand thoroughly to prepare moulding sand.
b) Now spread the green moulding sand over the pattern and completely fill the drag and rammer to get even surface.
c) Reverse the Drag and place another part of dumbell over it.
d) Now please the Cope on the drag and Sprinkle the loose or dry sand all over the pattern and place runner and riser over it vertically up.
e) Now spread the green moulding sand all around the cope and ram the sand thoroughly.
f) Then reverse the runner and riser pins and carefully separate cope and drag.
g) Now remove the pattern from cope and drag with the help of draw spike.
h) Using the gate cutter make gates in the drag.
i) Remove the sand particles which fall into the cavity with the help of lifter and slick.
j) Create holes using vent rod.

4. PRECAUTIONS:

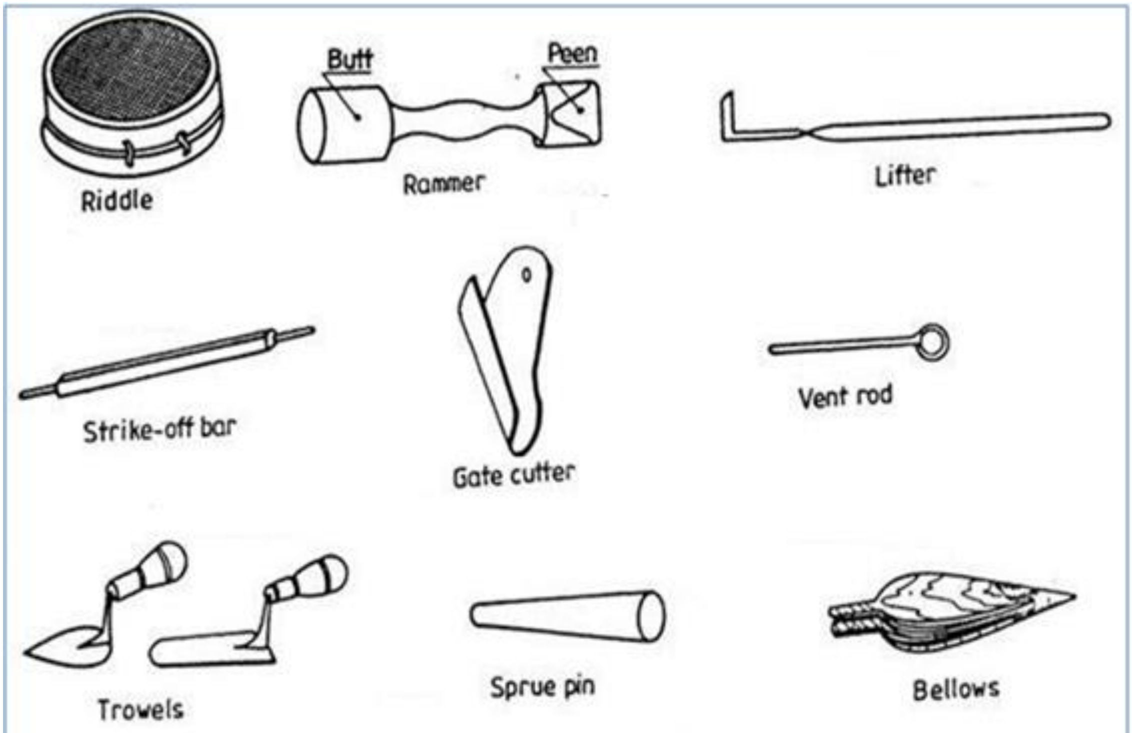
a) Wear apron and shoes.
b) Cut gates carefully.
c) Take care while removing the pattern.

5. RESULT:

The required mould cavity for dumbell is prepared.



Mould cavity (using dumbell pattern)



Tools used in Foundry (Mould making)

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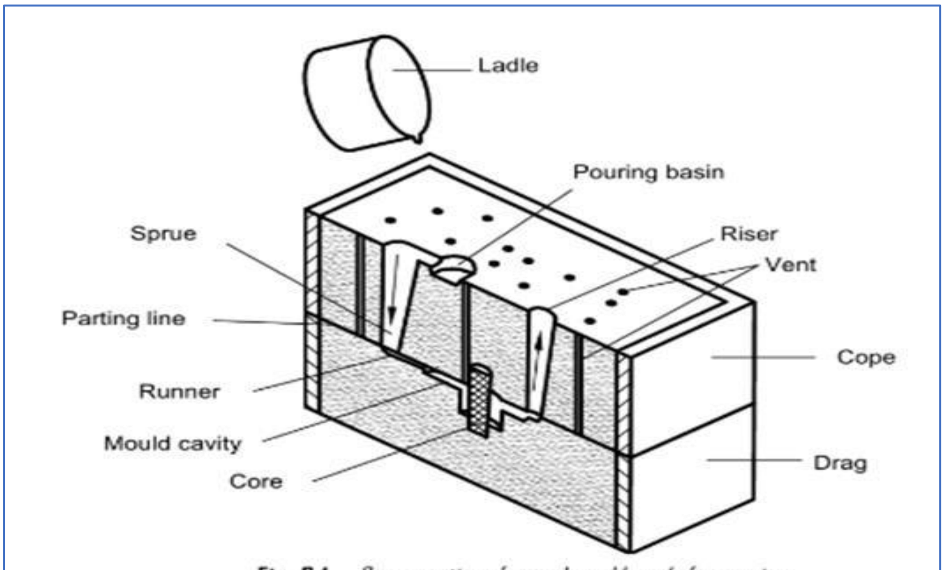


Fig. 3.1 *Cross section of a sand mould ready for pouring*

Moulding Process:

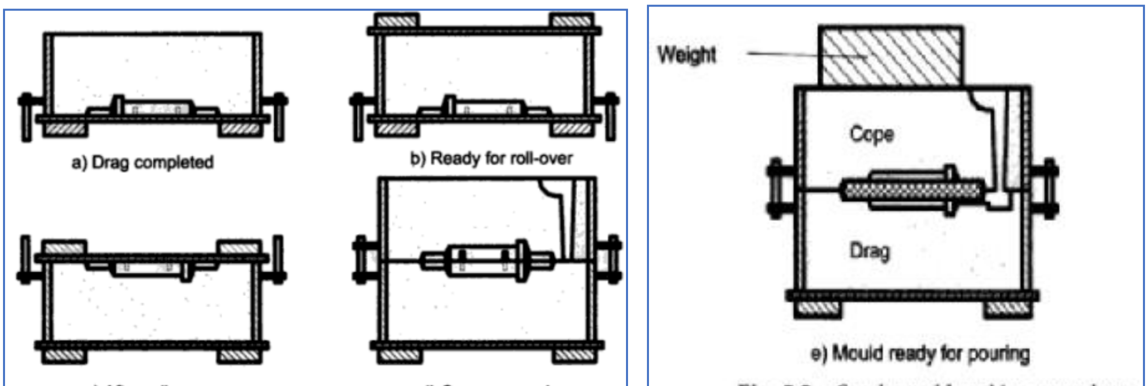


Fig. 3.2 *Sand-mould-making procedure*

Experiment No. 3

SAND TESTING

1. AIM: To prepare the sand moulding and to find the permeability number, compressive strength test.

2. MATERIAL Required:

a) Sand
b) Clay
c) Coal Powder
d) Chalk Powder
e) Water

Size of Specimen: Outer diameter = (50+0.1)mm, Height= (50.8 + 0.8)mm

3. APPARATUS:

a) Sand Ramming machine
b) Permeability testing machine
c) Universal strength testing machine

4. PROCEDURE:

A) Specimen Preparation:

Since the permeability of sand is dependent to great extent on the degree of ramming, so it is necessary, that the specimen to be prepared under standard conditions. Following procedures are to be followed to prepare the specimen:

a) The sand is a mixture of standard sand, bentonite powder, coal powder, chalk powder, water etc.

b) Sand rammer is used along with a specimen tube. One side of the specimen tube is closed with a lid.

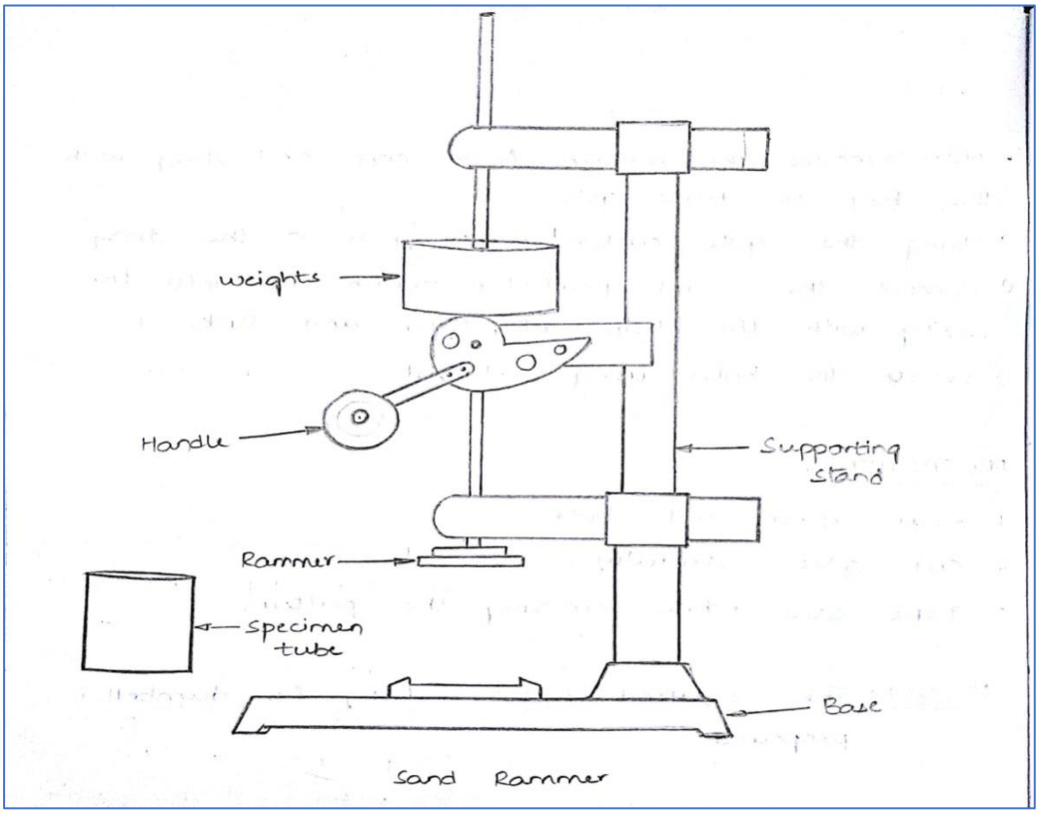
c) The measured amount of sand, ***145 to 175*** gms, is filled in the specimen tube.

d) The apparatus is kept on the platform exactly at the specified place.

e) Rammer with a fixed weight of ***6.35 to 7.25*** kg is allowed to fall on the sand three times.

f) The top of the rammer should exactly coincide with the ZERO mark indicated in the apparatus.

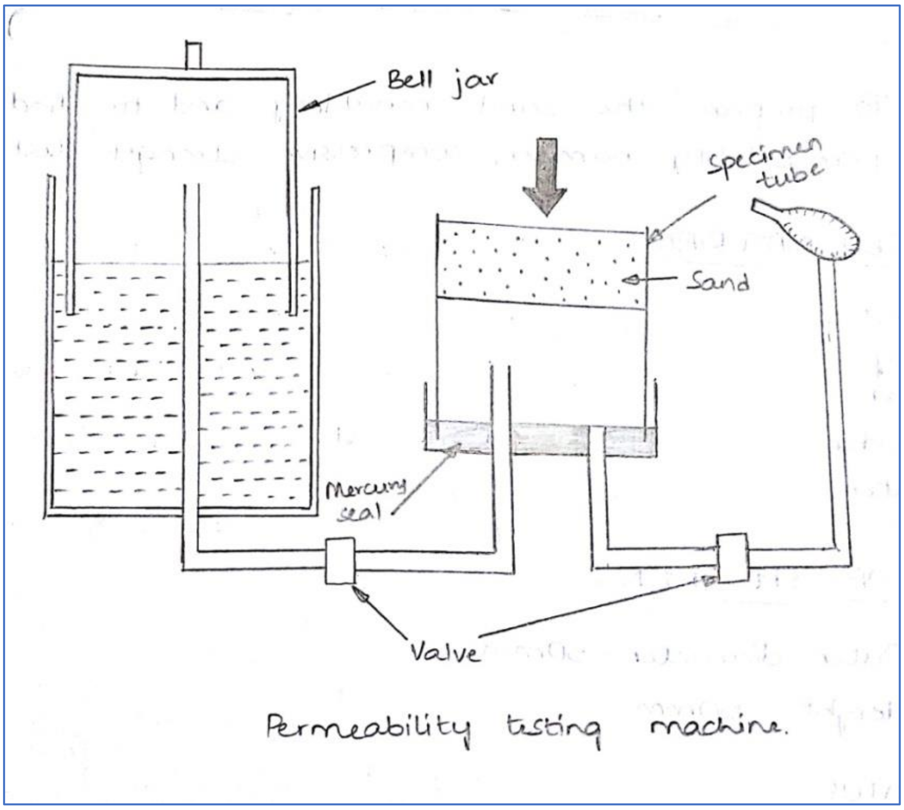
g) The final diameter and height of the specimen should be ***50.0+0.1*** and ***50.8+0.8*** respectively.



B) Permeability Test:

During the solidification of a casting, large amount of gases are to be expelled out from the mould. The gases are those which are absorbed by the metal in the furnace, air absorbed from the atmosphere, steam and other gases that are generated by the moulding and core sands. If these gases are not allowed to escape from the mould, they could be trapped inside the casting, causing defects. The moulding sand should be sufficiently porous, so that the gases are allowed to escape from the mould. This gas evolution capability of the moulding sand is termed as permeability.

a) Keep the pressure Valve in D Position.
b) Place the sand specimen at specified place in inverted position.
c) Fill water in the large vessel upto $3/4^{th}$ of the volume.
d) Insert the upper jar such like the the "**0- line**" on the upper jar should exactly matches the lower jar top periphery (volume of the air trapped between it is 2000cc).
e) Turn the valve from "**D- position**" to "**O- position**". This will bring a locking position for the upper jar.
f) Fill some water in the manometer tube so that it touches the "**O- position**" in the scale.
g) Turn the valve to " **P- position**"; this makes the air to flow through the sand specimen.
h) Pass the air till the upper jar comes down to the level of lower jar.
i) Start the stop watch to note down the time to pass 2000cc of air from the specimen.
j) After full air passes, turn the valve to **"D- position".**
k) Remove the specimen with the help of removing rod.



Observation: (Refer formula below and the units)

- Record the values of V, H, p, A & T
- Calculate the permeability number from the recorded values using formula
- Note the permeability number from the chart on the test equipment
- Compare both the calculated value and the chart value

Permeability Number (**P**) $= \frac{VH}{pAT}$

V = Volume of the air passing through the specimen in cc = 2000cc

H = Height of the specimen in cm = 5.08 cm (50.8 mm)

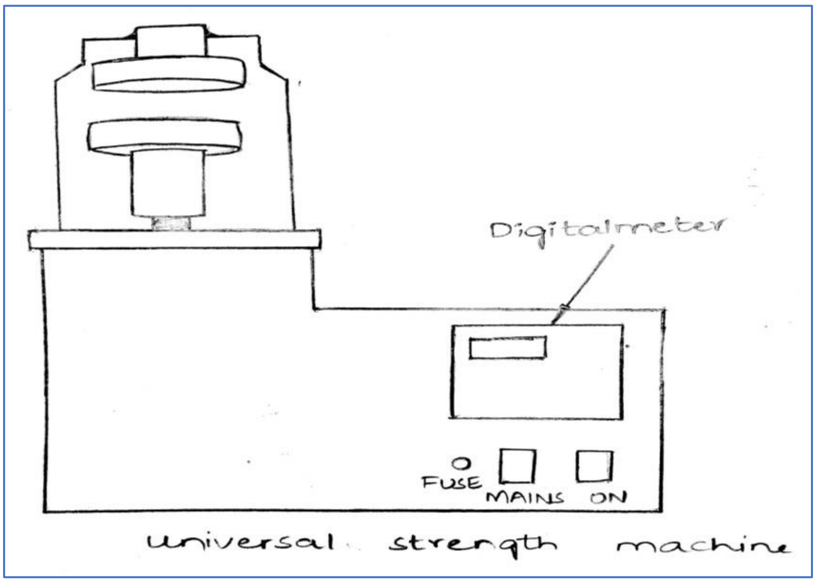
p = pressure of air (in g/cm^2) = gm/cm^2

A = cross section area of the specimen in cm^2 (d = 50mm= 5cm) = $\boldsymbol{\pi d^2 / 4 = 19.64\ cm^2}$

T = time in minutes. (**Record in seconds** and **convert into minutes**)=

C) Compression Test:

a) The sample removed from the tube is kept under the universal testing machine.
b) Start the machine and set the value to zero.
c) Set the mode of the machine to **"Compression".**
d) Now allow the compressive load to act on the specimen.
e) After some time buzzer will sound or the machine stops loading.
f) Note down the reading on the digital meter. It will give the compressive strength of the specimen in ***Kg/ cm²***



5. PRECAUTIONS:

a) Machine parts should be kept lubricated.
b) Apply rust preventive oil to the machine.
c) Clean the machine after each test.

6. RESULT:

Permeability:

a) The permeability number of the specimen as per formula = ____________

b) The permeability number of the specimen as per chart is = _____________

Compressive Strength:

a) Compressive strength of the specimen is __________

- - - - -Below figures are for understanding only (Not required in observation/ record) - - - -

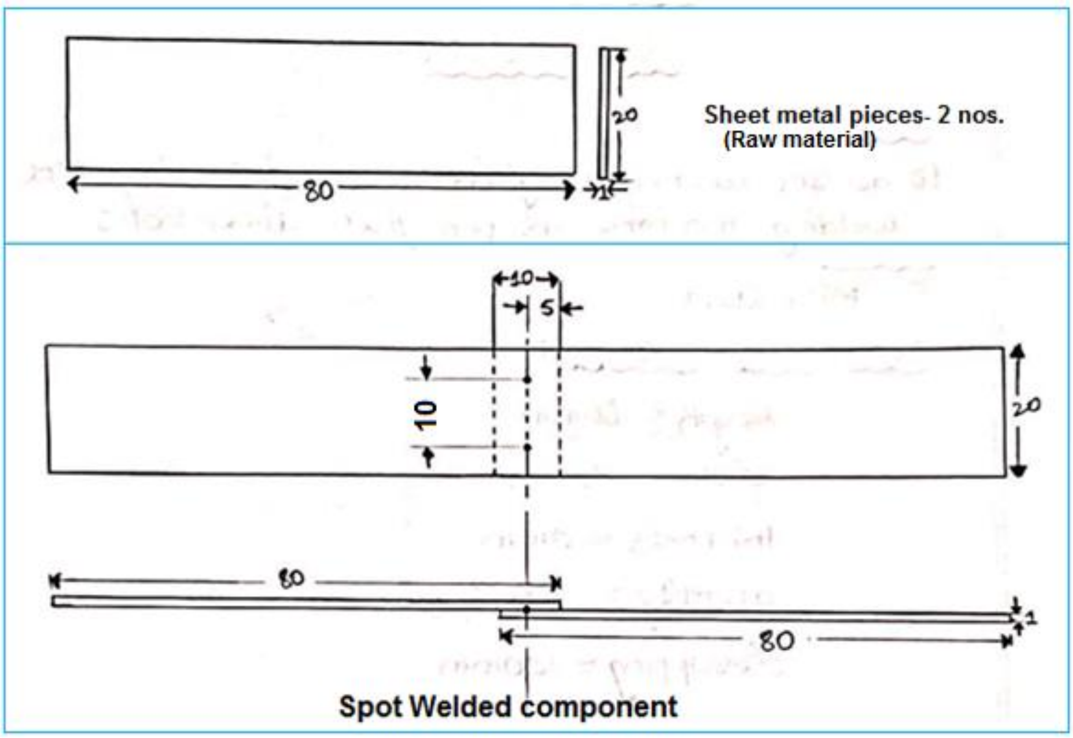
Experiment 4 (Welding)

SPOT WELDING

1. **AIM:** To do spot welding on given M.S strips using spot welding machine as per the given dimensions.
2. **MATERIAL:** Mild steel

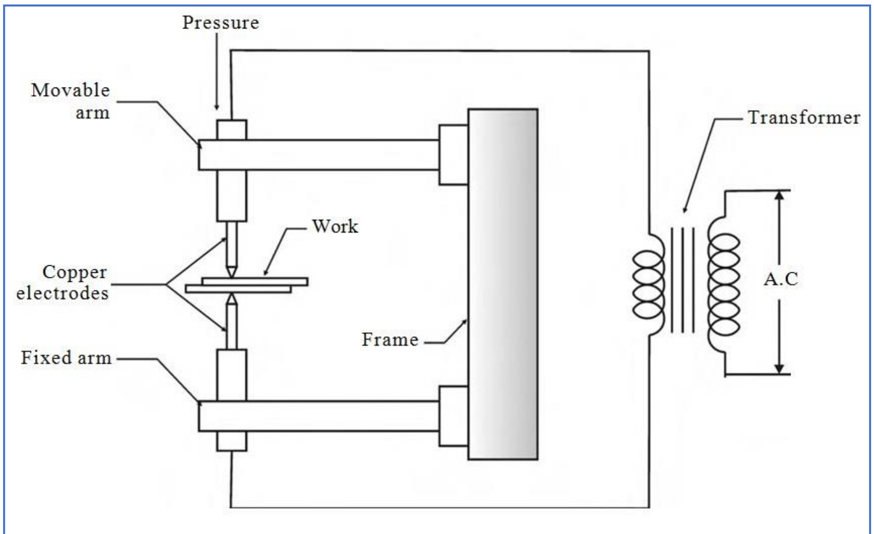
   RAW MATERIALS SIZES :

   a) Length = 80mm
   b) Width = 20mm
   c) Thickness = 1mm
   d) Quantity = 2 strips
   e) Overlapping size = 10mm

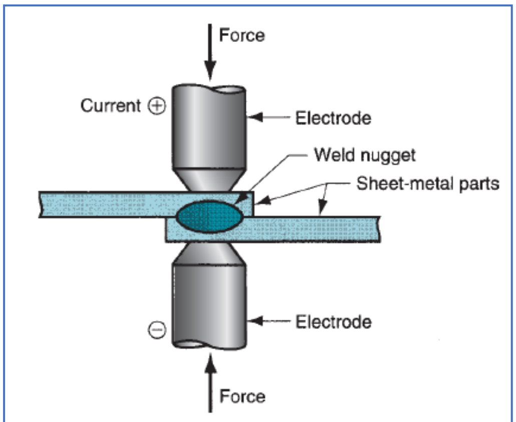


3. **TOOLS & EQUIPMENTS:**

   a) Resistance welding machine
   b) Secondary Voltage = 1V
   c) Current = 2000 Ampere
   d) No. of Cycles = 6
   e) Mild steel metal of 1mm thickness.



Resistance welding



Spot Welding
(a type of Resistance Welding RW)

4. THEORY & DESCRIPTION OF THE EQUIPMENT:

THEORY:

Spot welding is category of Resistance welding (RW). resistance welding (RW) covers a number of processes in which the heat required for welding is produced by means of electrical resistance across the two components to be joined. These processes have major advantages, such as no need of consumable electrodes, shielding gases, or flux.

The heat generated in resistance welding is given by the general expression:

$$\mathbf{H = I^2RT}$$

Where,

H = heat generated (joules or watt-seconds)
I = current (Amperes),
R= resistance (Ohms), and
T= time of current flow (Seconds)

The actual temperature rise at the joint depends on the specific heat and on the thermal conductivity of the metals to be joined.

In spot welding, a satisfactory weld is obtained when a proper current density (A/Sq mm) is maintained. The current density depends on the contact area between the electrode and the work piece. With the continuous use, if the tip becomes upset and the contact area increases, the current density will be lowered and consequently the weld is obtained over a large area. This would not but able to melt the metal and hence there would be no proper fusion.

The tips of two opposing solid cylindrical electrodes touch a lap joint of two sheet metals, and resistance heating produces a spot weld. In order to obtain a strong bond in the **weld nugget,** pressure is applied until the current is turned off. Accurate control and timing of the electric current and of the pressure are essential in resistance welding.

The strength of the bond depends on surface roughness and on the cleanness of the mating surface. Oil, paint, and thick oxide layers should, therefore, be removed before welding. The presence of uniform, thin layers of oxide and of other contaminants is not critical.

The weld nugget is generally 6 to 10 mm in diameter. The surface of the weld spot has a slightly discoloured indentation.

Currents range from 3000 A to 40000 A, the level depends on the materials being welded and on their thicknesses.

EQUIPMENT: A typical resistance spot welding machine essentially consists of two electrodes, out of which one is fixed. The other electrode is fixed to a rocker arm (to provide mechanical advantage) for transmitting mechanical force from a pneumatic cylinder. This is simplest type of arrangement. The other possibility is that of a pneumatic or hydraulic cylinder being directly connected to the electrode without any rocker arm.

For welding large assemblies such as car bodies, portable spot welding machines are used. Here the electrode holder and the pneumatic pressurizing system is present in the form of a portable assembly which is taken to the place, where the spot is to be made. The electric current, compressed air and the cooling water needed for the electrodes is supplied through cable and hoses from the main welding machine to the portable unit.

The sequence of events (Cycle) in the Resistance Spot Welding process is as below**:**

a) ***Squeeze time***: is the time required for the electrodes to align and clamp the two workpieces together under them and provide the necessary electrical contact.
b) ***Weld time***: is the time of the current flow through the workpieces till they are heated to the melting temperature
c) ***Hold time***: is the time when the pressure is maintained on the molten metal without the electric current. (during this time the pieces will be ***forge welded***)
d) ***Off time***: is the time during which the pressure on the electrode is taken off so that the plates can be positioned for the next spot. (off time is not specified for simple spot welding normally, but given when a series of spots are to be made in a predetermined pitch)

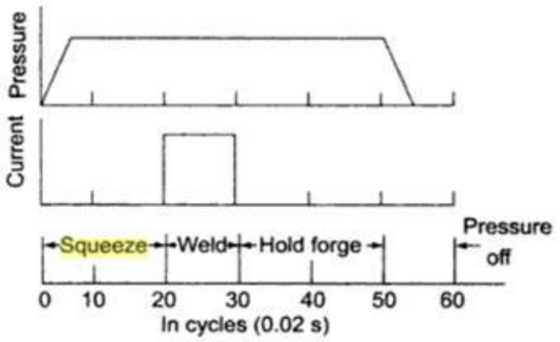


Fig. 9.63 *Simple electric resistance-welding schedule*

APPLICATION OF SPOT WELDING:

a) Welding of low carbon steels, high speed steels, stainless steels, AI, Cu, nickel, nickel alloys etc.
b) In automobile (doors, body etc) and aircraft industries.
c) Steel household furniture.
d) Containers.

5. PROCEDURE:

a) Switch on the machine and set the current in the machine to 2000 Ampere
b) Set the timer to 6 Cycles.
c) Work piece to be welded is cleaned with empery paper for removing burrs and cleaning rust if any and then clean with dry cloth.
d) Mark at 10mm on both the plates from one end using scale and scriber.
e) Overlap the two metal pieces to the required size and place them between the two electrodes.
f) Apply pressure by foot on the lever such that two electrodes come into contact if the over lapped metals.
g) After 6 Cycles remove the pressure on the lever slowly.
h) Remove the work piece.
i) Now the joint is ready for use.
j) Repeat the same procedure at various amperes
k) Test the strength of the joints using universal testing machine.

6. OBSERVATION:

Check the joint made is of sufficient strength or not by applying load in axial and transverse directions.

7. PRECAUTIONS:

a) Wear gloves, googles, apron and shoes.
b) Take care of finger or any body part must not be in touch with the machine (between the electrodes)
c) Proper care should be taken while keeping the metal sheets in between the electrodes.

8. RESULT:

Two metal sheets are welded by spot welding & the required joint is made with sufficient strength.

- - - - -Below figures are for understanding only (Not required in observation/ record) - - - -

Spot Welding Machine

Current

Current & Timer Setting

Experiment No. 5

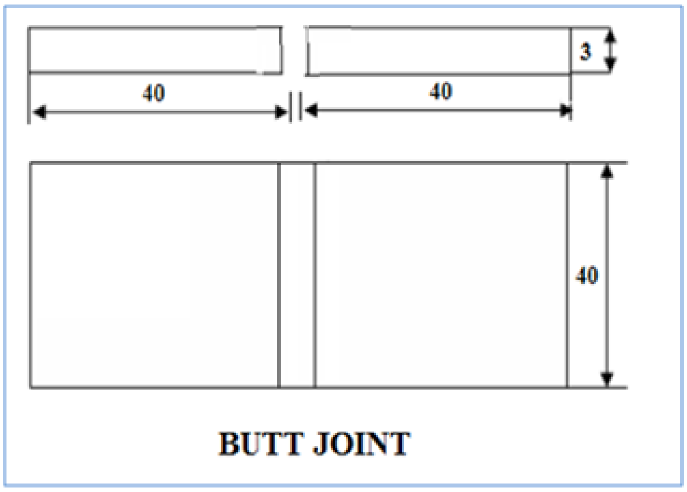
TUNGSTEN INERT GAS (TIG) WELDING

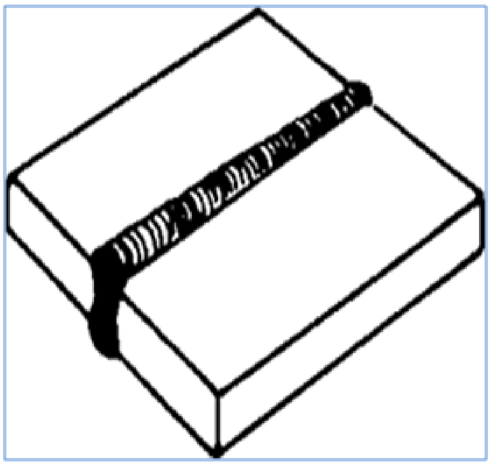
1. AIM: To prepare a Butt Joint Using TIG Welding.

2. MATERIAL AND APPARATUS REQUIRED:

a) MS flat 40 x 40 X 3 mm3 - 2Nos.
b) Tong,
c) Chipping Hammer,
d) Goggles,
e) Tungsten Electrode,
f) Ceramic Nozzle and
g) Filler rod.
h) Water pump

3. EQUIPMENT REQUIRED: Transformer, High Frequency Unit, Rectifier and Argon gas cylinder.





4. SPECIFICATION:

a) Input Voltage = 415+/-10%V, 50Hz
b) 3 Phase
c) Input KVA (At 60% duty cycle) = 22
d) Open circuit voltage (DC) = 80V
e) Welding Current(At 60% duty cycle) = 400A
f) Welding Current(At 100% duty cycle) = 300A
g) Cooling = Water Cooled
h) Insulation = Class ‘H’
i) Short Circuit Current = <u>120 Amps</u>
j) Gas Pressure = <u>1.5 kg/cm</u>^{2}
k) Gas Flow Rate = 2.5 Lit/min
l) Tungsten electrode Diameter = 2.4 mm

5. THEORY:

The Endeavour of welder is always to obtain a joint which is as strong as the base metal and at the same time, the joint is as homogeneous as possible. To this end, the complete exclusion of oxygen and other gases which interfere with the weld pool to the detriment of weld quality is very essential. In manual metal arc welding, the use of stick electrodes does this job to some extent but not fully. In inert gas shielded arc welding processes, a high pressure inert gas flowing around the electrode while welding would physically displace all the atmospheric gases around the weld metal to fully protect it. The shielding gases most commonly used are argon, helium, carbon dioxide and mixtures of them. Argon and helium are completely inert and therefore they provide completely inert atmosphere around the puddle, when used at sufficient pressure. Any contaminations in these gases would decrease the weld quality.

Argon is normally preferred over helium because of a number of specific advantages. It requires a lower arc voltage, allows for easier arc starting and provides a smooth arc action. A longer arc can be maintained with argon, sincearc voltage does not vary appreciably with arc length. It is more economical in operation. Argon is particularly useful for welding thin sheets and for out of position welding. The main advantage of *Helium* is that it can with stand the higher arc voltages. As a result it is used in the welding where higher heat input is required, such as for thick sheets or for higher thermal conductivity materials such as copper or aluminium. *Carbon dioxide* is the most economical of all the shielding gases. Both argon and helium can be used with AC as well as DC welding power sources. However, carbon dioxide is normally used with only DC with electrode positive.

TUNGSTEN INERT GAS(TIG) WELDING:

Tungsten inert gas (TIG) welding is as inert gas shielded arc welding process using non consumable electrode. The electrode may also contain 1 to 2% thoria mixed along with core tungsten or tungsten with 0.15 to 0.4% zirconia. The pure tungsten electrodes are less expensive but will carry less current. The thoriated tungsten electrodes carry high currents and are more desirable because they can strike and maintain stable arc with relative ease. The zirconia added tungsten electrodes are better than pure tungsten but inferior to thoriated tungsten electrodes.

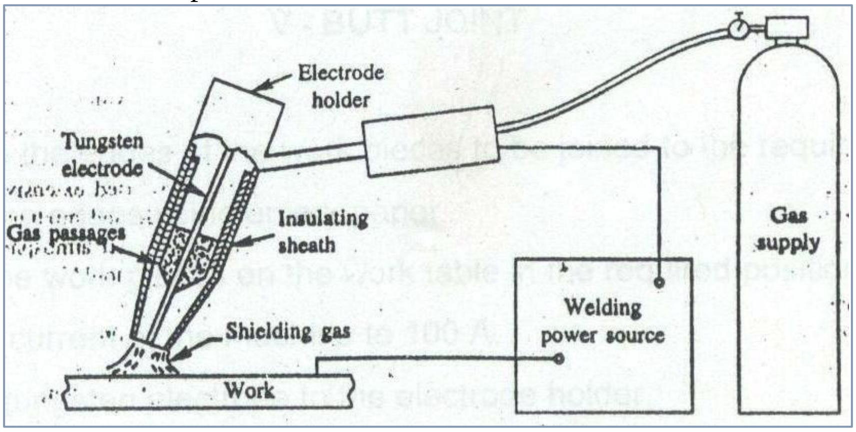
A typical TIG welding setup is consists of a welding torch at the centre of which is the tungsten electrode. The inert gas is supplied to the welding zone through the annular path surrounding the tungsten electrode to effectively displace the atmosphere around the weld puddle. The TIG welding process can be used for the joining of a number of materials though the most common ones are aluminium, magnesium and stainless steel.

The power sources used are always the constant current type. Both DC and AC power supplies can be used for TIG welding. When DC is used, the electrode can be negative (DCEN) or positive (DCEP). With DCEP is normally used for welding thin metals whereasfrom deeper penetration welds DCEN is used. An Ac arc welding is likely to give rise to a higher penetration than that of DCEP.

6. PROCEDURE:

i) Prepare the edges of the work pieces to be joined to the required shape.
ii) Finish the edges using emery paper.
iii) Place the work pieces on the work table in the required position.
iv) Set the current of the machine as perrequirement.
v) Fix the tungsten electrode to the electrode holder.
vi) Required size of the nozzle is selected and it is fixed to the torch.
vii) Adjust the inert gas pressure and flow rate to the required rate.
viii) Select the filler rod (same as base metals) of required diameter.
ix) Switch on the water pump (which act as a coolant for torch)

x) Touch the electrode to the work, so that current flow will be established and then separated by a small distance and the arc will be generated.
xi) Move the electrode slowly along the length of the joint with the filler rod, so that the filler metal will be deposited in the joint.
xii) Repeat the operation for the second pass, so that required amount of filler metal will be deposited on the work pieces.



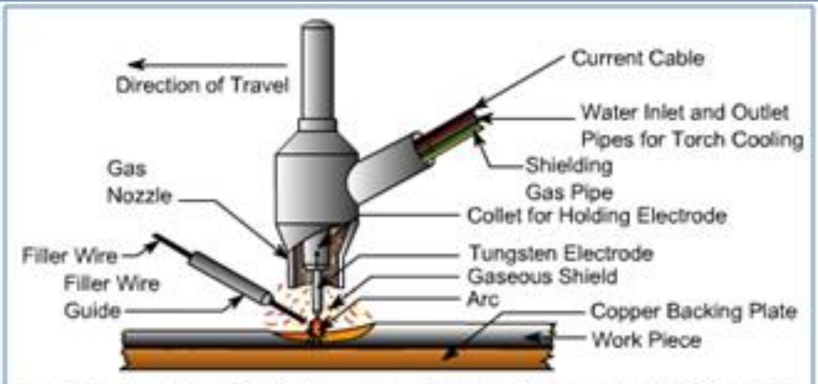


Fig 10.1: Principle of TIG Welding. (http://nptel.ac.in/courses/112107144/34)

7. PRECAUTIONS:

a) Never look at the arc with the naked eye. Always use a shield while welding.
b) Always wear the safety hand gloves, apron and leather shoes.
c) Ensure proper insulation of the cables and check for openings.
d) Select the parameters of the machine properly based on the metals to bewelded.
e) Set these parameters properly before performing the operation.
f) Inflammable and combustible materials are removed from the vicinity of weldingoperations.

8. OBSERVATION:

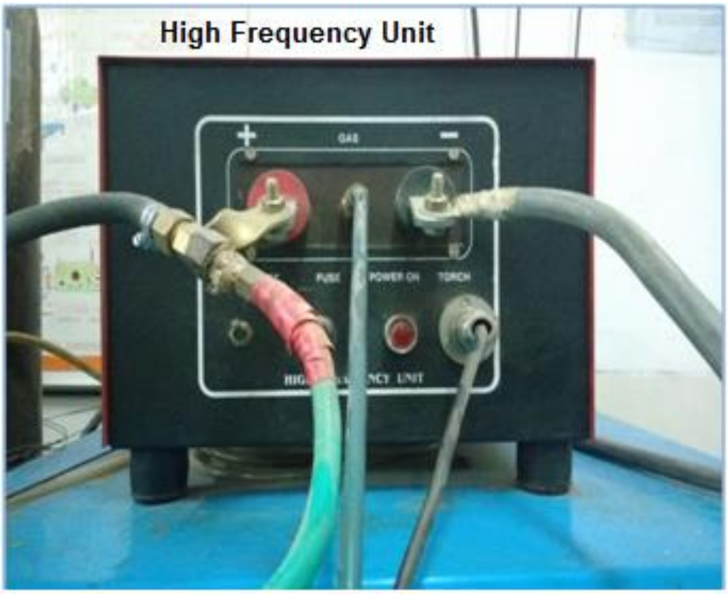
a) Check the joint made is of sufficient strength or not by applying load in axial and transverse directions.
b) Check for any blow holes, porosity, material filing and finishing.

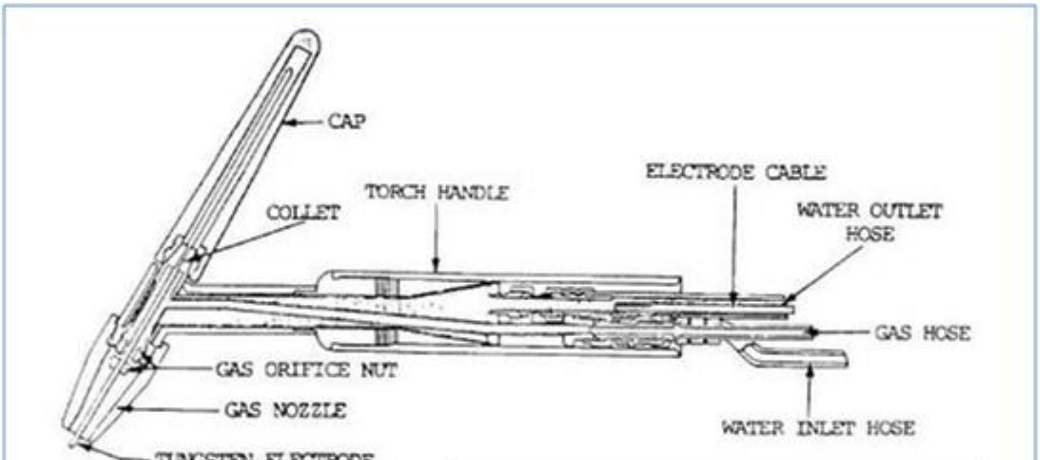
9. RESULT:

Hence the two metals are welded by TIG welding & the required joint is made.

---Figures for review purpose---------------------------------------


WELDING MACHINES
WR 400 A





Schematic Diagram of Welding Torch

Experiment

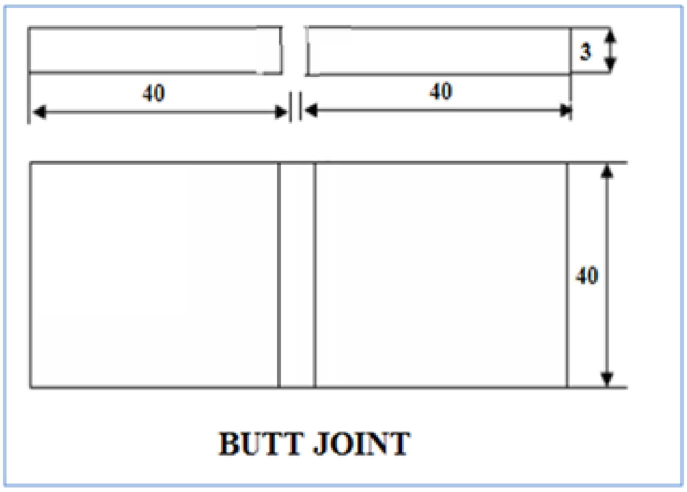
METAL INERT GAS (MIG) WELDING

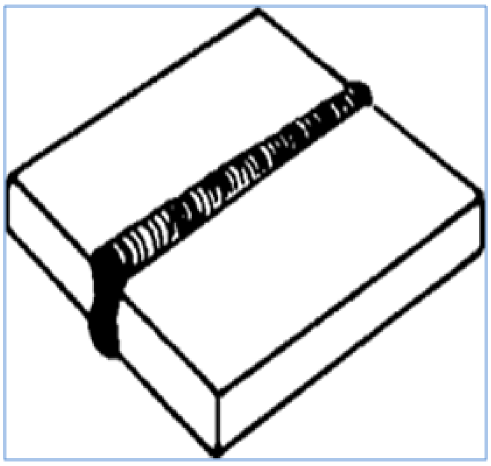
1. AIM: To prepare a Butt Joint Using MIG Welding.

2. MATERIAL AND APPARATUS REQUIRED:

i) MS flat 40 x 40 X 3 mm3 - 2Nos.
j) Tong,
k) Chipping Hammer,
l) Goggles,
m) MIG welding setup
n) Filler material

3. EQUIPMENT REQUIRED: MIG Welding setup, CO2 gas cylinder, safety goggles, gloves, shielding mask, tong, wire brush





Specimen

4. SPECIFICATION:

m) Input Voltage = 415+/-10%V, 50Hz
n) 3 Phase
o) Input KVA (At 60% duty cycle) = 22
p) Open circuit voltage (DC) = 80V
q) Welding Current(At 60% duty cycle) = 400A
r) Welding Current(At 100% duty cycle) = 300A
s) Insulation = Class 'H'
t) Short Circuit Current = 120 Amps
u) Gas Pressure = 1.5 kg/cm^2

5. THEORY:

This process is based on the principle of developing weld by melting faying surfaces of the base metal using heat produced by a welding arc established between base metal and a consumable electrode. Welding arc and weld pool are well protected by a jet of shielding inactive gas coming out of the nozzle and forming a shroud around the arc and weld. MIG weld is not considered as clean as TIG weld. Difference in cleanliness of the weld produced by MIG and TIG welding is primarily attributed to the variation in effectiveness of shielding gas to protect the weld pool in case of above two processes. Effectiveness of shielding in two processes is mainly determined by two characteristics of the welding arc namely stability of the welding arc and length of arc besides other welding related parameters such as type of shielding gas, flow rate of shielding gas, distance between nozzle and work-price. The MIG arc is relatively longer and less stable than TIG arc. Difference in stability of two welding arcs is primarily since in MIG arc is established between base metal and consumable electrode (which is consumed continuously during welding) while TIG welding arc is established between base metal and nonconsumable tungsten electrode. Consumption of the electrode during welding slightly decreases the stability of the arc. Therefore, shielding of the weld pool in MIGW is not as effective as in TIGW

Metal inert gas process is similar to TIG welding except that it uses the automatically fed consumable electrode therefore it offers high deposition rate and so it suits for good quality weld joints required for industrial fabrication. Consumable electrode is fed automatically while torch is controlled either manual or automatically. Therefore, this process is found more suitable for welding of comparatively thicker plates of reactive metals (Al, Mg, Stainless steel). The quality of weld joints of these metals otherwise is adversely affected by atmospheric gases at high temperature.

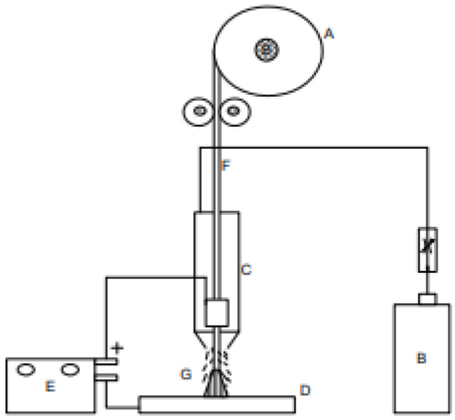


Fig. 17.1 Schematic of GMAW process showing important elements A) Welding spool, B) Shielding gas cylinder, C) welding torch, D) base plate, E) welding power source, and F) consumable electrode.

Power source for MIG welding

Depending upon the electrode diameter, material and electrode extension required, MIG welding may use either constant voltage or constant current type of the welding power source. For small diameter electrodes (< 2.4 mm) when electrical resistive heating controls the melting rate predominantly, constant voltage power source (DCEP) is used to take advantage of the self regulating arc whereas in case of large diameter electrode constant current power source is used with variable speed electrode feed drive system to maintain the arc length

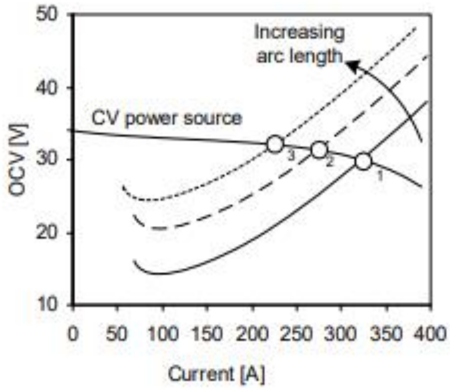
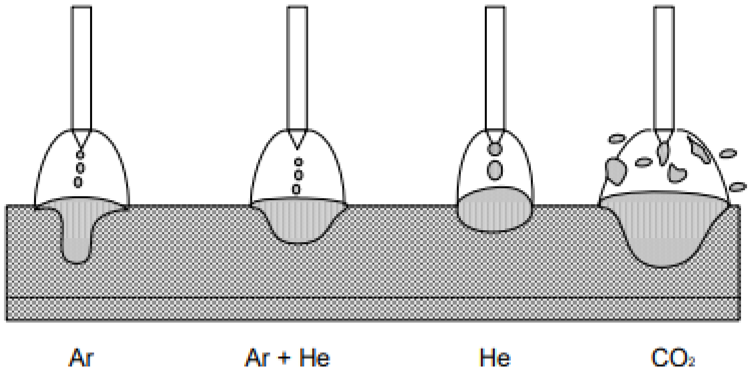


Fig. 17.2 Static characteristics of constant voltage power source showing effect of arc length on operating point

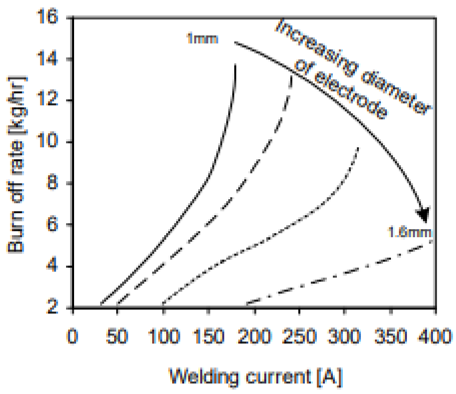
Shielding gases for MIG welding

Like TIG welding, shielding gases such as Ar, He, CO2 and their mixtures are used for protecting the welding pool from the atmospheric gases. Effect of the shielding gases on MIG weld joints is similar to that of TIG welding. Inert gases are normally used with reactive metal like Al, Mg and while carbon dioxide can be used for welding of steel for reasonably good quality of weld joints. Application of CO2 in welding of reactive none-ferrous metal is not preferred as decomposition of CO2 in arc environment produces oxygen. Interaction of oxygen with reactive metals like Al and Mg (which show greater affinity to the oxygen) form refractory oxides having higher melting point than the substrate which interferes with melting as well as increases the inclusion formation tendency in the weld metal. Moreover, shielding gases in MIGW also affect the mode of metal transfer from the consumable electrode to the weld pool during welding. MIG welding with Ar as shielding gas results in significant change in the mode of metal transfer from globular to spray and rotary transfer with maximum spatter while He mainly produces globular mode of metal transfer. MIG welding with CO2 results in welding with a lot of spattering. Shielding gas also affects width of weld bead and depth of penetration owing to difference in heat generation during welding.



Schematic showing influence of shielding gas on mode of metal transfer

Effect of MIG welding process parameters Among various welding parameters such as welding current, voltage and speed probably welding current is most influential parameters affecting weld penetration, deposition rate, weld bead geometry and quality of weld metal. However, arc voltage directly affects the width of weld bead. An increase in arc voltage in general increases the width of the weld. Welding current is primarily used to regulate the overall size of weld bead and penetration. Too low welding current results pilling of weld metal on the faying surface in the form of bead instead of penetrating into the work piece. These conditions increase the reinforcement of weld bead without enough penetration. Excessive heating of the work piece due to too high welding current causes weld sag. Optimum current gives optimum penetration and weld bead width.



Effect of welding current on melting of electrode of different diameter

6. PROCEDURE:

xiii) Prepare the edges of the work pieces to be joined to the required shape.
xiv) Finish the edges using emery paper.
xv) Place the work pieces on the work table in the required position.
xvi) Set the current of the machine as per requirement.
xvii) Clamp the negative terminal to the work table
xviii) Adjust the CO2 gas pressure.
xix) Touch the electrode to the work, so that current flow will be established and then separated by a small distance and the arc will be generated.
xx) Move the electrode slowly along the length of the joint with the filler rod, sothat the filler metal will be deposited in the joint.
xxi) Repeat the operation for the second pass, so that required amount of fillermetal will be deposited on the work pieces.

7. PRECAUTIONS:

g) Never look at the arc with the naked eye. Always use a shield while welding.
h) Always wear the safety hand gloves, apron and leather shoes.
i) Ensure proper insulation of the cables and check for openings.
j) Select the parameters of the machine properly based on the metals to bewelded.
k) Set these parameters properly before performing the operation.
l) Inflammable and combustible materials are removed from the vicinity of weldingoperations.

8. OBSERVATION:

c) Check the joint made is of sufficient strength or not by applying load in axial and transverse directions.
d) Check for any blow holes, porosity, material filing and finishing.

9. RESULT:

Hence the two metals are welded by MIG welding & the required joint is made.

Experiment 7. (Welding &Brazing)

BRAZING OPERATION

1) AIM: To make a joint by brazing operation by using oxy-acetylene welding equipment.

2) MATERIAL REQUIRED: Mild Steel.
SIZES OF RAW MATERIAL: 40 X 40 X 3 mm
QUANTITY: Two pieces (2 nos)

3) EQUIPMENT REQUIRED:
Oxygen and acetylene gas cylinders, Welding torch & nozzle (tip), Filler rod and Borax flux.

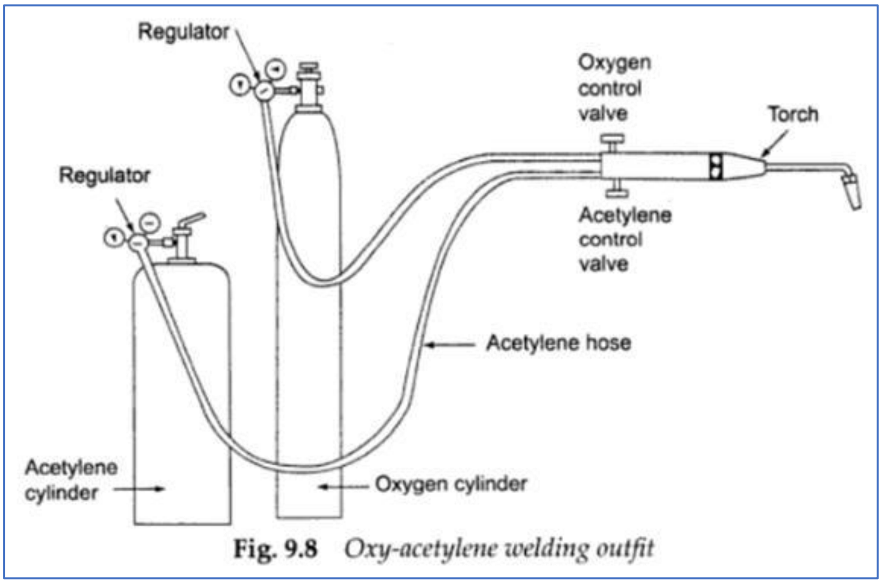


Fig. 9.8 *Oxy-acetylene welding outfit*

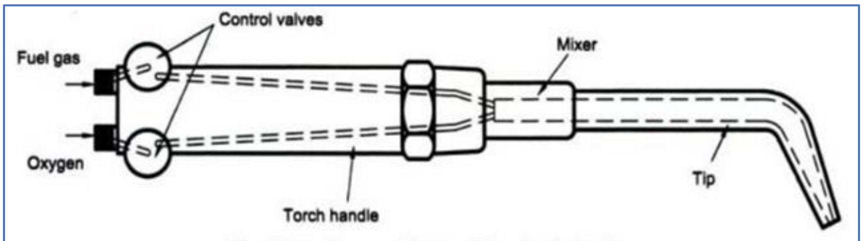


Fig. 9.10 *Oxy-acetylene welding torch details*

4) THEORY:

- Brazing is metal joining process using a ***filler metal whose liquidus temperature is above 450 °C***, and below the solidus temperature of the base metal.
- The filler metal is drawn into the joint by ***capillary action***.

a) The brazing methods: there are 4 methods of brazing as below**.**

i) Torch brazing
ii) Dip brazing
iii) Induction brazing
iv) Furnace brazing

b) Brazing joint types:

- The types of joints made in brazing are butt, lap and combination of them as below-

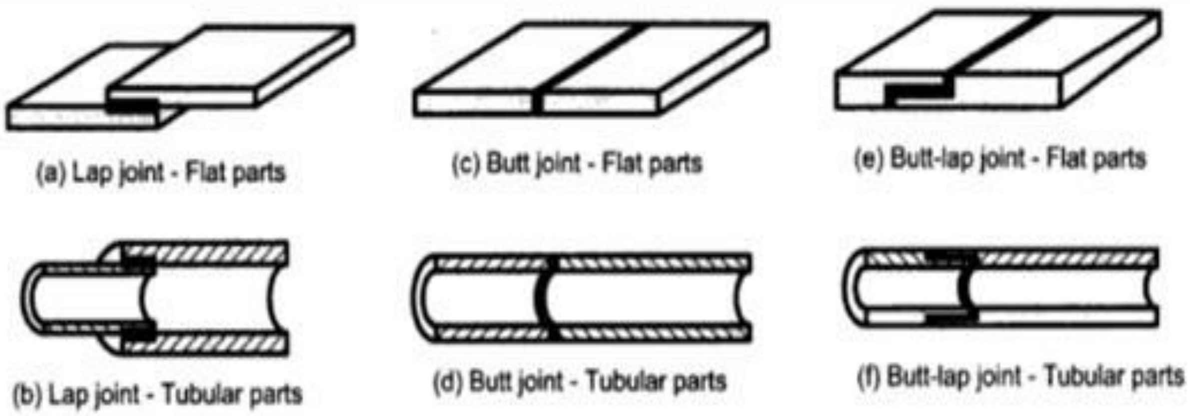


Fig. 10.8 *Brazing joints*

c) Filler materials:

The joint in brazing is obtained by ***diffusion of the filler metal into the base metal***, associated with the surface alloying.

- ***Copper based materials*** are used as fillers for brazing base metals of ***ferrous materials*** (Copper alloys with high zinc -70% are not used because of their brittleness)

  - copper base zinc alloy consisting of normally 50-60% Cu, approximately 40% Zn, 1% Ni, 0.7 % Fe and traces of Si and Mn, which is brass and termed as 'spelter'. In some cases around 10% Ni may also be added to filler alloys
    Copper base alloys may be available in the form of rod,

  - Silver brazing filler metal may consists of 30-55% Ag, 15-35% Cu, 15-28% Zn, 18-24% Cd and sometimes 2-3% Ni or 5% Sn. Silver brazing alloys are available in form of wire, strip, rods and powders.
- ***Aluminum-silicon*** filler materials are used for the base metals of ***aluminium***
- ***Silver*** is also used for brazing, to give ***high strength joints*** (tensile strengths upto 900 MPa)

d) Fluxes used in brazing:

- Fluxes are used in brazing to **remove the oxides or prevent oxide** formation at the joint, during brazing.
- Enough fluxes should be applied at the joint so that it lasts throughout the brazing session.
- Different types of fluxes used in brazing are-
  Borax, Boric acid, and active chemicals such as Chlorides, Fluorides, Tetra borates **and other wetting agents**.

- **Mixtures of borax** (75%) and **boric acid** (25%) in a paste form for ***ferrous metals***
- ***Alkaline biflourides*** are used for Stainless steels, aluminium, or beryllium-copper alloys
- ***Sodium cyanide*** (special flux) is used in brazing ***tungsten to copper.***

Method of application*:* ***Spraying, brushing*** or with the help of pressurized applicator.

5) PROCEDURE: (Torch brazing)

A) Setting required pressures of the gases- Oxygen & acetylene, with the help of the pressure regulators.

B) Set the flame to neutral flame (just before brazing)

- Open acetylene valve in the torch slightly and light the torch at the tip of the nozzle.

- Increase the acetylene gas, and increase the oxygen gas by controlling their flow, individually to get a neutral flame (bluish outer feather, and a fine inner white cone)

C) **Brazing process:**

i) Take a mild steel material of 40 x 3 mm strip and cut it into two pieces of 40 mm length each. Remove burrs and clean the surfaces thoroughly.

ii) Place the two pieces together, with minimal gap to ensure capillarity.

iii) Set required pressures of the gases- Oxygen & acetylene, with the help of the pressure regulators.

iv) Set the flame to neutral or reducing flame, by adjusting the valves of acetylene and oxygen in the torch.

v) Heat both the work pieces at the joint area, with the torch

vi) Dip the brass filler rod in borax powder (flux) and place it near the joint and heat it to melting condition, which will be deposited on the joint.
Ensure that the molten filler metal with penetrate the cavity by capillary action.to be made by the pressure of oxy acetylene flame.

vii) Repeat the procedure till the complete joint is obtained, without gaps.

viii) Allow the work piece to cool.

ix) Inspect the work piece for clean and complete brazing. If the joint is not clean and complete, repeat the brazing in the missing places

6) PRECAUTIONS:

a) Wear apron, shoes, and protective goggles.

b) Take care that there is no leakage in cylinder.

7) RESULT:

By using Oxygen and Acetylene gases, the required clean and complete joint is obtained between two pieces by brazing operation.

Experiment 8 (Metal Forming)

BLANKING AND PIERCING

1. AIM: To make (obtain) blanking and piercing on the given metal strip as per the dimensions by the simple fly press.

2. MATERIAL: Mild steel strips.

Sizes of the Strip:

- Length = 75mm
- Width = 30mm
- Thickness = 1mm

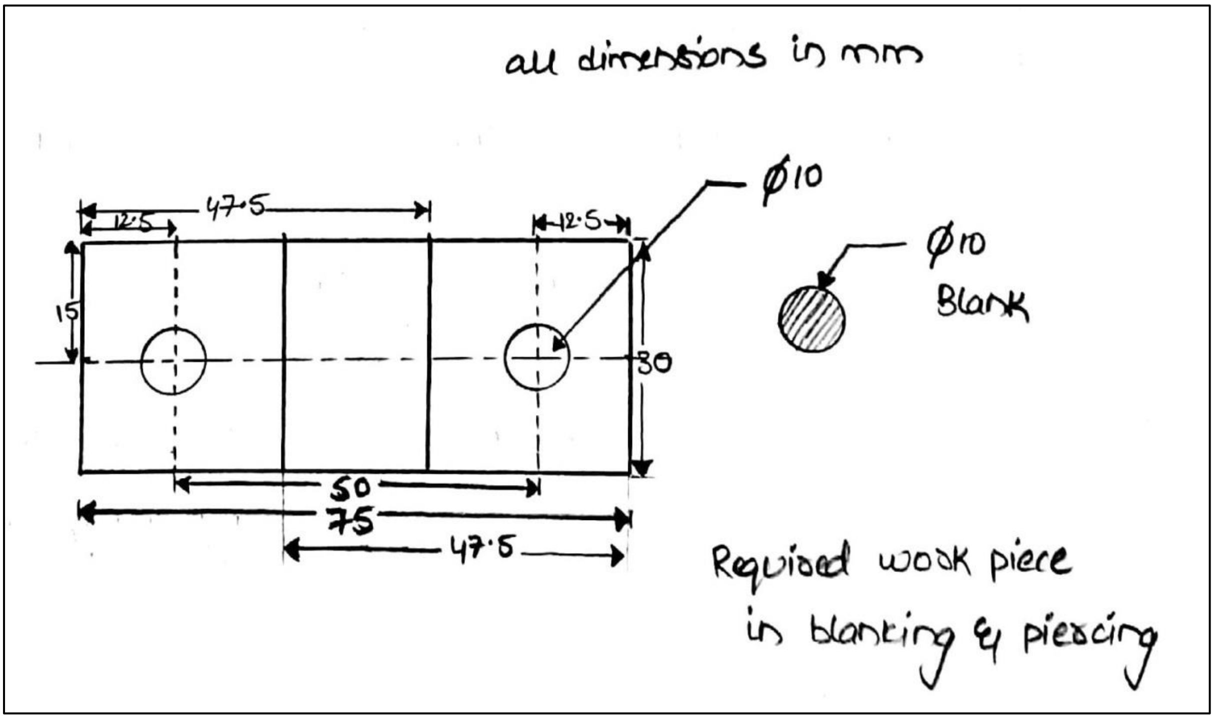
Piercing Hole Size:

Diameter of the hole = 10mm

Blank Size:

Diameter of the blank=10mm

3. Equipment and Tool: Fly Press, Punch and Die set



4. THEORY:

Press working may be defined as a chip less manufacturing process by which various components are made from sheet metal. This process is also termed as cold stamping.

Mechanical Presses

These presses can be classified as plain and geared. In the first design, the flywheel is mounted directly on the driveshaft. On a geared press, the flywheel is carried on an auxiliary shaft which is connected to the main shaft through one or more gear reductions, depending upon size and energy needed. The energy of flywheel is utilized which is transmitted to the work piece by gears, cranks, eccentrics or levers. Fly wheel is used to supply energy for that period of operation which requires more energy and during other periods, it stores the energy.

Press selection

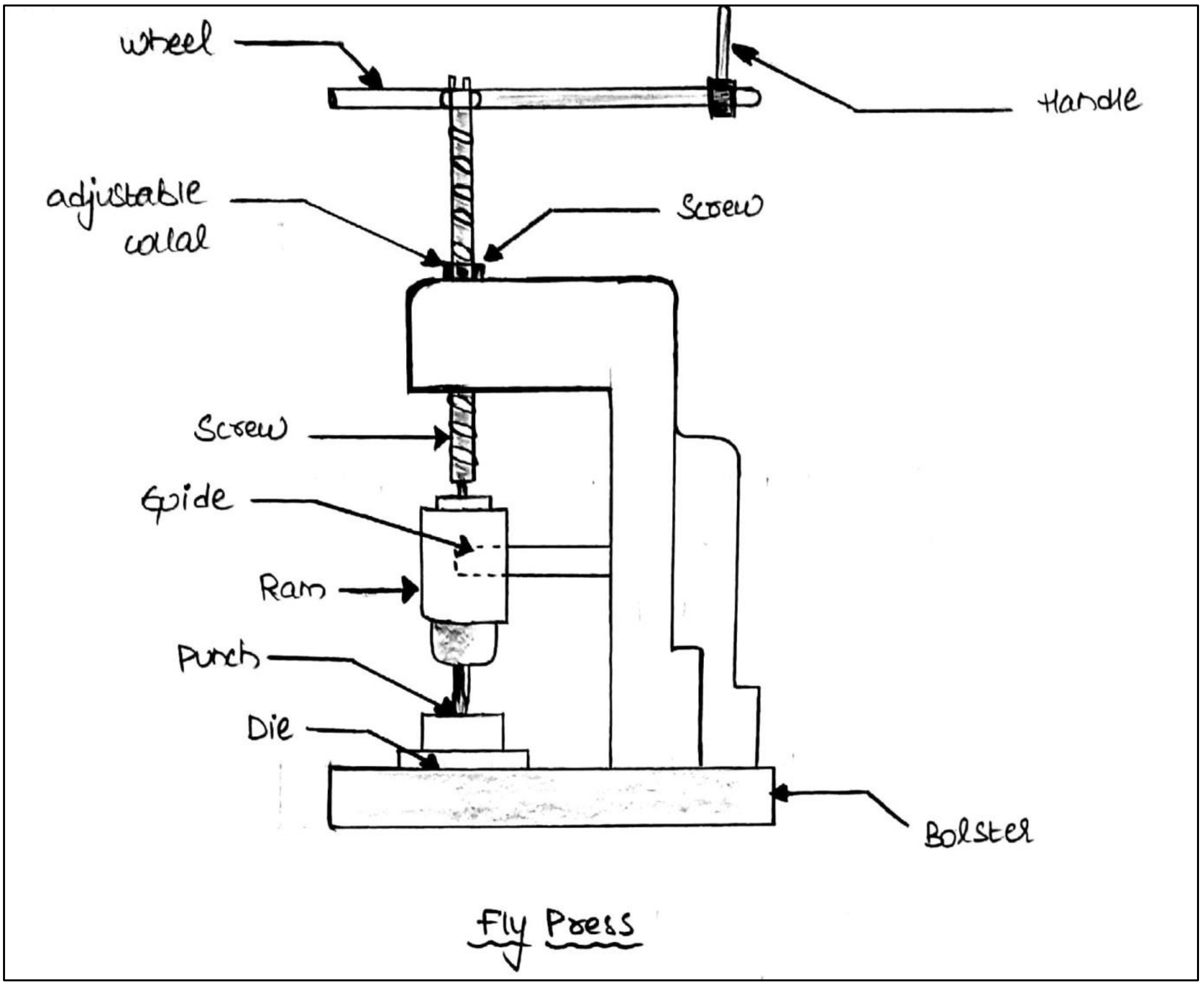
The factors which should be considered while selecting a press for a given job are:

a) The overall work size,
b) The stock thickness and material,
c) Kind of operation to be performed,
d) Power required,
e) Speed of operation.

For punching, blanking and trimming operations, usually the crank or eccentric type mechanical press is used. This is due to their small working strokes and high production rates.

Press Working Terminology:

a) Bed: The bed is the lower part of a press frame that serves as a table to which a bolster plate is mounted.
b) Bolster Plate: This is a thick plate secured to the press bed, which is used for locating and supporting the die assembly. It is usually 5 to 12.5 cm thick.
c) Die set: It is unit assembly which incorporates a lower and upper shoe, two or more guide posts and guide post bushings.
d) Die: The die may be defined as the female part of a complete tool for producing work in a press. It is also referred to a complete tool consisting of a pair of mating members for producing work in a press.
e) Die Block: It is a block or a plate which contains a die cavity.
f) Punch: This is the male component of the die assembly, which is directly or indirectly moved by and fastened to the press ram or slide.
g) Punch plate: The punch plate or punch retainer fits closely over the body of the punch and holds it in proper relative position.
h) Shut height: It is the distance from top of the bed to the bottom of the slide, with its stroke down and adjustment up.
i) Stroke: The stroke of a press is the distance of ram movement from its up position to its down position. It is equal to twice the crankshaft throw or eccentric drives.
j) Adjustable Collar: It is used for locking the motion of fly wheel.



Blanking

It is a process in which the punch removes a portion of material from the stock which is a strip of sheet metal of the necessary thickness and width. The removed portion is called a blank and is usually further processed to be of some use. In this operation the cut out piece is of importance and in it we can measure only the maximum diameter. Therefore in case of blanking operation the die should be given exact size and the clearance should be made on the punch.

Piercing

Piercing also called sometimes as punching, is used for making hole in a sheet. It is identical to blanking, except of the fact that the punched out portion coming out through the die is discharged as scrap. In this case the left out piece is importance and in it the minimum diameter is measured. Thus the punch should be given exact size and the clearance should be provided on the die.

Cutting forces

The max force F_{max} in newton needed to cut a material is equal to the area to be sheared times the shearing strength, τ_s in N/mm*2 for the material. For a circular blank of diameter D mm and of thickness t mm the cutting force will be given as:

$$F_{max} = \pi D t \tau_s = P t \tau_s$$

Where P is the perimeter of the section to be blanked

7. PROCEDURE

Piercing and Blanking

a) Cut the strips to the required dimensions and mark the required lines for reference.
b) Fix the punch to the ram of the press.
c) Fix the die on the bed of the machine using clamps, bolts and nuts.
d) Place the blank of required size between the die and punch.
e) Keep the strip (metal strip) on lines and adjust to correct dimensions.
f) Clearance must be provided as per the thickness of plate.
g) Apply pressure mechanically through Fly Press on the blank through the punch so that Piercing or Blanking will take place.
h) The process may be repeated to produce the components in mass production.

8. OBSERVATIONS

Compare the diameter of punch tool and the punch made for piercing as well as the part considered for a blank.

9. PRECAUTIONS

The die should be properly clamped to the bed of the machine and it is not disturbed during the process.

a) The punch is properly fixed to the ram of the machine.
b) Wear apron and shoes.
c) Place the metal strip exactly about the die.
d) The load should be applied uniformly on the blank.
e) The ram should be fed slowly towards the die and make sure that it is properly in line with the die.

10. RESULT: Blanking and piercing operations are done to the required dimensions.

Experiment 9

BENDING OPERATION

1. AIM: To make a right angle bend or ‘L-bend’ on a given MS strips as per given dimensions.

2. MATERIAL: Mild Steel

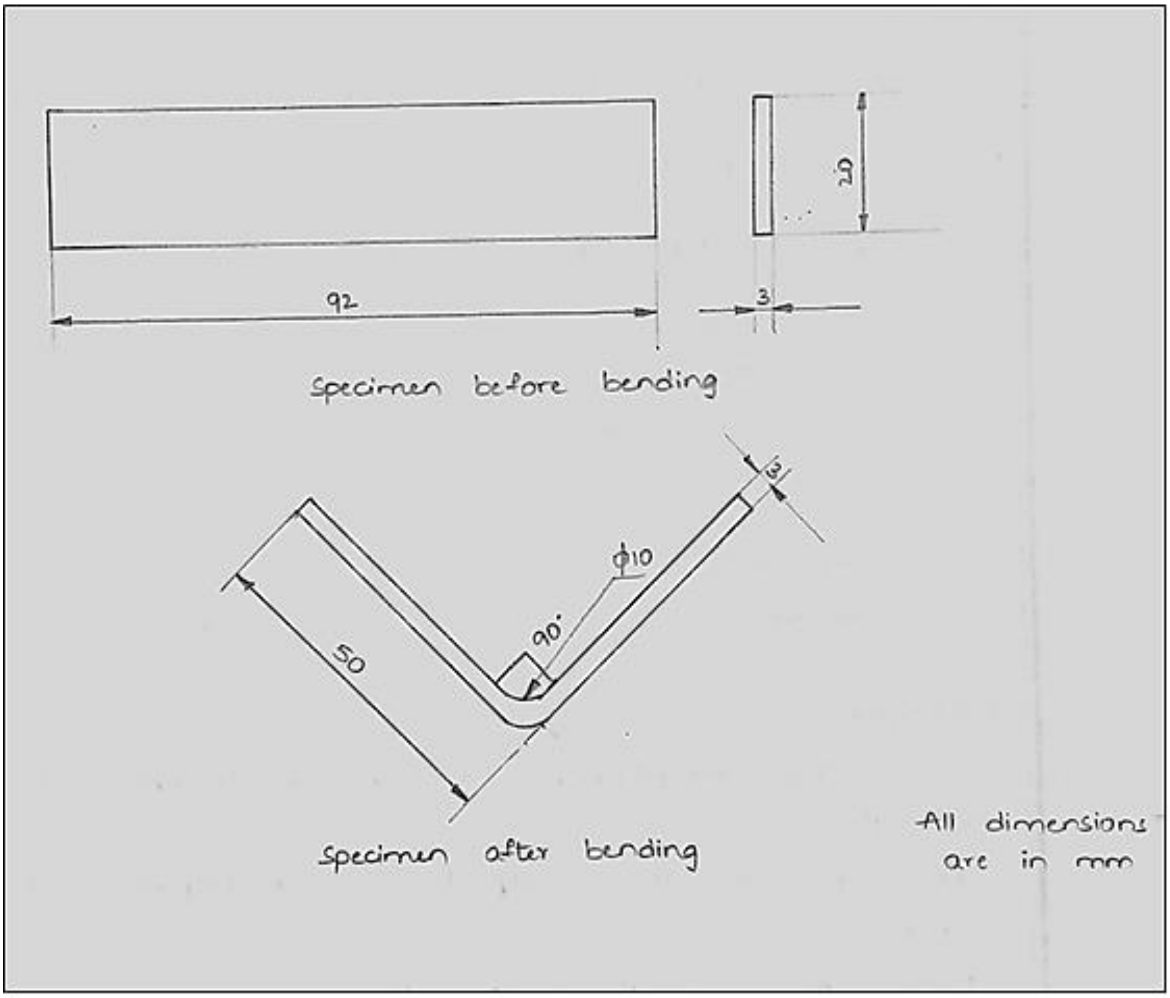
Sizes of Raw Material:

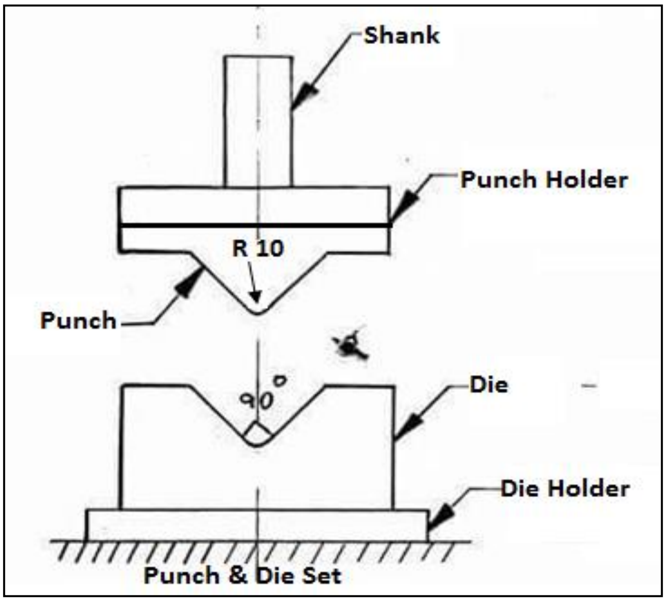
a) Length = 92mm
b) Width = 20mm
c) Thickness = 3mm

Sizes of bent strip (‘V’):

a) 50 x 50
b) Radius = 10mm

3. EQUIPMENT AND TOOLS REQUIRED: Hydraulic Press, V-Punch, V-groove die and Inclinometer.





4. BENDING ALLOWANCE:

BA = Ө(R + KT)

BA = Bending Allowance

Ө = Bend angle in radians

R = Inside bend radius

K = Bending factor, constant

T = thickness of sheet

5. THEORY:

(A) Bending:

Bending is the metal working process by which a straight length is transformed in to the curved length. It is a very common forming process for changing sheet and plate into channels, drums, tanks etc. During the bending operation, the outer surface of the material is in tension and the inside surface is in compression. The strain in the bent material increases with decrease in the radius of curvature. The stretching of the bend causes the neutral axis of the section towards the inner surface. In most cases the distance of the neutral axis to the inside of the bend is 0.3t - 0.5t where 't' is the thickness of the part.

(B) V-Bending:

In V bending, a wedge shaped punch forces a metal sheet or strip in to a wedge shaped die cavity .The bend angle may be acute, 90^0 or obtuse. As the punch descends the contact forces at the die corner produces a sufficiently large bending moment at punch corner to cause the necessary deformation. To maintain the deformation to be plane - strain, the side creep of the part during its bending is prevented or reduced by incorporating a spring loaded knurled pin in the die. The friction between pin and the part will achieve this. Plane strains conditions will also be established in the centre of the sheet if its width is more than 10 time its thickness.

(C) Spring Back:

At the end of the bending operation, when the pressure on the metal is released, there is an elastic recovery by the material. This causes a decrease in the bend angle and this phenomenon is termed as spring back for low carbon steel it can be 1^0 - 2^0 and for medium carbon steel, it can be $3^0 – 4^0$ for phosphorus bronze and spring steel can be $10^0 – 15^0$. To compensate for spring back the wedge shaped punches and the mating dies are made with included angles somewhat less than required in the formed component. Due to this the component will be bent to a greater angle than desired but will spring back to the desired angle for other types of bending the part is over bent by an angle equal to the spring back angle by having the face of the punch undercut or relieved.

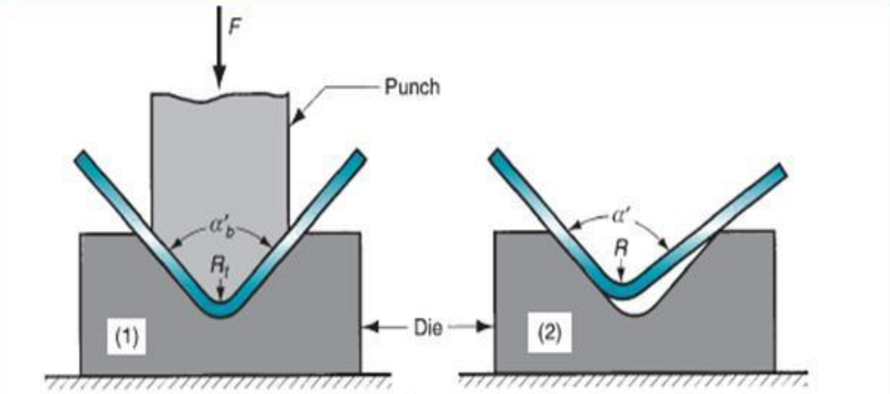


FIGURE 20.13 Springback in bending shows itself as a decrease in bend angle and an increase in bend radius: (1) during the operation, the work is forced to take the radius R_t and included angle α'_t = determined by the bending tool (punch in V-bending); (2) after the punch is removed, the work springs back to radius R and included angle α'. Symbol: F = applied bending force.

6. PROCEDURE:

a) Fix the V-shaped punch to the ram of the press.
b) Fix the V-shaped die cavity on the bed of the press using clamps, bolts and nuts.
c) Place the MS plate between the punch and die.
d) Apply pressure on the plate by moving the ram in downward direction with the help of hydraulic press through the punch.
e) As the punch descends, the contact forces at the die corner produce a sufficiently large bending movement at the punch corner to cause the necessary deformation.
f) Then the bar will take the shape of die cavity.
g) Measure the included angle of the bar using inclinometer and repeat the process until the included angle reaches 90^0.

7. PRECAUTIONS:

a) Wear apron and shoes.
b) Never place your hands near the die during punching.
c) The die should be properly clamped to the bed of the machine and it is not disturbed during the process.
d) The punch is properly fixed to the ram of the machine.
e) The load should be applied uniformly on the bar.

f) The bar should be held properly on the die block.

8. RESULT:

Thus, the given right angle bend of a given material is obtained.

--Figure for review---

Bending Machine

V-punch and V-groove die

Experiment 10

INJECTION MOULDING

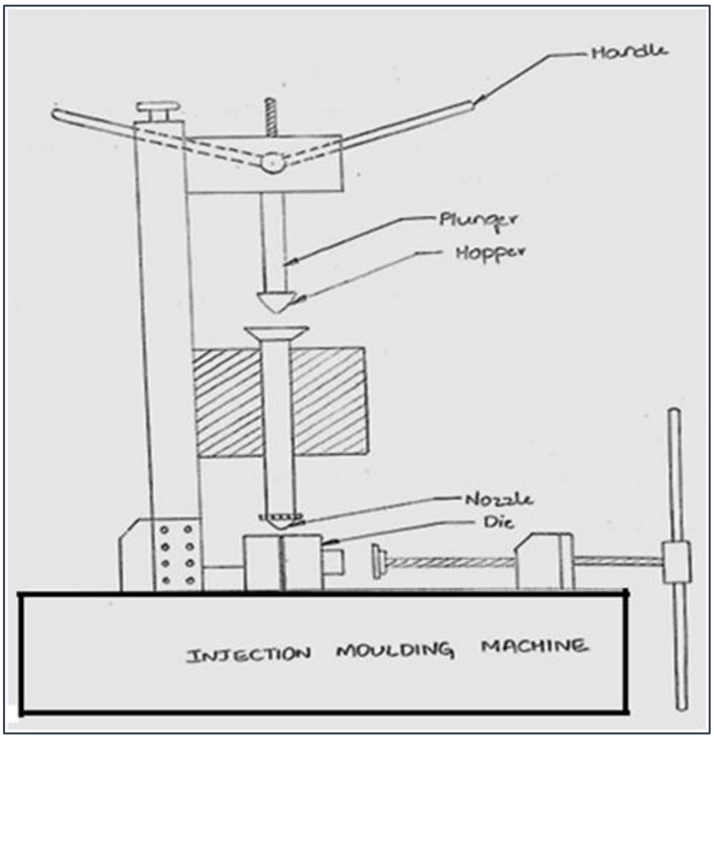
1. AIM: To prepare a plastic product (Screw Type Bottle Cap) using injection molding machine.

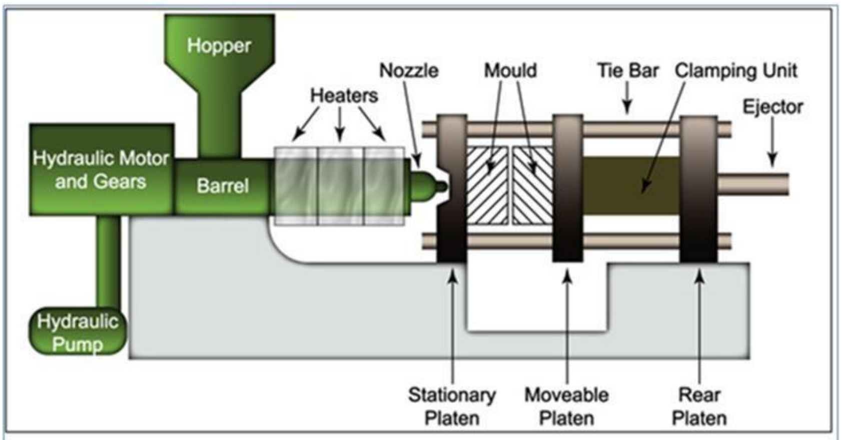
2. MATERIALS REQUIRED: High-grade polyethylene.

3. EQUIPMENT: Injection molding machine with Die.

(A) Description of the Equipment:

Injection moulding machine consists of a vertical plunger controlled by handle used to apply pressure on molten plastic. A horizontal screw used to hold the die corresponding to a nozzle hole. A Hopper is used to direct the plastic granules directly into the heating chamber. Circumferential heating chamber is used to convert solid plastic into molten state. Die used is a 3 piece bottle cap die usually made of alloy Steel.





Automated Injection Moulding Machine

4. THEORY:

(A) Plastics:

Polymers can be divided into three broad divisions: plastics, fibers and elastomers (polymers of high elasticity, for example, rubber). Synthetic resins are usually referred to as plastics. Plastics derive their name from the fact that in a certain phase of their manufacture they are present in a plastic stage (that is acquire plasticity), which makes it possible to impart any desired shape to the product. Plastics fall into a category known chemically as high polymers.

Thus Plastics is a term applied to compositions consisting of a mixture of high molecular compounds (synthetic polymers) and fillers, plasticizers, stains and pigments, lubricating and other substances. Some of the plastics contain nothing but resin (for instance, polyethylene, polystyrene).

(B) Types of Plastics:

Plastics are classified on the broad basis of whether heat causes them to set (thermosetting) or causes them to soften and melt(thermoplastic). Thermosetting Plastics: These plastics undergo a number of chemical changes on heating and cure to infusible and practically insoluble articles. The chemical change is not reversible. Thermosetting plastics do not soften on reheating and cannot be reworked. They rather become harder due to completion of any leftover polymerization reaction. Eventually at high temperatures, the useful properties of the plastics get destroyed. This is called degradation. The commonest thermosetting plastics are: alkyds, epoxides, melamines, polyesters, phenolics and ureas.

(C) Thermoplastic Plastics:

These plastics soften under heat, harden on cooling, and can be re-softened under heat. Thus they retain their fusibility, solubility and capability of being repeatedly shaped. The mechanical properties of these plastics are rather sensitive to temperature and to sunlight and exposure to temperature may cause thermal degradation. Common thermoplastics are: acrylics, poly tetra fluoroethylene (PTFE), polyvinyl chlorides (PVC), nylons, polyethylene, polypropylene etc.

(D) Processing of Thermoplastic Plastics:

The common forms of raw materials for processing plastics into products are: Pellets, Powders, Sheet, Plate, and Tubing. Liquid plastics are used especially in the fabrication of reinforced plastic parts. Thermoplastics can be processed to their final shape by moulding and extrusion processes. However, extruding is often used as an intermediate process to be followed by other processes for example vacuum forming or machining. An important industrial method of producing articles of thermoplastics is Injection Moulding.

5. PROCEDURE:

a) Initially heat the heating chamber by adjusting the knob of heater by setting required temperature.
b) Required amount of plastic granules are taken into heat chamber through hopper. The plastic pellets enter into the container. The container is heated with the coil, which is wounded around it.
c) The plastic pellets are converted into molten stage at a temperature of 800°C.
d) Wait till the molten plastic comes out through nozzle hole freely due to gravity.
e) When molten plastic start coming out from the nozzle place the die by aligning the entry hole of the die with nozzle.
f) The die is fixed by tightening the screw with the help of handle
g) While fixing the die the molten metal coming out of nozzle hole is prevented by blocking its way.
h) After fixing the die, the molten plastic is injected into the die at high pressure by pushing the plunger.
i) Then retract the lever arm slightly and open the mould.
j) Release the die and allow it to cool and remove the mould carefully.
k) Then eject the mould piece of the required shape from the die.

6. PRECAUTIONS:

a) Do not touch or approach closely to the Apparatus while operating.
b) Align the die entry hole with nozzle hole carefully.
c) Push the plunger with the help of handle continuously without any time lapse, while injecting plastic material into the die.
d) The material should not be heated rapidly.
e) The die should be placed exactly below the nozzle.
f) Proper temperature should be maintained while heating the plastic.

7. RESULT:

The required bottle cap is made using injection moulding process , and its fitment is verified by assembling with the bottle.

---------------------------------------Figures for review---

Injection Moulding Machine

Experiment - 11

BLOW MOULDING

1. Aim: To produce a bottle by blow moulding process.

2. Material Required:

- Blow Grade HDPE

3. Equipment:

(a) Blow Moulding Machine Working Details:

- Machine Model: JBM-1
- Component Name: 250ml Bottle
- Injection Pressure: 5kg/cm^2
- Release Pressure: 2kg/cm^2
- Blow Pressure: 0.5kg/cm^2 to 1kg/cm^2
- Injection Time: 4 to 5 sec OR Parison comes upto beyond mould bottom
- Blow Time: 6 – 10 sec

(b) General Details:

- Max blown container size: 0.5ltr
- Die clamping & unclamping: Manual
- Injection of parison, release & blowing of parison: Pneumatic
- Die Height: Min. 80mm & Max. 400mm

(c) Pneumatic Details:

- Max working pressure: 10kg/cm^2
- Release Pressure: 2kg/cm^2
- Blowing Pressure: upto 7kg/cm^2

(d) Electrical Details:

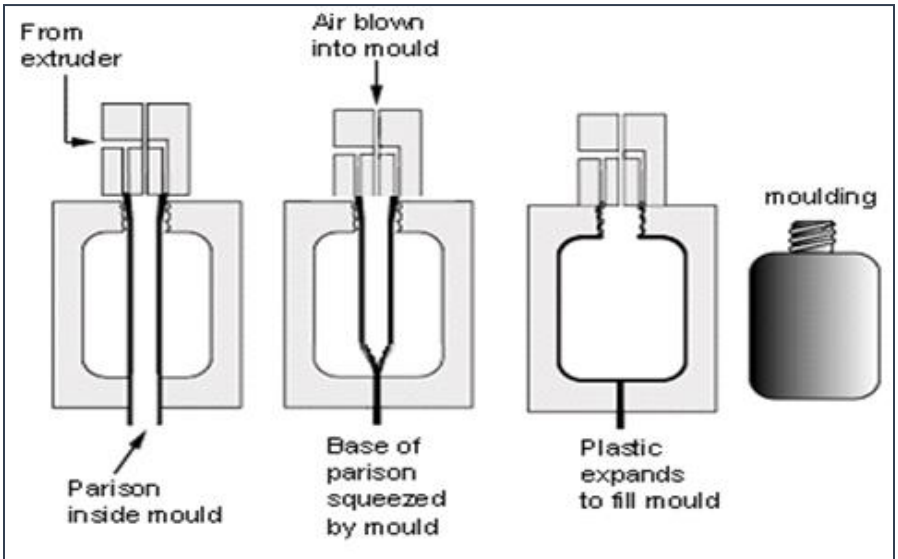
- No. of heaters: 3
- Top heater: 500W
- Middle heater: 1000W
- Bottom heater: 750W
- Total heater capacity: 2.25kW
- Voltage: 230V AC, 50Hz 1-ϕ
- Temperature controller setting range: 0 – 350^{o}C
- Timers for top and middle heaters: 0 – 60 sec

(e) Machine Dimension Details:

- Machine Size: 0.925m * 0.4m * 2.55m
- Machine Weight: 200kg (approx.)

4. WORKING PRINCIPLE:

The process is applied to only thermo plastics, which are used for producing hollow objects such as bottle, and flow table objects by applying air pressure to the sheet material when it is in heated and in soft pliable condition. Blow moulding can be accomplished in two manners; one is direct blow moulding and other indirect blow moulding. In the former case, a measured amount of material in the form of tube is either injected or extruded in a split cavity die. The split mould is closed around the tube, sealing off the lower end. The air under pressure is blown into the tube, which causes the tube to expand to the walls of cavity. In the latter case, a uniformly softened sheet material by heat is clamped at the edges between the die and cover, which causes the sheet to attain a hemispherical shape or the configuration of mould whatever it may be parts obtained by indirect blow moulding have excellent appearance but they are more costly as only to percent of the sheet stock is utilized and also there is a tendency for excessive thinning of sheet at the deepest point.



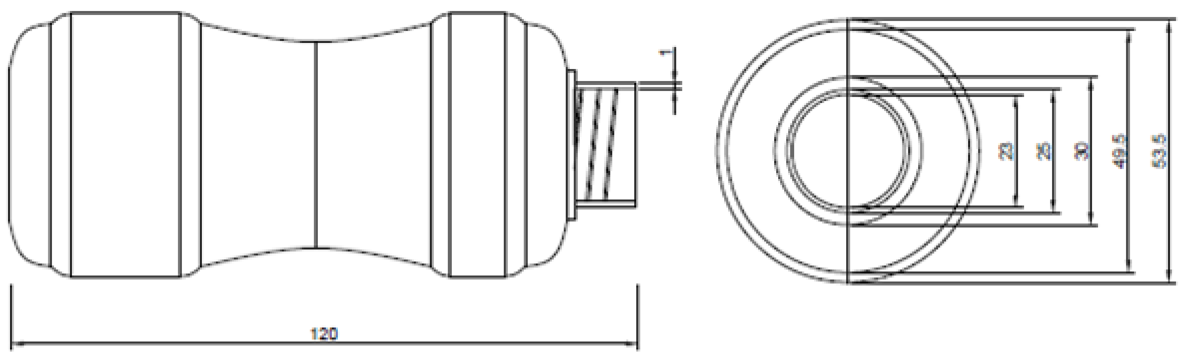
Blow Moulding Process

5. OPERATING INSTRUCTIONS:

a) Install the machine on leveled strong flooring near the compressor (within 2 meters). For letter rigidity foundation bolt is recommended & anti vibration rubber mounting can be used.
b) The machine must be placed in a position where all parts are accessible readily.
c) Check for any loose electrical connection with the help of certified electrician and with the electrical circuit enclosed.
d) Fill the lubricator with SAE 20 grade oil to the level indicated. The lubrication has been set to allow one drop of oil for every 5 strokes of air cylinder (oil) drop is factory set, no need to adjust)
e) Connect the air filter to the compressor by rubber/nylon hose (Min inside dia. 10mm), pressure with standing capacity 20kg/cm^2.
f) Set the pressure switch in the compressor as per the compressor manual to switch on 7 kg/cm^2 pressure & switch off at 10kg/cm^2 (NOTE: The air pressure should not exceed 10cm^2)
g) Set the air pressure in machine by adjusting the injection & release regulator (18).
h) Set release pressure 2kg/cm^2 by adjusting release regulator.
i) Operate the hand lever valve (13) and check for smooth functioning of plunger.

j) Set the blow pressure in regulator (15) and operate the hand lever valve (14) to check flow of air throw blow nozzle.
k) Electrical connection should be given as indicated on the main plug phase, neutral and earth.
l) Proper earthing should be done.
m) Check the incoming voltage (230VAC, 50Hz) Now the machine is ready for operation.

6. PROCEDURE:



Blow moulded bottle

a) Set the die in position. Adjust the guide rod nuts to suit die height. Align the tapered face of the die for sealing the parison while blowing also checks for the face opening and closing of the die.
b) Ensure minimum die height is 80mm. provide spacing plates if necessary.
c) Set the injection, release and blow pressure by rotating (clockwise) the regulator knob to suit the requirement of moulding the container.
d) Feed correct quantity & quality of plastic material and switch on the power supply.
e) Switch on the heater.
f) Set the required timings controller to control the bottom heater.
g) Allow sufficient time to stabilizer.
h) When temperature reached, operate the hand lever valve.
i) Extrude the parison (Tubular form) to the required length and close the two die halves. Release the injection cylinder.
j) Operate the hand lever valve and blow the air so that the parison to form the shape of the container as designed in the die.
k) Allow the component to cool.
l) Open the die & take the product out of the die.
m) Now the machine is ready for next cycle.

7. PRECAUTIONS:

a) Do not use die height more than 400mm.
b) Do not inject while die is in closed condition.
c) Do not open die when blowing the container.
d) Do not run the machine without the required pressure of air.
e) Do not run the machine without oil in the lubricator.
f) Wear proper safety gadgets while operating.

8. RESULT: Required bottle is produced using blow moulding process.

--Figures for Review--

Blow Moulding Machine

Bottle Die

LABORATORY MANUAL

VEHICLE MAINTENANCE AND TESTING
Course Code: 18PC2AE09

IV B.Tech I Semester (R18)

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INDEX

EXPERIMENT-1

VEHICLE INSPECTION

Aim: To inspect the given vehicle

Tools required: Vehicle

Procedure:

ENGINE

1. Check water pump/Alternator drive belt for tension and wear.
2. Check for Engine coolant level and leakage.
3. Inspect and replace engine oil and oil filter.
4. Check Cooling system hoses and connections for leakage and damage.
5. Check Engine mounting and manifold fixings for loose, damage.
6. Check Valve clearance.
7. Check Camshaft timing belt for damage and wear.
8. Check Exhaust system for noise, leakage etc.
9. Inspect Positive crank case ventilation system for hoses, connections and valves.

IGNITION

1. Check Ignition Wiring for Damage, Deterioration.
2. Clean the Spark plugs and adjust the gap.

FUEL

1. Clean the Air Cleaner.
2. Inspect and lubricate accelerator cable and shaft
3. Check fuel tank Cap, fuel lines and connections for leakage and damage
4. Check Fuel filter for Leakage

CLUTCH AND TRANSMISSION

1. Check Clutch pedal for play (M/T only)
2. Check Clutch slipping for dragging or excessive damage
3. Check Manual Transmission Oil for Level and Leakage
4. Check gear shifter cables for operation ((M/T only)

DRIVE SHAFTS

1. Check Drive shaft boot for Boot cut/Damage
2. Check Drive shaft for Noise

BRAKE

1. Check for Brake fluid Level and Leakage.
2. Check for Brake pedal Pedal-to –wall clearance.
3. Check for play and damage in Parking brake lever and cable.
4. Inspect Brake discs and pads for wear.
5. Inspect Brake drums and shoes for Wear.
6. Check Master cylinder, wheel cylinder, caliper piston for Fluid leakage, Boot/Seal Damage.
7. Check Brake Hoses and Pipes for Fluid leakage and Damage
8. Check and Adjust brake shoe to drum clearance

WHEEL

1. Check Tyres for Air pressure, Abnormal wear, Crack, Rotation
2. Check for Wheels Damage
3. Check for Front/Rear wheel bearings Loose and Damage

FRONT AND REAR SUSPENSION

1. Check Suspension strut for Oil leakage and Damage.
2. Check for Suspension arms/knuckles support Loose and Damage.
3. Check for Rear spring damage.
4. Check Shock absorbers for Oil leakage and damage.
5. Check and tighten all bolts and nuts.
6. Check Suspension arms and Tension rods.

STEERING

1. Check Steering wheel play.
2. Check all rods and arms for loose, Damage, Wear.

ELECTRICAL

1. Check for Battery electrolyte level and leakage.
2. Check for Wiring harness connection Looseness, Damage.
3. Check for lighting system Operation, Stains, Damage.
4. Check for Horn Operation.
5. Check for System voltage.
6. Check for wiper operation.

BODY

1. Tighten all chassis bolts and nuts.
2. Check for all latches, hinges and locks operation.
3. Check for seat belt operation.
4. Check for seat latch, lever and knob operation.

ROAD TEST

1. Check for Operation of Brakes, Gear shifting and speedometer.
2. Check for Body and chassis noise.

AIR CONDITIONER (IF EQUIPPED)

1. Check for drive belt tension and damage.
2. Tighten compressor mounting bolts.
3. Check and tighten all hoses joints.
4. Check functioning of Recirculating flap.
5. Clean condenser with low pressure water
6. Check belt for frayed edges, change if necessary
7. Check all mounting bolts

RESULT:

EXPERIMENT-2

ENGINE COMPRESSION TEST

AIM

To Performing dry and wet compression test on a given petrol engine

TOOLS REQUIRED

Compression Tester, 16mm ring spanner, 10 mm Spark plug adapter, Motor oil.

Theory

A compression test is used to determine the health of the engine by measuring cylinder pressure. It can quickly determine if the engine can generate adequate pressure needed for combustion. If the engine has loss of power, or simply won't start, a compression test should be performed

Causes for Low Cylinder Pressure:

- Excessively worn piston rings
- Broken valve spring
- Incorrect valve adjustment
- Sticking valves
- Worn or burned valves
- Worn or burned valve seats
- Worn camshaft lobes
- Dished or worn valve filters
- Cylinder head gasket is blown

Compression Test

This test measures the dynamic pumping pressure of the cylinder when the crankshaft is rotated. This test should be performed when the engine is warm – not cold and not hot.

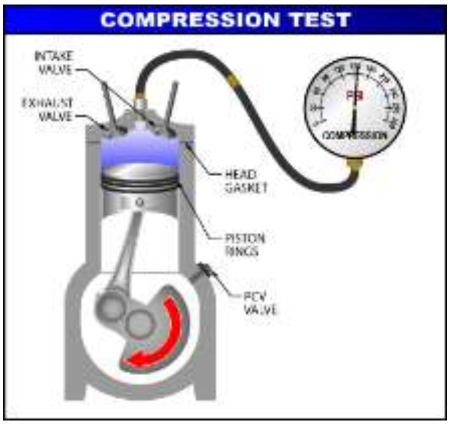


Fig: Compression test

Dry Test

Install the compression gauge into the spark plug hole and crank engine over 5-10 revolutions. For consistency, crank the engine over the same number of revolutions for each cylinder. If one cylinder has a lower reading this indicates the problematic cylinder. The dry test should yield readings within 10% of manufacturer's specifications. If no compression information is available, use 100 psi as a reference test pressure. However, it does not indicate whether the cylinder or piston rings are the cause. The wet compression test is effective at determining the source of the problem.

Wet Test

With the spark plug removed, squirt about one teaspoon of 30-weight motor oil into the spark plug hole. Take a compression reading and observe the difference between the wet and dry tests.

- Readings from the wet test should not increase by more than 10 percent, cylinder to cylinder.
- If the compression increases with the wet test, the results identify the problem as the piston rings and/or cylinder walls. The theory behind this test is that the oil is providing a wet seal for the rings. If they are not sealing on their own they will when the oil creates a seal and an increase in compression will be observed.
- If the compression stays the same, the results point to the valve train. The theory is that when the rings are sealing, the oil will have no effect on compression and therefore the valves are most likely the cause of the problem.

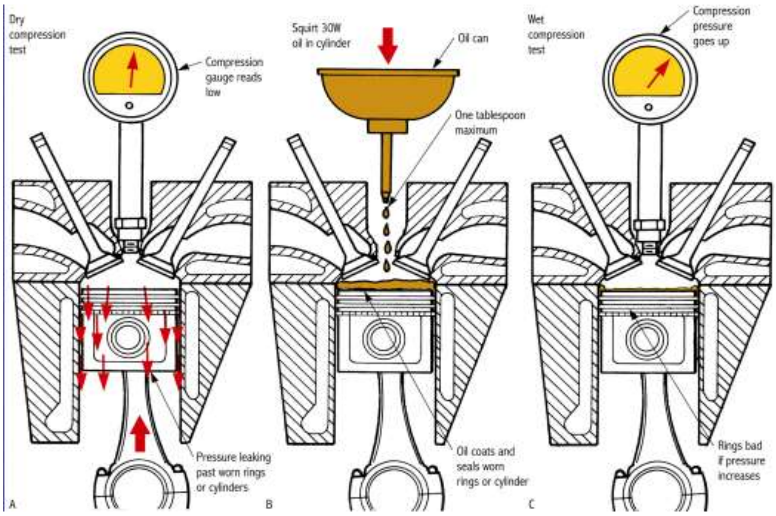


Fig: Dry and Wet Compression Test

Cylinder Pressure

Typical gasoline engines: 125-175 psi (860-1200kPa)

Typical diesel engines**:** 275-400 psi (1900-2750kPa)

The results of a compression test indicate the particular area that needs attention

Worn piston rings / cylinder walls: After running the first test, squirt a tablespoon of oil into the cylinder and rotate the crankshaft six more turns per cylinder. If the compression increases, the piston rings are at fault.

Burned valves: If results remain the same after injecting oil, one of the valves are bad or not seating correctly. Low compression in only one cylinder typically indicates a bad valve. Exhaust valves burn due to hot gases passing through. Intake valves have the advantage of being cooled by the incoming fuel.

Valve timing: When all of the cylinders are low and inserting oil into the cylinder does not increase compression, the camshaft timing is likely off. The timing belt can slip on the sprockets resulting in staggered and low compression results.

Hole in piston: A hole in a piston will result in no compression in that cylinder. Remove the oil cap or PCV valve from its grommet. Blowby caused by this hole can be seen seeping through these openings.

Carbon buildup: Carbon buildup on the top of a piston will increase compression readings. It can be seen with a probe inserted into the cylinder.

Faulty head gasket: A faulty or blown head gasket will leak compression between two adjacent cylinders. When the other cylinders are within specifications and two cylinders next to each other on the same bank are low, suspect a faulty head gasket.

Description

Fig: Compression Tester Kit

The compression kit in the illustration above has a flexible hose that makes it easy to insert into hard to reach areas of the engine. The fittings are threaded to fit the spark plug hole in the cylinder head. It has a 0 – 300 psi. Pressure gauge with a vent valve to relieve pressure after the measurement has been taken. Sometimes swivel spark plug sockets, different lengths of locking extensions and even swivel ratchets are required to remove the spark plug from these difficult to reach locations. Use an oil injector. Attach a small rubber hose to help inject oil into the hard to reach cylinder if a wet test is necessary.

Procedure

1. Warm up the engine up to normal operating temperature to allow the piston rings to fully expand.
2. Remove the Spark plug.
3. Disable the fuel injection system by removing the 15amp fuse found in the panel over by the battery.
4. Connect the 10 mm adopter to connection hose.
5. Put some motor oil on the threads and O-rings to ensure they won't get damaged during the test.
6. Install the 10 mm fitting and hose in to a cylinder.
7. Connect the compression gauge to the other end of the connection hose
8. Hold throttle wide open and run the starter motor until the gauge needle stops moving.
9. Record the reading.
10. If the reading is less than 100 psi , then perform wet test.

11. If compression rises significantly after performing wet test, it indicates the piston rings are worn.
12. If adding oil does not increase the compression pressure, the leakage is due to
    Broken valve spring
    Incorrect valve adjustment
    Sticking valves
    Worn or burned valves
    Worn or burned valve seats
    Worn camshaft lobes
    Dished or worn valve filters
    Cylinder head gasket is blown
    Necessary service is carried out according to the fault.
13. Repeat the procedure for all cylinders if it is multi cylinder engine
14. Record the reading from each cylinder.
15. No problem is indicated if any of the readings vary within or up to 10% from each other.
16. No further testing may be necessary and the compression can be considered optimal.
17. For a variance of more than 10%, problem may be with that cylinder

Observations:

S. No	Compression test		Cylinder 1	Cylinder 2	Cylinder 3
1.	Dry test	Trail 1			
2.		Trail 2			
3.		Trail 3			
4.	Wet test	Trail 1			
5.		Trail 2			
6.		Trail 3			
Problem identified					

Results:

EXPERIMENT-3

ENGINE MANIFOD VACUUM TEST

AIM

To determine the mechanical condition of the engine.

TOOLS REQUIRED

Vacuum and fuel pressure tester kit, engine.

Vacuum Gauge:

Description

The vacuum gauge is a type of pressure gauge .It measures the pressure in a closed space and compares it with atmospheric pressure. Atmospheric pressure is 14.7 psi at sea level. When the pressure is less than atmospheric; the reduced pressure is a vacuum

A partial vacuum exists if the pressure in the closed space is less than atmospheric pressure. The vacuum gauge (5-22) reads in inches of mercury. However there is no mercury in the gauge.

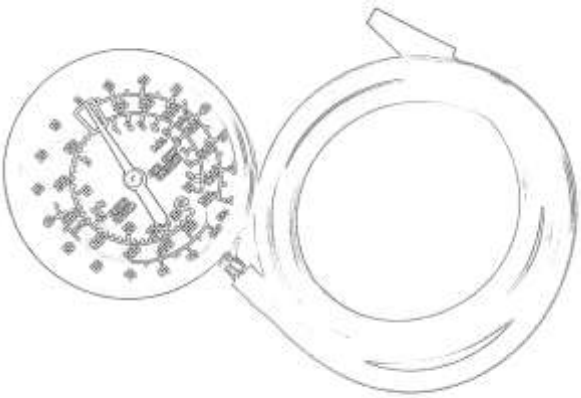


Fig: vacuum gauge

The vacuum gauge has a bellows or diaphragm linked to a needle on the dial face. Applying a vacuum moves the bellows or diaphragm. This causes the needle to move to show the amount of vacuum.Instead of a needle and dial face, some vacuum guage have a digital display.

Theory

The engine is a sort of vacuum pump. The intake stroke creates a vacuum that causes the air-fuel mixture to enter the cylinders. The amount of vacuum the engine develops is a measure of its condition. Suppose the engine is running at a steady idle speed. Normal vacuum in the intake manifold should be from 5 to 22 inches of mercury.

If the engine cannot produce normal vacuum something is wrong. Improper vacuum may affect braking, fuel economy, and exhaust emissions. It may also affect the shifting of the automatic transmission, and the operation of the heater and air conditioner. Bad valves, leaking gaskets, and poor piston rings cause a low production of vacuum.

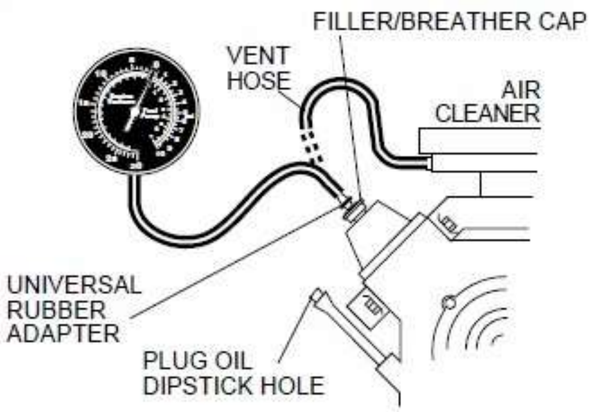


Fig shows a vacuum guage connected to the intake manifold to read manifold vacuum. The gauge measures vacuum in inches of mercury. There is no mercury in the gauge. The reading only indicates how high the vacuum would raise a column of mercury in a barometer. This instrument for measuring atmospheric pressure.

Common vacuum gauge readings are described below:

1. A steady and fairly high reading on idle indicates normal performance. Specifications vary with different engines. A reading between 17 and 22 inches of mercury usually indicates normal engine operation. The reading will be lower at higher altitudes because of lower atmospheric pressure. For every 1000 feet above sea level the reading is reduced about 1 inch (25.4mm) of mercury (Hg)
2. A steady and low reading on idle indicates late ignition or valve timing or possibly leakage past the piston rings. This excessive blow by could be due to worn or stuck piston rings, or worn cylinder walls or pistons. Any of these reduces engine power. With less power, the engine does not develop or “pull’ as much vacuum.

3. Steady and very low reading on idle indicates an air leak at the intake manifold or throttle body. The leak could be around the throttle shaft. Air leakage into the intake manifold reduces vacuum and engine power. Incorrect timing may also cause this condition.
4. A reading that varies rapidly increasing with engine speed between 10 and 22 inches indicates a weak or broken valve spring.
5. A reading that drops back to zero as engine speed increases indicates a restricted exhaust system.
6. Regular dropping back of the needle indicates a valve that is burned or sticking open or a spark plug not firing.
7. Irregular dropping back of the needle indicates valves that are sticking open only part of the time.
8. Floating motion or slow back and forth movement of the needle indicates that the air-fuel mixture is too rich.

Vacuum –Gauge Reading	Diagnosis
Average and steady at 17-22 in-Hg	Everything is normal.
Extremely low reading-needle holds steady	Air leak at the intake manifold or throttle body; incorrect timing.
Needle fluctuates between high and low reading	Blown head gasket between two side –by-side cylinders. Check with compression test
Needle fluctuates very slowly, ranging 4 or 5 points	Idle mixture needs adjustment ,spark-plug gap too narrow, valves sticking open.
Needle fluctuates rapidly at idle- steadies as RPM is increased.	Worn Valves guides.
Needle drops to low reading, returns to normal ,drops back , etc at a regular interval	Burned or leaking valve.
Needle drops to zero as engine RPM is increased	Restricted exhaust system.

Needle holds steady at 12 to 16-drops to 0 and back to about 21 as throttle is opened and released	Late ignition or valve timing. Leaking piston rings. Check with compression test

Table: Vacuum-gauge readings and their meanings.

Procedure:

1. Connect the vacuum gauge to the intake manifold.
2. Start the engine and run it until it reaches normal operating temperature.
3. Note the vacuum reading at idle and other speeds.
4. Check the above table for the meaning of various vacuum gauge readings
5. Repair or replace the defective parts as needed and reconnect the hoses.

Observations:

Trail. No	Speed (rpm)	Vacuum-gauge reading (in-Hg)
1		
2		
3		

Result: Vacuum test is performed on the given engine and determined the mechanical condition of the engine

EXPERIMENT-4

INDUCTIVE TIMING LIGHT

Aim: To perform Ignition test on Maruti Suzuki 800 Alto vehicle

Equipment's required: Inductive timing light, Vehicle

Theory:

In a spark ignition internal combustion engine, Ignition timing refers to the timing, relative to the current piston position and crankshaft angle, of the release of a spark in the combustion chamber near the end of the compression stroke.

The need for advancing (or retarding) the timing of the spark is because fuel does not completely burn the instant the spark fires. The combustion gases take a period of time to expand and the angular or rotational speed of the engine can lengthen or shorten the time frame in which the burning and expansion should occur. In a vast majority of cases, the angle will be described as a certain angle advanced before top dead center (BTDC). Advancing the spark BTDC means that the spark is energized prior to the point where the combustion chamber reaches its minimum size, since the purpose of the power stroke in the engine is to force the combustion chamber to expand. Sparks occurring after top dead center (ATDC) are usually counter-productive (producing wasted spark, back-fire, engine knock, etc.) unless there is need for a supplemental or continuing spark prior to the exhaust stroke.

Setting the correct ignition timing is crucial in the performance of an engine. Sparks occurring too soon or too late in the engine cycle are often responsible for excessive vibrations and even engine damage. The ignition timing affects many variables including engine longevity, fuel economy, and engine power. Many variables also affect what the 'best' timing is. Modern engines that are controlled in real time by an engine control unit use a computer to control the timing throughout the engine's RPM and load range. Older engines that use mechanical distributors rely on inertia (by using rotating weights and springs) and manifold vacuum in order to set the ignition timing throughout the engine's RPM and load range.

Early cars required the driver to adjust timing via controls according to driving conditions, but this is now automated.

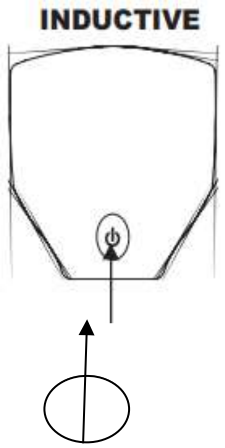
There are many factors that influence proper ignition timing for a given engine. These include the timing of the intake valve(s) or fuel injector(s), the type of ignition system used, the type and condition of the spark plugs, the contents and impurities of the fuel, fuel temperature and pressure, engine speed and load, air and engine temperature, turbo boost pressure or intake air pressure, the components used in the ignition system, and the settings of the ignition system components. Usually, any major engine changes or upgrades will require a change to the ignition timing settings of the engine.

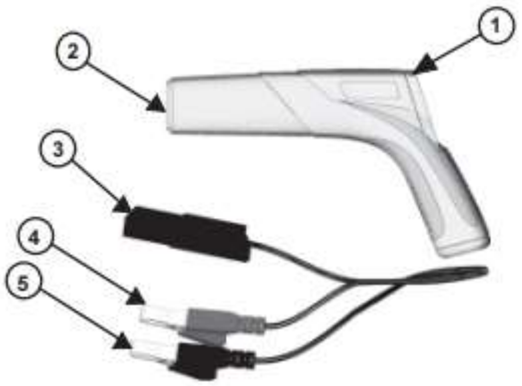
Working Principle

It works on principle of stroboscope. A stroboscope in an instrument used to make cyclically moving object appear to be moving slow or stationary. The principle is used for the study of rotating, reciprocating, oscillating or vibrating objects. Machine parts and vibrating strings are common examples.

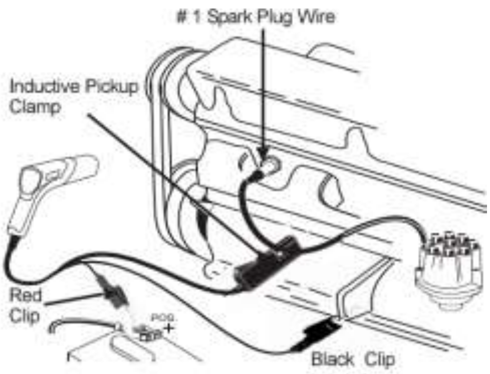
In its simplest form, a rotating disc with evenly-spaced holes is placed in the line of sight between the observer and the moving object. The rotational speed of the disc is adjusted so that it becomes synchronised with the movement of the observed system, which seems to slow and stop. The illusion is caused by temporal aliasing, commonly known as the stroboscopic effect.

In electronic versions, the perforated disc is replaced by a lamp capable of emitting brief and rapid flashes of light. The frequency of the flash is adjusted so that it is an equal to, or a unit fraction below or above the object's cyclic speed, at which point the object is seen to be either stationary or moving backward or forward, depending on the flash frequency.





1.Timing Light
2.Lens
3.Inductive Pickup Clamp
4.Red Clip
5.Black Clip
6.ON Button



Inductive Timing Test Diagram

Procedure:

1.Turn Vehicle OFF

2.Open the hood and locate crankshaft pulley.

3.Check the mark on the crankshaft pulley along with degree marks on the timing cover

4.Attach Inductive Pickup Clamp on the spark plug wire

5.Connect Red Clip of Inductive timing to positive (+) battery post

6. Connect Black Clip of Inductive timing to engine ground

7.Start engine and warm to operating temperature

8. Locate the timing marks on the engine

9. Aim timing light at crankshaft damper (pulley) depending on location of timing marks.

10.Write down initial timing by counting the timing marks on the engine.

Observations:

Ignition timing mark on crankshaft pulley 10-12 bTDC

Result: Ignition timing test is performed on the given vehicle

EXPERIMENT-5

AUTOMOTIVE BATTERY TEST

Aim

To test battery in a vehicle using batter tester and multimeter.

Tools required

Battery tester, multimeter and vehicle.

Description

The BAT 131 Battery Conductance and Electrical System Analyzer tests 6 & 12-volt regular flooded, AGM flat plate, AGM spiral, and gel batteries, as well as 12 & 24- volt starting and charging systems for passenger cars and light trucks. It displays the test results in seconds and features a built-in printer to provide customers with a copy of the results. Additional features include the ability to: test batteries from rated from 100 to 2000 CCA, detect bad cells, protect against reverse polarity, test discharged batteries, test multiple rating systems (EN, EN2, DIN, SAE, IEC, JIS), a multi-lingual user interface.

1 Printer
2 Displays
3 POWER to switch BAT 131 on/off and function key MENU
4 Cover for current probe connection socket
5 Connecting cable with terminals for the battery
6 USB interface (customer service only)

Test Preparation

Test Preparations Before connecting the tester, clean the battery posts or side terminals with a wire brush and a mixture of baking soda and water. When testing side-post batteries, install and tighten lead terminal adapters. A set of adapters is included with the tester.

Do not test at or with steel bolts. Failure to install terminal adapters or installing terminal adapters that are worn or dirty may result in inaccurate test results. To avoid damage, never use a wrench to tighten the adapters more than ¼ turn.

If you are testing in the vehicle, make sure all accessory loads are off, the key is not in the ignition, and the doors are closed.

Test Procedure

1. Connect the red clamp of battery tester to the positive (+) terminal of the battery.
2. Connect the black clamp of battery tester to the negative (–) terminal of the battery.
3. For a proper connection, rock the clamps back and forth. The tester requires that both sides of each clamp be firmly connected before testing. A poor connection will produce a "**CHECK CONNECTION or WIGGLE CLAMPS"** message. If the message appears, clean the terminals and reconnect the clamps.
4. **BAT. LOCATION** Scroll to and select IN VEHICLE or OUT OF VEHICLE for a battery not connected to a vehicle. Following an "IN VEHICLE" test you will be prompted to test the starting and charging systems.
5. The performance of the starting and charging systems depends on the battery's condition. It is important that the battery is good and fully charged before any further system testing.
6. **POST TYPE** (In-Vehicle only) Scroll to TOP POST, SIDE POST or JUMP START POST where applicable. Battery assessment is only performed if the "BATTERY POST AT TOP" option is selected.
7. **APPLICATION** Scroll to and select AUTOMOTIVE, MOTORCYCLE, MARINE, LAWN AND GARDEN, GROUP 31 or COMMERCIAL-4D/8D. For MOTORCYCLE select "BEFORE DELIVERY" or "IN SERVICE" and scroll to the correct BATTERY NUMBER and press E to begin the testing process.
8. **BATTERY STANDARD** Scroll to and select STANDARD, AGM FLAT PLATE, AGM SPIRAL, or GEL where applicable.
9. **BATTERY'S RATING SYSTEM** Select the battery standard to be applied. For JIS scroll to the correct BATTERY NUMBER and press E to begin the testing process.
10. **BATTERY RATING** Scroll to and select the numeric rating units. Hold down or up arrow to decrease or increase the scrolling speed.
11. Press 'Enter' to start test. After several seconds the tester displays the decision on the battery's condition and the measured voltage. The tester also displays your selected battery rating and the rating units.

Starting System Test:

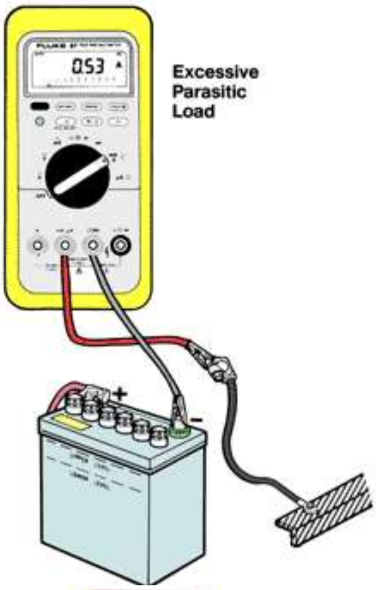
12. Before starting the test, inspect the alternator drive belt. A belt that is glazed or worn or lacks the proper tension will prevent the engine from achieving the RPM levels needed for the test.
13. Press 'Enter' to proceed with the starter test.

14. Start the engine when prompted.
15. The tester displays the cranking voltage and cranking time in milliseconds.

Charging System Test:

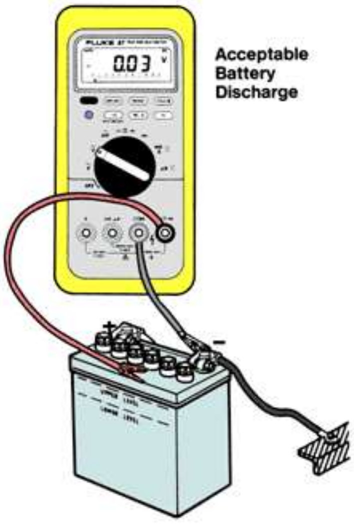
16. Press ‘Enter’ to proceed with the charging test.
17. Follow the on-screen prompts.
18. Rev the engine with loads OFF.
19. Turn ON the high beams, head lights and blower fan.
20. Rev engine with loads ON.
21. Idle engine and turn OFF loads.
22. The tester displays the charging voltage for no-load and loaded conditions.
23. Press ‘left arrow’ to print the test results.
24. Press power button to return to the Menu.

Parasitic Drain Test Check for excessive battery drain or parasitic loads using an ammeter. Make sure all electrical loads are off in the car, doors closed, and the key is out of the ignition switch. Disconnect one of the battery cables from the battery, placing an ammeter in series between the battery post and cable clamp (Figure). The current draw reading should be less than 35 milliamps. A reading higher than this (or manufacturer specifications) would indicate excessive battery drain. Vehicles today typically will draw less than 20 milliamps of current to maintain electronic memories and circuits.



Battery Discharge / Case Drain Test

Check for battery discharge (case drain) across the top of the battery using a digital voltmeter. Connect the negative (black) test lead to the battery's negative terminal post, and connect the positive (red) test lead to the top of the battery case. If the meter reads more than 0.5 volt, clean the case top using a solution of baking soda and water. Remove excess water from top of battery.

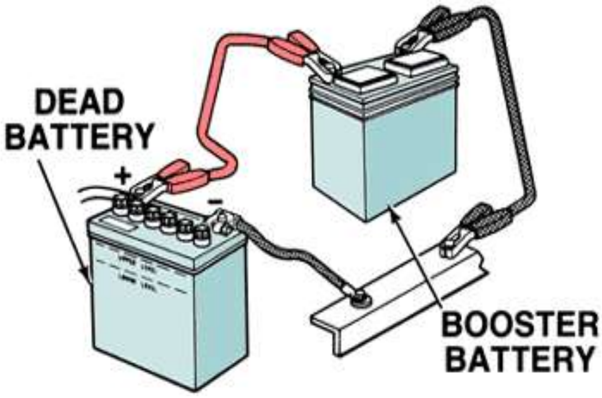


Battery Clamp - Post Resistance Check

Resistance between the battery terminal post and the clamp can account for the battery not being completely recharged and is often a problem. Although it may visually look all right, oxidation of the metal or slight corrosion can cause excessive resistance at the connection, thus creating a voltage drop and lowering current flow to the starter. Battery post and clamps should be cleaned at each battery inspection. To check for excessive resistance, perform a voltage drop between the battery terminal post and the clamp while cranking the engine. The voltage drop reading should be 0.0 volts. Any voltmeter reading higher than "zero" volts requires cleaning the connection and rechecking.

Battery Jumping with Booster Cables

Jump starting a dead battery with a booster battery or battery in a car can be dangerous, so the proper sequence of connections will prevent sparks. First, connect the two positive terminals, one from the good battery and the other to the dead battery. Next connect one end of the jumper cable to the negative terminal of the booster (Good) battery. Finally connect the other end to a good ground on the engine away from the dead battery. If a spark occurs, it won't be near the battery, thus reducing the chance for explosion. If the jump starting from another vehicle, start the vehicle, running the engine at 1500 RPM for a few minutes. While the engine is running, start the dead vehicle.



Observations:

Results: Performed battery testing using battery tester, parasitic drain test, battery discharge/case drain test and battery clamp - post resistance check.

EXPERIMENT-6

WHEEL BALANCING OF WHEEL AND TYRE ASSEMBLY

Aim

To conduct the wheel balancing test on the given wheel and tyre assembly.

Tools required

Wheel balancer, wheel and tyre assembly, balancing weights and wheel balance weight plier.

Theory

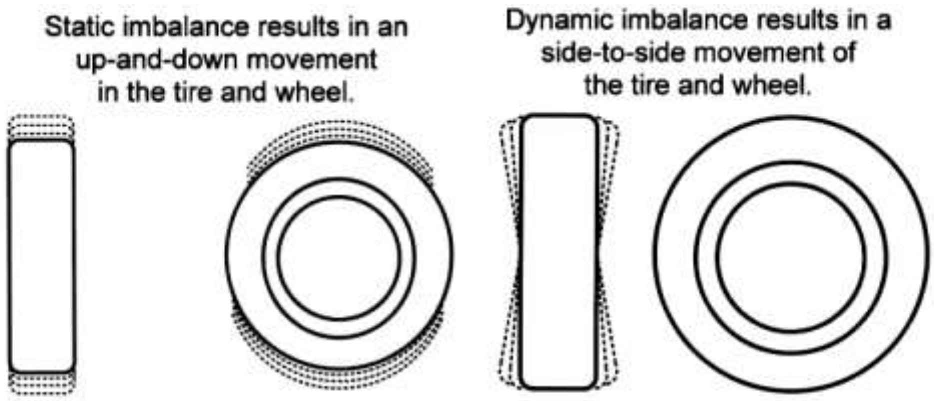
Wheel balancing is the process of balancing the weight of a tyre and wheel assembly so that it travels evenly at high speeds. Balancing requires putting a mounted wheel and tyre on a balancer, which centers the wheel and spins it to determine where the weights should go. Every time a wheel is first mounted onto a vehicle with a new tyre, it has to be balanced. The goal is to make sure the weight is evenly distributed throughout each of the wheels and tyres on a vehicle. This process evens out heavy and light spots in a wheel, so that it rotates smoothly. If there is even a slight difference in weight in the wheels, it will cause enough momentum to create a vibration in the car.

When the tyre rotates, imbalance in the tyre-wheel assembly causes it to wobble, which eventually results in vibrations in the steering wheel. The technical term for vibration in the steering wheel is known as 'shimmy.' Usually the shimmy occurs at a particular road speed and can die out as the speed increases, coming up again at a higher speed. When the shimmy is set in, it has a severe effect on the suspension ball joints. These ball joints can wear and usually any worn ball joints in the steering linkage can be heard as a distinct rattle. At higher speeds when the vibrations increase the risk of tyre and suspension damage and increased wear and tear also increase.

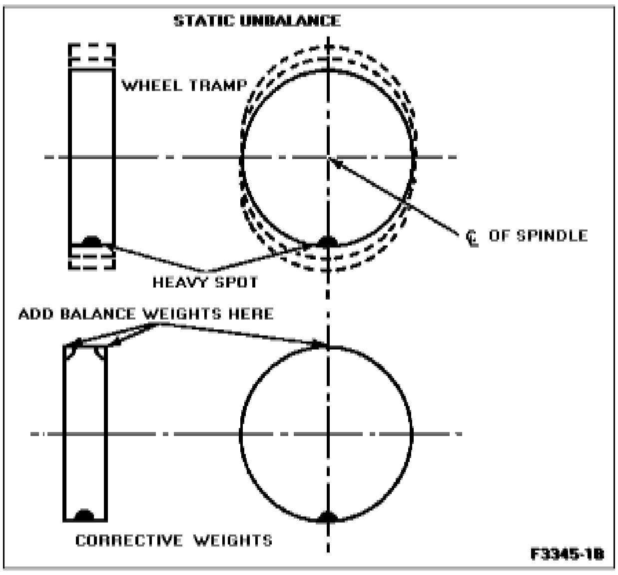
Wheel balancing is done by adding clipped on or stuck on counterweights on the wheel using a balancing machine that judges the irregularities and tells the technician where to add counter-weights to essentially balance off the imbalance in a tyre. Counter weights are small weights that have a certain mass and help in counter-acting the forces acting to imbalance the weight. Keeping these important factors in mind will surely prolong tyre life. Under ideal conditions, wheel balancing should be done whenever you find uneven tyre wear or uncomfortable feedback on the steering wheel. That said, when balancing a particular wheel, if you require weights upwards of 100 grams it is advisable to get your rim or tyre (or both) changed.

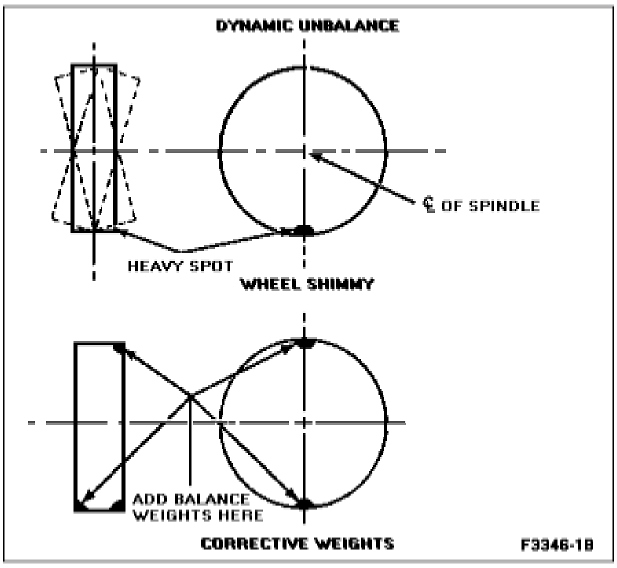
Types of Tyre Imbalance

1. **Static Imbalance** also called as wheel tramp or hop, lies in the plane of wheel rotation, which causes the tyre to vibrate up and down. For a wheel and tyre assembly to be in static balance, the weight must be evenly distributed around the axis of rotation.
2. **Dynamic Imbalance** lies on either or both sides of the center line of the tyre, which causes the tyre to vibrate up and down (wheel hop) and from side to side (wheel shimmy). To be in dynamic balance, the top-to-bottom weight and the side-to-side weight must all be equal.



To static balance a wheel and tyre assembly, add wheel weights opposite the heavy area of the wheel. If a large amount of weight is needed, add half to the outside and the other half to the inside of the wheel. This will keep the dynamic balance of the tyre. However, when dynamically balancing a wheel and tyre assembly, the weights must be added exactly where needed.





Tyre Rotation:

Drawbacks of Wheel Imbalance:

Unevenly balanced wheels lead to more serious, and potentially far more expensive, problems in the long run. These include:

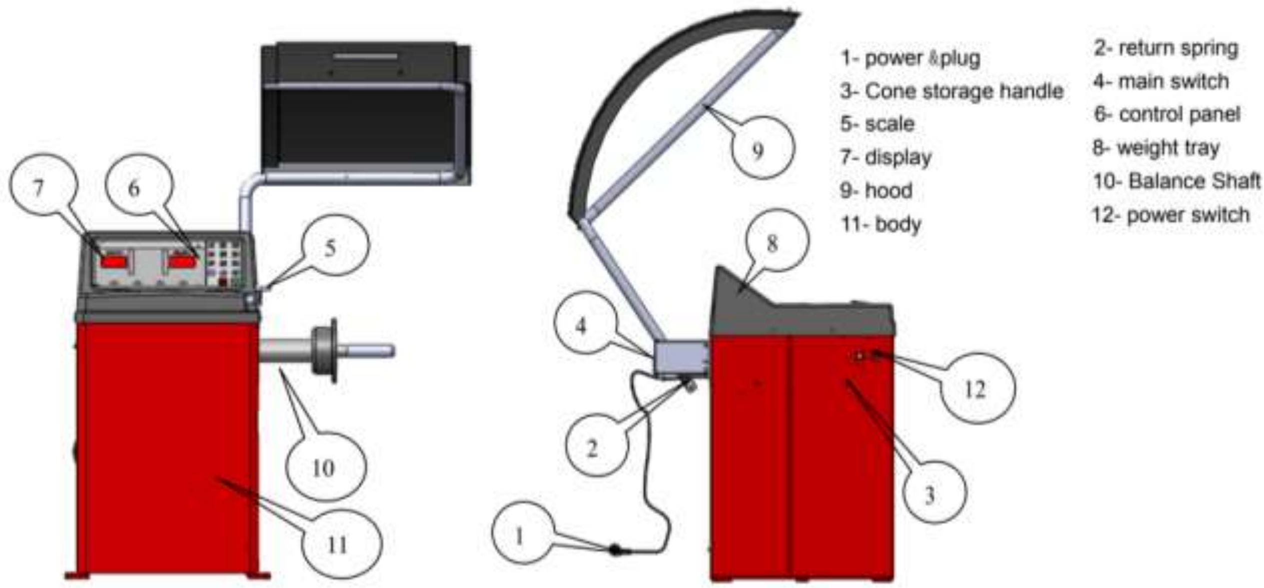
- Poorer fuel economy, caused by the extra rolling resistance resulting from wheels not all moving in the same direction.
- Uneven and premature wear to tyres, caused by the way in which heat accumulates at the spots around a tyre which are forced to take an unequal proportion of the force being exerted on them.
- Potential vibration feeding through to a vehicle’s steering, making it more difficult to keep control.
- Out-of-balance tyres also put excessive force on a vehicle’s wheel bearings, and its whole suspension system, which can again cause them to wear more quickly than should be the case.

So as you can see, maintaining the proper balance in any vehicle’s wheels contributes greatly to its safety, as well as the smooth ride enjoyed by occupants and cargo.

But more importantly, it helps ensure that tyres, wheels and suspension work in proper unison, and eliminates many possible risks associated with early wear of any of these components

Wheel Balancer Description:

The WBE 2210 is a wheel balancing machine featuring mechanical wheel clamping for the balancing of car, light van and motorcycle wheels with a rim diameter of 10’’-26’’ and a rim width of 1’’-20’’.



Procedure

Fitting the Wheel

1. Switch on the machine WBE 2210 with the On/Off switch.
2. Position a suitable cone on the shaft.
3. Use a wire brush to remove any dirt
4. Place the wheel on the shaft against the cone
5. Push the unlocked quick –action clamping nut onto the shaft and press firmly against the wheel
6. Release the lock and turn the quick-action clamping nut clockwise until the wheel is firmly braced. The wheel is secure.

Wheel Balancing

7. Enter A & D wheel dimensions using offset arm.
8. Before a wheel can be balanced, wheel dimensions must be recorded.

   A = Offset – The distance measured from the balancer to inner plane of the wheel rim.

   W = Width – The width of the wheel at the rim flanges, measured with calipers.

   D = Diameter – The diameter of the wheel as indicated on the tyre.
9. For automatic measurement, pull the offset arm out to the wheel, hold it still against the wheel flange and wait for a "beep." Return the arm to home position.
10. Enter the wheel width dimension. Use plastic calipers to measure wheel width for manual entry. Use the keypad to enter width value.
11. Note the value entry of the W dimension.
12. Lower the hood. The wheel will spin and unbalances are measured and displayed. The corrective weight amount appears in the weight display window for inboard and outboard weight locations.
13. Raise the hood after the tyre stops rotating. Make sure that the wheel has stopped before raising the hood.
14. Inboard center bar blinks. If an inboard corrective weight is not required, the outboard center bar will blink.
15. Attach inboard corrective weight. Attach specified weight amount at top-dead-center on the inside flange of the wheel.
16. Attach outboard corrective weight. Attach specified weight amount at the top-dead-center on the outside flange of the wheel.

17. Lower the hood to respin the tyre/wheel and check balance. The weight readings should now be 0.00.

Removing the Wheel

18. Turn the quick action clamping nut anti-clockwise and release the wheel.
19. Unlock and take off the quick-action clamping nut.
20. Remove the wheel.

Observations

i) Offset distance from the balancer to inner plane of the wheel rim
ii) Width of the wheel at the rim flange
iii) Diameter of the wheel
iv) Wheel designation
v) Tyre designation
vi) Unbalance weights on inner and outer planes of wheel assembly

<table>
<tr><th></th><th>No. of Trail</th><th>Unbalance weight on inner plane of wheel (gm)</th><th>Unbalance weight on Outer plane of wheel (gm)</th></tr>
<tr><td rowspan="4">Tyre 1</td><td>1.</td><td></td><td></td></tr>
<tr><td>2.</td><td></td><td></td></tr>
<tr><td>3.</td><td></td><td></td></tr>
<tr><td>4.</td><td></td><td></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="4">Tyre 2</td><td>1.</td><td></td><td></td></tr>
<tr><td>2.</td><td></td><td></td></tr>
<tr><td>3.</td><td></td><td></td></tr>
<tr><td>4.</td><td></td><td></td></tr>
</table>

Results: Wheel balancing test on the given wheel and tyre assembly is performed.

Additional Information

Tyre Rotation:

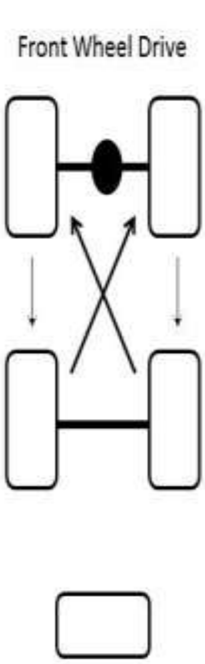
Tyre rotation refers to the timely shifting of a car's wheels and tyres’ position to ensure uniform tread wear and longer tread life. Usually, front tyres get subjected to more pressure than the ones at the rear due to both front-wheel-drive configuration in most modern cars and the added constant weight of the engine and gearbox. Even with cars that have an all-wheel-drive or rear-wheel-drive setup, the front tyres still tend to wear out faster as most of the weight is offset to the front of the car. Other reasons for general wear for the front tyres include the fact that they do most of the steering and almost all of the braking in any vehicle which in turn results in varying degrees of pressure exerted on them.

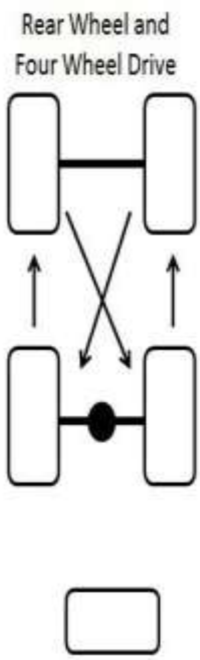
To reduce excessive wear on a single pair of tyres, rotation should be done periodically as recommended by the car manufacturer. There are two ways of rotating one’s tyres. The two methods, the 4-tyre and 5-tyre as explained below.

1. Four Wheel Rotation Method

This method is applied when only the running wheels are being used. In India, it is common to have one damaged or worn tyre is spare, such rotation is handy. Also it cannot be done on a selection of modern cars (Usually imported) that come with a space-saver tyre (a smaller, limited-use spare tyre) provided by the manufacturer. The 4-tyre method is also applicable if your car has a combination of tube and tubeless tyres.

For front wheel drive cars, the front wheels and tyres are to be installed on their corresponding rear hubs. The rear tyres should in turn be criss-crossed with the front hubs. So, the front left wheel will be installed on the rear left side whereas the rear left wheel will be crossed over and installed on the front right side.



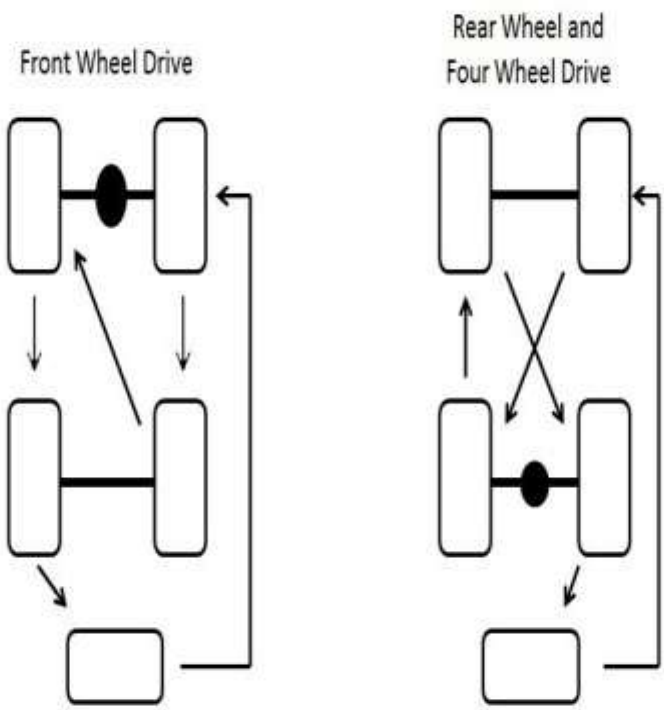


For all wheel drive and rear wheel drive cars, the rear wheels and tyres are to be installed on the corresponding front hubs. The front tyres in turn should be criss-crossed with the rear hubs. In this method, the rear left wheel will be installed on the front left wheel and the front left wheel will be crossed over and installed on the rear right side.

2. Five Wheel Rotation Method

The five wheel method is slightly complicated but if mastered can ensure even wear on all five tyres. One must have a good quality and a full size spare wheel if one intends to use this method of wheel rotation. Also, as before, all tyres or wheels have to be either tube type or all tyres have to be tubeless for rotational purposes.

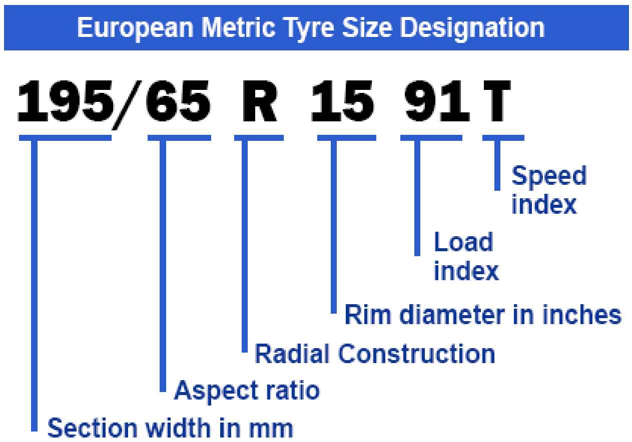
For front wheel drive cars, both front wheels are to be installed on their corresponding rear wheel hubs. The rear left wheel is then supposed to be used as the spare wheel while the spare wheel is to be installed in place of the front right wheel. The rear right wheel then goes in place of the front left wheel completing the rotational procedure.



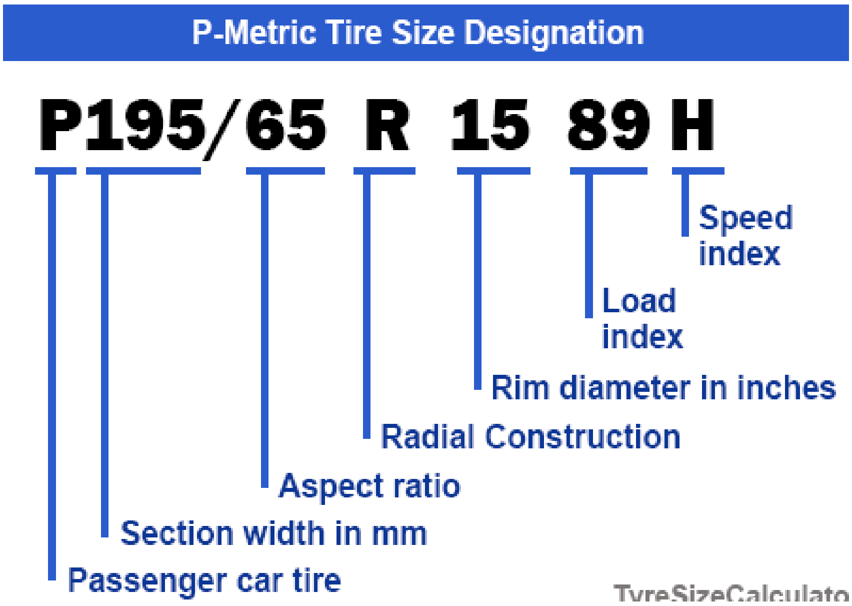
For rear wheel drive and all wheel drive cars, the swap is a little more complicated. First, both front wheels are to be criss-crossed and installed on the opposite rear wheel hubs. The rear left wheel then gets installed on the front left wheel hub while the spare wheel gets installed on the front right wheel hub. In this method, the rear right wheel finally goes in the place of the spare wheel thereby completing rotational procedure.

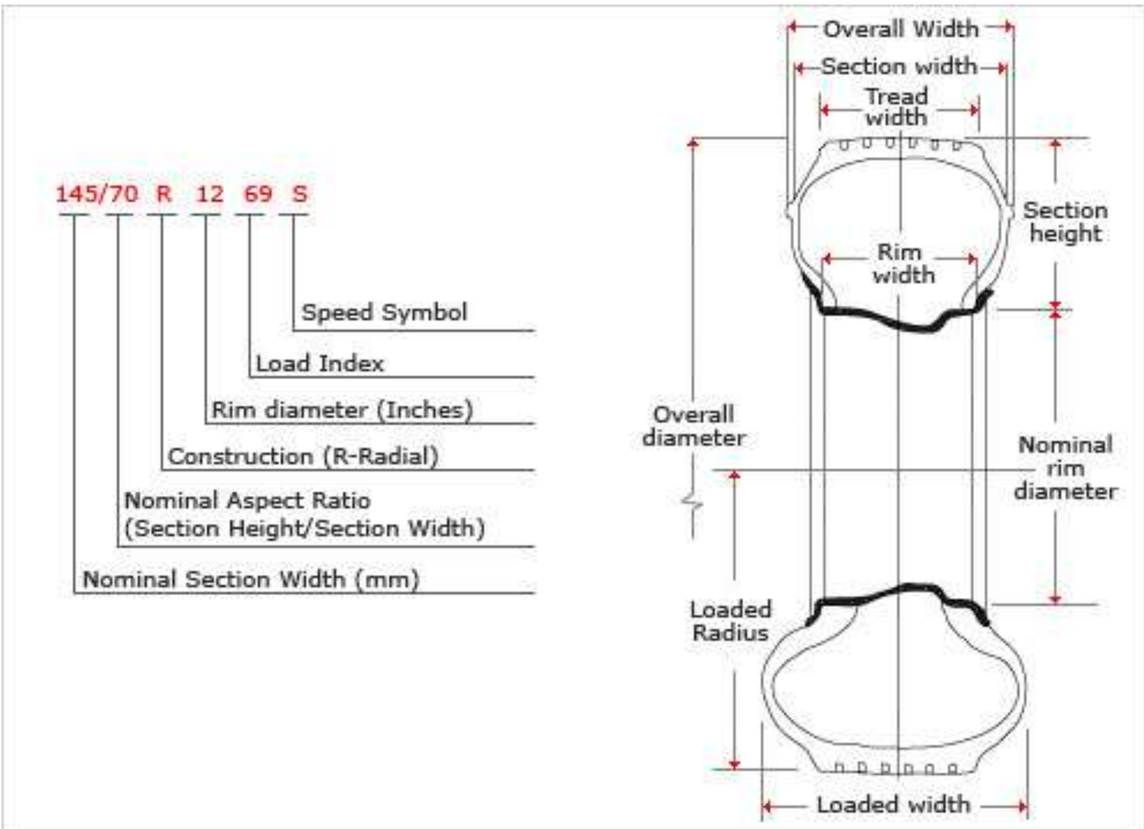
Rotation of one's tyres is essential if one wants to ensure the best performance out of their tyres. One must remember though, if you have unidirectional tyres, you cannot swap them from left to right and vice versa unless you invert them face-to-face on the rim.

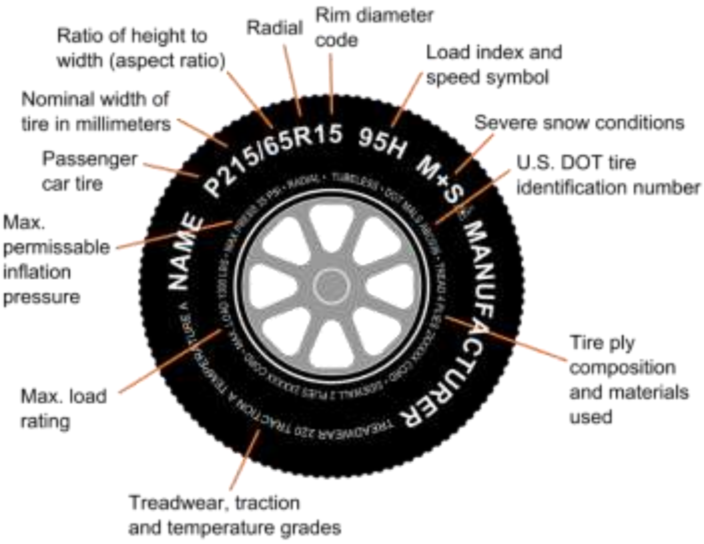
Tyre Designation European Metric Tyre Size Designation



P-Metric Tire Size Designation
(Valid in North America)







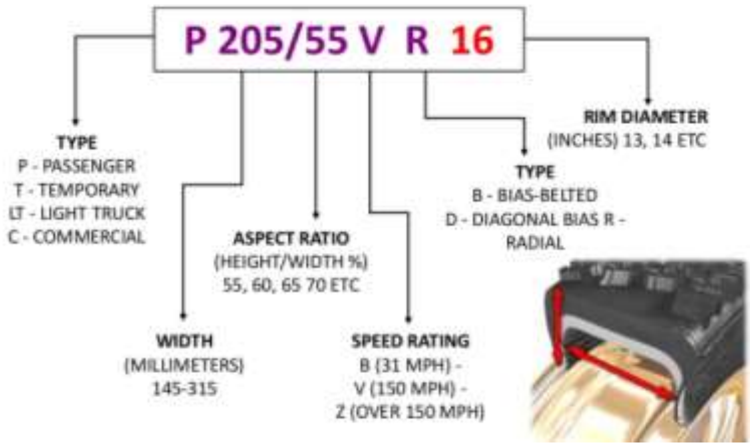
SPEED SYMBOL: This indicates the maximum safe speed corresponding to its given load index at which the vehicle can be plied, under specified conditions.

Speed Symbol	Speed Km / hr	Speed Symbol	Speed Km / hr	Speed Symbol	Speed Km / hr
A1	5	D	65	Q	160
A2	10	E	70	R	170
A3	15	F	80	S	180
A4	20	G	90	T	190
A5	25	J	100	U	200
A6	30	K	110	H	210
A7	35	L	120	V	240
A8	40	M	130	W	270
B	50	N	140	Y	300
C	60	P	150		

LOAD INDEX: Index figure indicating the maximum load (mass), the tyre can carry under specified conditions.

Load Index	TLCC* Kg	Load Index	TLCC* Kg	Load Index	TLCC* Kg
60	250	77	412	94	670
61	257	78	425	95	690
62	265	79	437	96	710
63	272	80	450	97	730
64	280	81	462	98	750
65	290	82	475	99	775
66	300	83	487	100	800
67	307	84	500	101	825
68	315	85	515	102	850
69	325	86	530	103	875
70	335	87	545	104	900
71	345	88	560	105	925
72	355	89	580	106	950
73	365	90	600	107	975
74	375	91	615	108	1000
75	387	92	630	109	1030
76	400	93	650	110	1060

Tyre Specifications



Ply Rating / load range

PLY RATING	LOAD RANGE	PLY RATING	LOAD RANGE
2	A	14	G
4	B	16	H
6	C	18	J
8	D	20	L
10	E	22	M
12	F	24	N

EXPERIMENT-7

WHEEL ALIGNMENT TEST

AIM:

To conduct the wheel alignment test on the given vehicle and to find the castor angle, total toe and camber for a given vehicle.

TOOLS REQUIRED:

Wheel aligner

Car

Scissor lift

Alignment gauge, spanner,

Theory

Wheel alignment geometry describes the positioning of the wheels, tires, and suspension components in relation to each other and to the vehicle as a whole. Proper relationships between these elements are necessary for safe, responsive handling, and maximum tire life.

Correct wheel alignment allows vehicle to run straight on the road with little steering effort and minimal tire wear.

Advantages of Wheel alignment

Directional stability during straight ahead position

Perfect rolling condition on steering

Recovery after rolling the turn

The symptoms of a car that is out of alignment:

- Uneven or rapid tire wear
- Pulling or drifting away from a straight line
- Wandering on a straight level road
- Spokes of the steering wheel off to one side while driving on a straight and level road

Wheel alignment geometry.

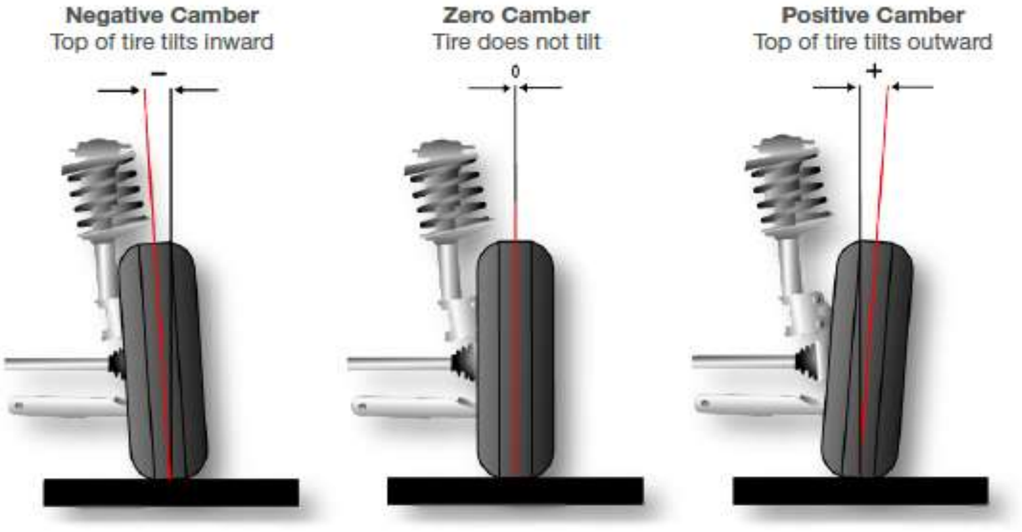
Camber

Camber describes the inward or outward tilt of the top of the tire compared to a vertical reference viewed from the front or rear. The camber angle is the angle formed by a vertical line and the tire’s centerline. Camber angle is measured in positive or negative degrees.

Positive camber is the outward tilt of the top of the tire.

Negative camber is the inward tilt of the tire at the top.

Zero Camber is absolutely the tire is vertical; the degree of camber would be zero



Purpose of Camber

Camber plays a major role in cornering and stability. Positive camber is for stability, while negative camber is common in high performance vehicles that require better cornering.

Effect of Camber when it is out of adjustment:

1. Excessive positive camber causes the tire to wear on its Outside shoulder
2. Excessive negative camber causes the tire to wear on its inside shoulder
3. Unequal camber in the front wheels also can cause the steering to lead to the right or left, the vehicle will lead to the side that has most positive camber.
4. A pull may be generated if left and right front camber angles differ by more than 0.50°.

Camber Is Measured With the Vehicle at Rest

Vehicle loading and suspension reactions to road irregularities result in a camber value that changes as the vehicle is in motion. A tire's static camber value is specified to achieve a balance between tire wear and handling performance when the vehicle is moving.

Camber Spread

Camber spread (or **cross camber)** is the difference in camber values between the left and right side of the vehicle. This difference is normally specified as a maximum of 30' (0.5°) or 45' (0.75°) depending upon the model.

CASTER

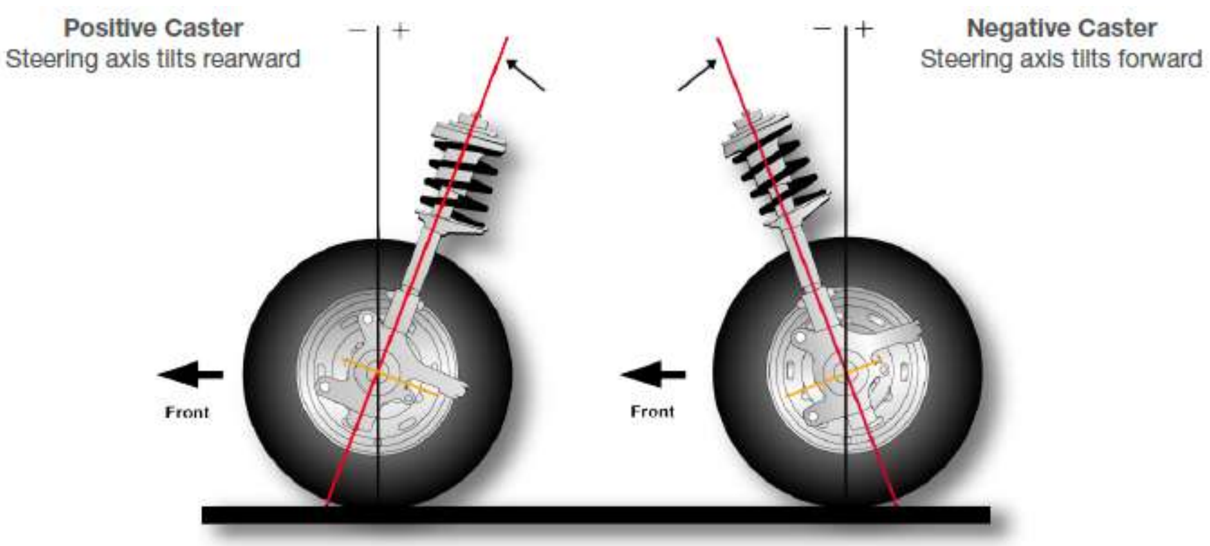
Caster describes the forward or rearward tilt of the steering axis compared to a vertical reference viewed from the side. The caster angle is the angle formed by the intersection of the steering axis and a vertical line through the wheel's centerline. Castor angle is measured in positive or negative degrees.

Positive Caster: Caster is positive when the top of the steering axis is tilted rearward

The advantage of caster adjusted toward negative is greater maneuverability; however, direction stability on open road driving is reduced.

Negative Caster: Caster is negative when the top of the steering axis is tilted forward

The advantage of positive caster is the strong directional stability and the ease of returning the steering to a straight-ahead position.



Purpose of Caster

Caster is designed into the front suspension geometry of a vehicle for two reasons:

1. Directional control
2. Steering returnability

Steering Axis

The steering axis is an imaginary line that the spindle pivots around.

- The upper and lower ball joints define the steering axis on a double wishbone suspended vehicle.
- The upper strut bearing and the lower ball joint define the steering axis on a MacPherson strut suspended vehicle.

Caster Spread

Caster spread (or **cross caster**) is the difference in caster values between the left and right side of the vehicle. Tweaked subframe positioning may also affect cross caster

Effect of Caster when it is out of adjustment:

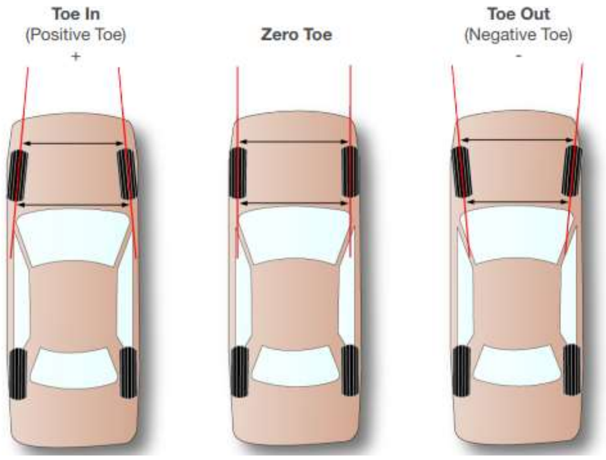
1. The vehicle pulls in the direction of the tire with the most negative caster value.
2. Excessive caster may cause front wheel shimmy and excessive steering effort
3. A pull may be generated if left and right front caster differ by more than 0.50°.

TOE

Toe is the difference in distance between the front of the tires and the rear of the tires viewed from above. When measured as an angle, toe describes the angle formed by the vehicle's centerline and a line extended through the center of the tires.

Toe-in is the measurement in fractions of an inch, millimeters or decimal of degrees that the tires are closer together in the front than they are in the back

Toe-out is the same measurement, except the tires are further apart in the front than in the rear



Purpose of Toe

The primary purpose of a static toe angle is to keep the front wheels operating at nearly zero toe when the vehicle is in motion.

Toe provides compensation for the various forces acting on the steering linkage while the vehicle is moving.

Toe Specifications

Differences in suspension and power train design determine the static toe specification.

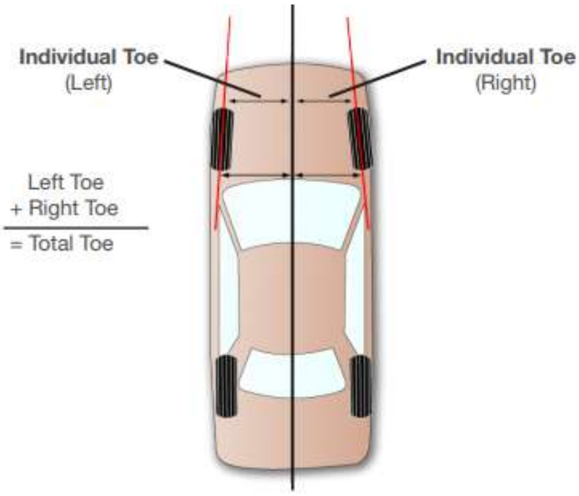
Most vehicles operate with a slight amount of toe-in.

Some front-wheel-drive designs may specify zero toe or even slight toe-out.

Individual Toe and Total Toe

Toe measurements can be total toe or individual toe.

Total toe is the sum of individual toe values.



Effect of toe when it is out of adjustment:

An incorrect toe in will cause rapid tire wear to both tires equally

Effect of Toe on Steering Wheel Alignment

Individual toe values determine the position of the steering wheel.

When individual toe values are equal and the rear wheels are in proper alignment, the steering wheel is centered when the vehicle is traveling straight down the road.

Ride Height Effect on Toe

The correct ride height is important since the toe values change as the suspension travels through compression and rebound.

Bump steer is caused when the right and left steering linkage and suspension travel in different paths or arcs

Caster & Camber Effect on Toe

Any changes in wheel or tire position (such as caster or camber adjustments) change the toe value.

For this reason, the front wheel toe is measured and adjusted after all other alignment adjustments have been made.

Steering Linkage Effect on Toe

Changes in the length of the steering linkage by either damage or adjustment error, or a change in overall tire/wheel diameter can also effect toe adjustment. The Repair Manual specifies total toe and requires tie rod length to be equal from side to side.

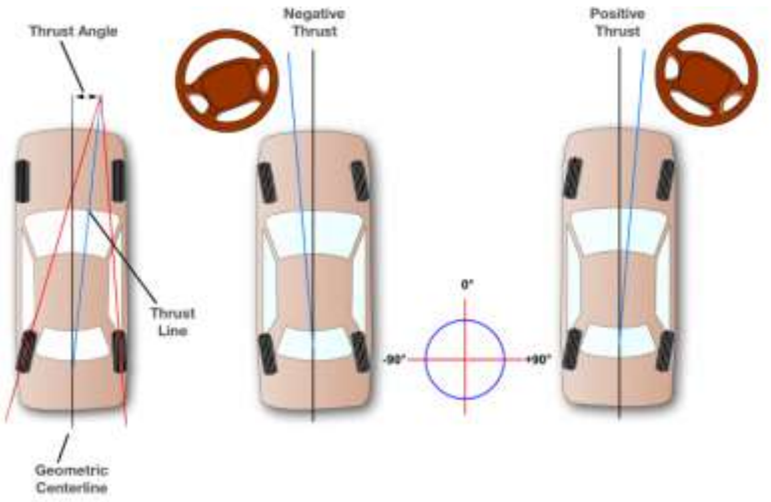
To accomplish equal individual toe, one-half the total toe value is applied to each wheel.

Thrust Line & Thrust Angle

The thrust line is the average direction of the rear wheels. The thrust line divides or bisects the vehicle's rear total toe value.

The intersection of the vehicle's geometric centerline and the thrust line form the thrust angle. The geometric centerline is an imaginary line extending through the midpoint of both the front and rear axles.

Thrust angle directly affects steering wheel position (steering wheel off center).



Test Procedure

1. Park the vehicle on the Scissor lift
2. Make sure the measuring and working height is identical
3. The turn tables and sliding bases must be pinned to the lifting platform
4. The locking pins must be inserted at the turn table when the vehicle is driven on the measurement bay
5. Start to fix universal clamp and targets
6. Fix the two smaller targets in front wheel onto clamp
7. Fix the two bigger targets in rear wheel onto clamp
8. Keep the spirit level upside
9. Ensure proper attachment to prevent damage to the seat and steering wheel.
10. After run-out compensation, fit the brake clamp for further measurements
11. Fit the steering wheel arrester
12. Keep the height between camera beam and lift platform about 700mm

13. Ensure that the camera can recognize 4 targets; you need to check if their image is caught in the monitor.
14. Maintain the distance from the centre of camera to the center of turntable between 2.5m to 2.8m
15. Make sure the vehicle is driven centrally and straight on to the measurement bay.
16. Drive the vehicle onto the turntable and sliding bases
17. Power on Computer
18. Double click on FWA4510
19. Check LED lights are blinking or not

Visual Inspection

20. Before Wheel alignment visual inspection is recommended
21. According visual inspection to check which parts of vehicle damaged or out of use
22. Software provides inspection lists for steering gear ,steering arm, brake system, exhaust system, light system
23. Press printer to print out the checking result

Standard measurement

1. After visual inspection enter standard measurement after pressing “next”
2. Select Car symbol to enter measurement
3. Press “New Customer” button to set up new customer information in the database or select an existing customer record.
4. Press “next” to continue ,”previous” to return
5. Input license plate number
6. Select vehicle specification, select vehicle brand, vehicle manufactured year, vehicle model
7. Click “next” or press F3 to continue to next step, rolling run-out compensation.
8. Preparation work:
   1. Install and level targets
   2. Install steering wheel lock
   3. Release hand brake
9. Press F3 to start measurements

10. Push vehicle backward 40 degrees , till the process is 100 % finished ,software display "STOP" to guide the operator stop
11. Push vehicle forwards onto the turntables
12. Install brake lock and press F3
13. Wait until step 9 is achieved and press "F3" to continue with castor measurement.
14. After Rolling run-out compensation ,software navigation bar is activated, operator can select the following measurements:
    - Castor measurement
    - Rear axle
    - Castor adjustment Front axle
15. Click one button; software will jump to the interface accordingly.
16. Castor measurement

    After run-out compensation, click Next or F3, enter castor measurement.

    Finish castor measurement according to software hints.

    During castor measurement, install brake lock is mandatory in order to prevent unnecessary movement on vehicle

    Remove Steering wheel lock

    Adjustment to steering center

    Find the start position before steering (front toe)

    Steering to left 20/10 degree (depending on software setting)

    Steering to right 20/10 degree (depending on software setting)

    During the sweep steering wheel to left or right , till the screen display "OK" follow the screen hint, till the measurement is finished.
17. Rear axle data

    After castor measurement, center steering wheel and insert the steering wheel arrestor.

    Press "Continue"

    The measurement screen shows the single toe, left/right camber and total toe.

    Click next or F3 to enter in the screen castor display.
18. Castor adjustment

    The measurement screen shows the single toe,left/right camber and castor.

    Click next or F3 to enter in the screen front axle data
19. Front axle data

    The measurement screen shows the single toe, left/right camber and total toe.

Zoom-in single value by double click, or select then press enter

20. Raised measurement

    In order to facilitate vehicle chassis adjustment, click vehicle symbol to do vehicle measurement in raised position.

21. Printing data

    After measurement, print measurement result in the last step

    Press F3 to change to measurement protocol preview

Quick Measurement

1. Return to home page
2. Select quick measurement
3. Customer information is not required in quick measurement, select vehicle directly
4. Overview of selected vehicle specific target data
5. Initial run out compensation is mandatory before starting the measuring routings
6. Live values display shown of front and rear wheels ,if operator confirms the following instructions
7. Display shows single toe and camber wheel.
8. Total toe thrust angle complete the display used for adjustment work and customer communication.
9. Results preview will introduce a complete evaluation according to the selected vehicle specific target data.

Random Measurement

1. Return to main screen
2. Select car symbol to enter the random measurement.
3. Finish Rolling run-out compensation
4. Random measurement includes following routines

   Standard alignment values for front and rear axle

   Camber/toe measurement and adjustment in raised position

   All data

   Additional measurements

   Castor adjustments Toe curve

   Super toe

RESULT: Thus the front wheel alignment geometry of the given car was studied and wheel alignment test on the given vehicle is performed

EXPERIMENT-8

HEADLIGHT ALIGNMENT TEST

AIM:

To test & adjust focus of headlight using the Headlight alignment on the given Vehicle

Tools Required:

Head light alignment tester, vehicle

Theory

Alignment of headlamp is important in the sense that the focus of beam needs to be directed properly on the road & the intensity of light. This becomes very important especially during night travelling as the absence of proper light; the vehicle may have an accident.

Headlight beam aligner consists of a base frame column, aligner & visor. The headlight beam from the vehicle is projected on a panel inside the aligner through a lens. The internal panel has markings for low beam & high beam. This marking can be changed according to manufacture specifications by adjusting a beam. The projected beam can be verified with the standard pattern & adjusted its necessary.

Headlight Alignment Tester

Parts:

A - Base

B - Column

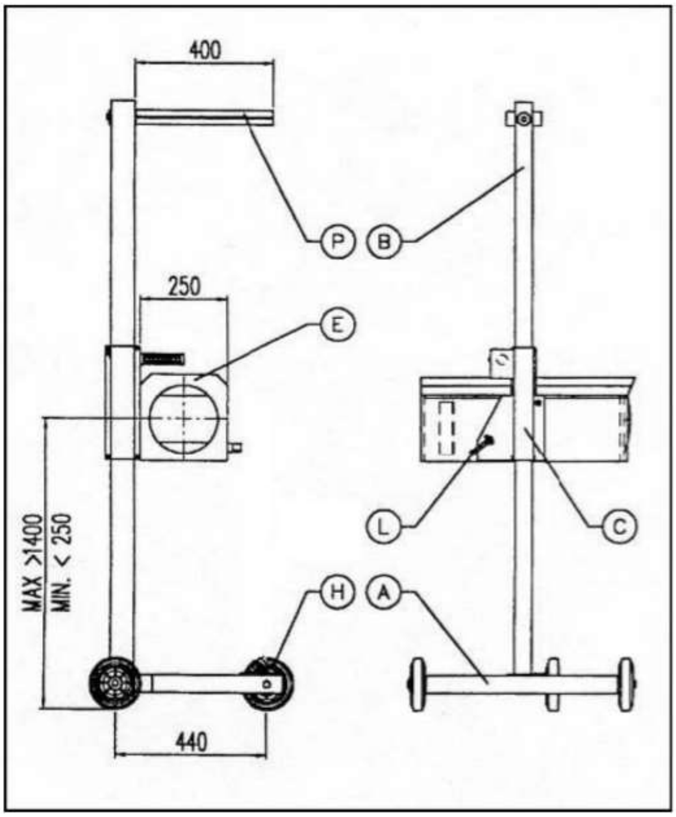
C - Vertical Sliding System

P - Mirror Viewer

E - Optical Box

H - Wheels

L - Clutch Lever



Procedure

1. **Working Surface:**

   When testing the headlights, the floor must be as flat as possible. Should that not be possible, both the headlight beam setter and the vehicle must be placed at least on a relatively uniform surface, but with a maximum 0,5% slope.

2. **Vehicle Preparation :**

   a) Straighten the car/bike wheel.

   b) Put 70 Kg weight on driver seat.

   c) Check the tyre pressure & inflate if necessary.

   d) Check the headlight for clean lense.

   e) Switch the engine 'ON' & check the headlights.

3. **Position of head light beam aligner**

a) Place the HLA in front of car headlights, about 30 to 50 cm away from the vehicle.

b) Set the aligner height: Measure the distance from the floor to the centre of the headlamp to be tested and set the aligner box to this height using the scale on the column

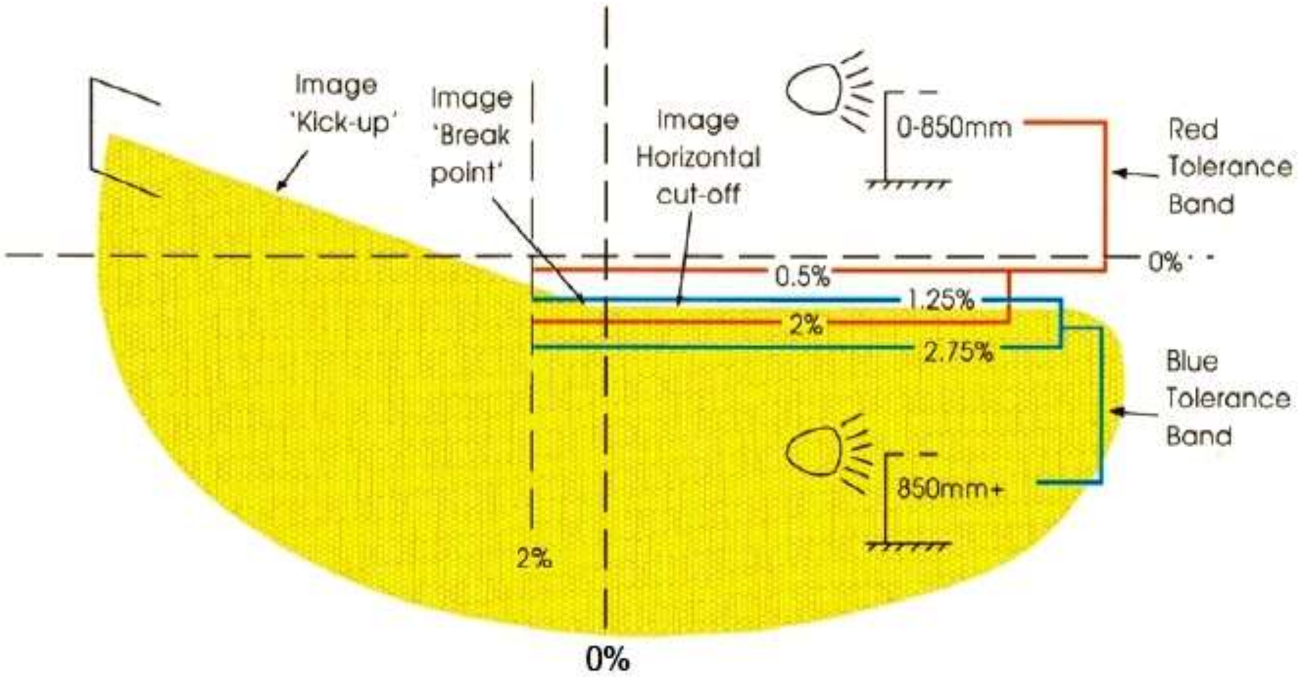
c) Set the aligner left/right position: Start with the right hand headlamp and move the aligner along the track until the front and rear sights on the aligner box line up with the centre of the lamp to be tested. Switch on the lamp and verify the spirit level reads correctly, adjust if not level.

d) Alignment check: The screen inside the equipment is viewed through the tinted top window. Switch on the headlamps and select dipped or main beam as appropriate. Observe the light pattern displayed on the screen. This should be checked for the headlamp type under test by reference to the Tester's manual.

4. **Checking Dipped Headlights**

a) Prepare the headlight beam setter and the vehicle as indicated above and switch on the dipped headlights: the projection of the headlights will appear on the internal panel.

b) Check that this coincides with the line.

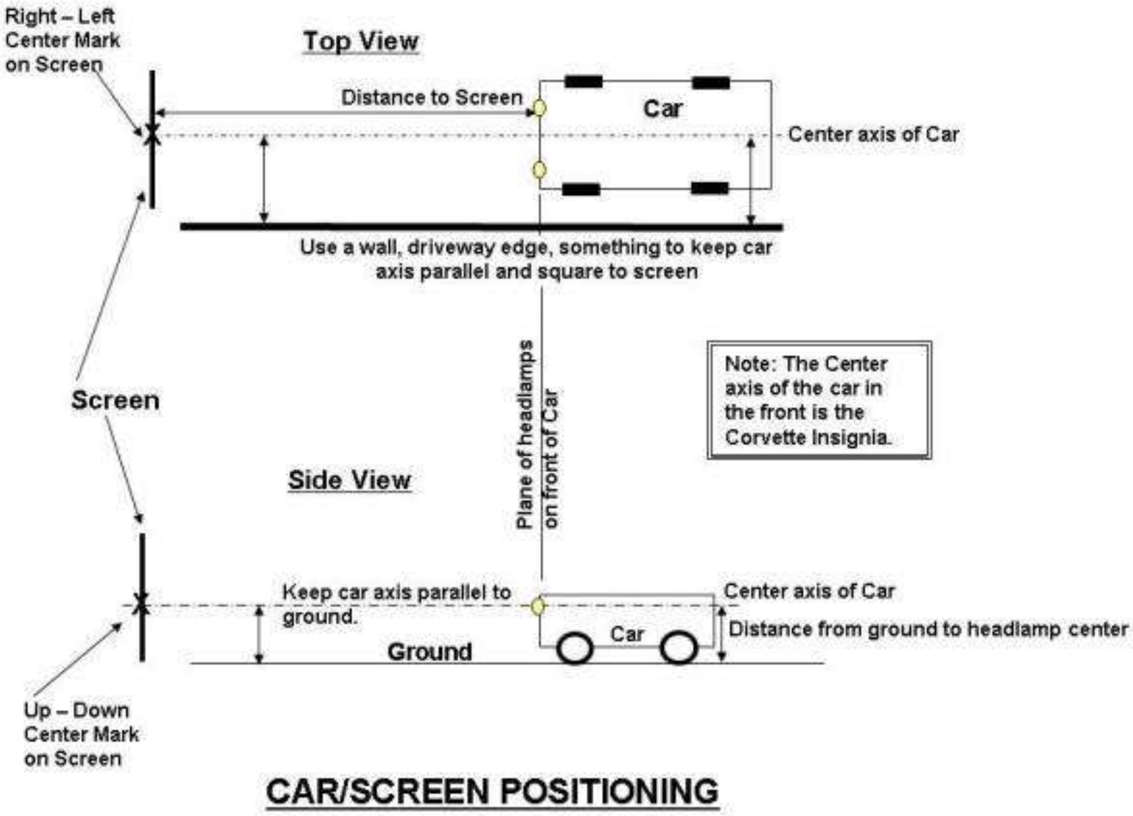


Headlight Low beam hotspot

c) Bulbs below 850mm from the ground: If the centre of the vehicle headlight bulb is less than 850mm from the ground, the top projection of the dipped beam should be between 0.5 % to 2.00 % below the horizontal zero percent line.

d) Bulbs above 850mm from the ground: If the centre of the vehicle headlight bulb is above 850mm from the ground, the top projection of the dipped beam should be between 1.25 % to 2.75 % below the horizontal zero percent line.

e). If necessary, use the headlights adjusting system to reach the desired result.



Observations:

1. Distance between headlight center and ground = …….mm
2. Distance between headlight center and center of beam aligner = ……mm

Result:

Head light alignment test for a given vehicle is done.

EXPERIMENT-9

PETROL VEHICLE EXHAUST GAS ANALYSIS

Aim

To measure the volumetric concentration of exhaust carbon monoxide (CO) and hydrocarbon (HC) emissions from road vehicles.

Tools required

Petrol vehicle and five-gas analyzer.

Theory

The exhaust gas analyzer measures the amount of various gases in the exhaust. The purpose of making these measurements is to help determine the condition of the engine, ignition system, fuel system and emission controls. The presence of oxygen in the exhaust gases indicates that the combustion of the mixture was not perfect, resulting in contaminant gases. Thus measuring the proportion of oxygen in the exhaust gases of these engines can monitor and measure these emissions. This measurement is performed through Lambda coefficient measurement.

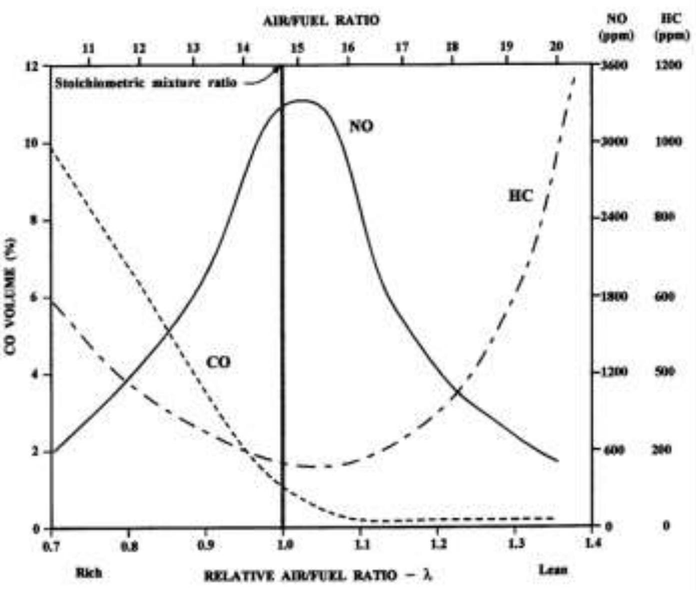


Figure 1: Exhaust emissions vs. Air-fuel ratio

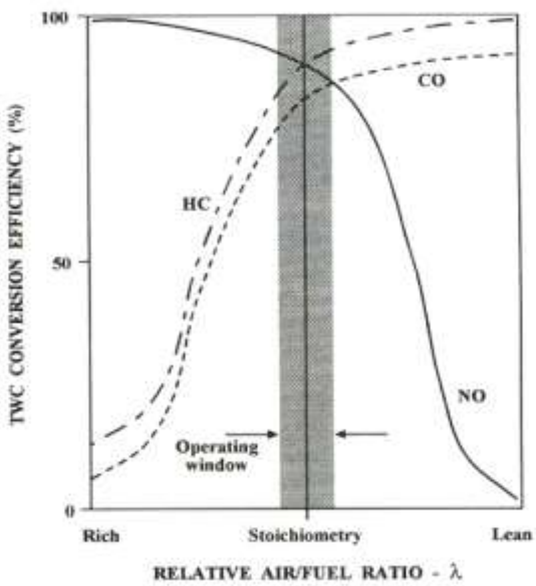


Figure 2: Three way catalytic converter conversion efficiency

The Lambda coefficient (λ) is obtained from the relationship between air and gasoline involved in combustion of the mixture. It is a measure of the efficiency of the gasoline engine by measuring the percentage of oxygen in the exhaust.

When gasoline engines operate with a stoichiometric mixture of 14.7: 1 the value of LAMBDA (λ) is "1".

If Lambda > 1 = lean mixture, excess of air. If Lambda < 1 = rich mixture, excess of gasoline.

Table 1: Typical petrol engine exhaust gas composition

Exhaust Constituents	**Driving Mode**			
	Idle	**Accn.**	**Cruise**	**Decn.**
HC (ppm)	300 -1000	300 – 800	250-550	3000 - 12000
CO (%)	4 - 9	1 – 8	1 - 7	3 - 4
CO_2 (%)	10	12	12.5	6
NO_X (ppm)	10 - 50	1000 - 4000	1000 - 3000	5 - 50
Oxygen (%)	2	1.5	1.5	8
Exhaust Temp. at silencer (^OC)	150 - 300	450 - 700	400 - 600	200 - 400
Exhaust Flow (m^3/min)	0.185 – 0.95	1.5 – 7.5	0.95 – 2.25	0.185 – 0.95

Description

Five-gas analyzer provide more complete analysis of the tailpipe exhaust gas. These gases are: carbon monoxide (CO), carbon dioxide (CO2), Hydrocarbons (HC), oxygen (O2) and nitric oxide (NO). The principles used for CO sensors (and other types of gas) are infrared gas sensors (NDIR) and chemical gas sensors. Insert the exhaust gas pickup or probe into the tailpipe of the vehicle. The probe draws out some of the exhaust gas and carries it through the analyzer.

Table 2: Specifications of AVL five-gas analyzer

nent Range	Accuracy
-10	0.01
-20	0.1
0000	1
-22	0.01
5000	1
to 125	1

Measurement principle of CO, HC & CO_2 – Infrared measurement

Measurement principle of O_2 & NO – Electrochemical measurement

Figure 3: Five-gas analyzer connected to tailpipe of a vehicle to test the exhaust gas

Procedure:

Vehicle Preparation

1. It shall be checked that the road vehicle exhaust system is leak proof and that the manual choke control has been returned to the rest position.
2. It shall be checked that the gas sampling probe can be inserted into the exhaust pipe to a depth of at least 300 mm. If this proves impossible owing to the exhaust pipe configuration, a suitable extension to the exhaust pipe(s), making sure that the connection is leak proof, shall be provided.
3. The vehicle shall have attained normal thermal conditions immediately prior to the measurement.
4. The vehicle idling speed shall be checked and set as prescribed by the manufacturer, with all the accessories switched off.

Measurement

5. Connect AVL Digas 444 to the power supply.
6. Make sure the clean air can be sucked in during zero point adjustment.
7. Switch on AVL Digas 444 and run self test
8. Check leak check.

9. Perform HC Residue test.
10. Immediately preceding the measurement, the engine is to be accelerated to a moderate speed with no load, maintained for at least 15 seconds, then returned to idle speed.
11. While the engine idles, the sampling probe shall be inserted into the exhaust pipe to a depth not less than 300 mm.
12. After the engine speed stabilises, the reading shall be taken.
13. The value of CO and HC concentration reading shall be recorded.
14. For the purpose of PUC (Pollution Under Control) certification, if the idling CO and/or HC are not within limits as per table given below.

Sr. No.	Vehicle Type (Petrol)	CO %	*HC (n – hexane equivalent) ppm
1.	2&3—Wheeler (2/4-stroke) (Manufactured on and before 31st March 2000)	4.5	9000
2.	2&3—Wheeler (2-stroke) (Manufactured after 31st March 2000)	3.5	6000
3.	2&3 – Wheeler (4-stroke) (Manufactured after 31st March 2000)	3.5	4500
4.	4-wheelers manufactured as per Pre Bharat Stage-II norms	3.0	1500
5.	4-Wheelers manufactured as per Bharat Stage-II, Bharat Stage-III or subsequent norms	0.5	750

Notes:

1. The emissions of carbon monoxide and hydrocarbon at idling from in-service vehicles fitted with spark ignition engines, as referred in CMVR-115 (2)(a) and for issue of "Pollution under control certificate" to be issued by authorized agencies under CMVR-115 (7).
2. Idling emission standards for vehicles when operating on CNG shall replace Hydrocarbon (HC) by Non Methane Hydrocarbon (NMHC). NMHC may be estimated by the following formula: NMHC = 0.3 x HC
   Where HC = Hydrocarbon measured (n – hexane equivalent)

3. Idling emission standards for vehicles when operating on LPG shall replace Hydrocarbon (HC) by Reactive Hydrocarbon (RHC). RHC may be estimated by the following formula: RHC = 0.5 x HC

Where HC = Hydrocarbon measured (n – hexane equivalent)

4. An exhaust gas analyzer can also be used to check for exhaust gas leakage into the cooling system and to locate fuel or fuel-vapour leaks.

Observations:

Trail No.	HC (ppm)	CO (%)	CO_2 (%)	O_2 (%)	NO_x (ppm)
1.					
2.					
3.					

- The HC meter reports the amount of unburned hydrocarbons in the exhaust. High HC could result from trouble in the emission controls or fuel or ignition system. The air-fuel mixture could be rich or lean so there is misfiring. The ignition system may be out of time or misfiring. An engine with worn rings and cylinders, burned valves or a blown head gasket emits high levels of HC.
- The amount of CO is measured as a percentage by volume. A rich mixture or not enough oxygen to burn the fuel produces excessive CO. Possible causes are misfiring, a restricted air filter and a leaking fuel injector or carburettor needle-and-seat.
- Any change in the air-fuel ratio and the combustion process causes a change in CO_2. Normally, CO_2 is above 8%. The highest CO_2 reading occurs at about the 14.7:1 stoichiometric air-fuel ratio. Low CO_2 reading indicates a rich mixture.
- At idle, the engine should produce less than 3% O_2. If the engine is running richer than 14.7:1, O_2 is low. As the air-fuel mixture becomes leaner than 14.7:1, O_2 increases. When lean misfire occurs O_2 increases greatly.
- NO_x emissions rise and fall in a reverse pattern to HC emissions. As the mixture becomes leaner more of the HC's are burnt, but at high temperatures and pressures (under load) in the combustion chamber there will be excess O2 molecules which combine with the nitrogen to create NO_x. NO_x increases in proportion to the ignition timing advance, irrespective of variations in air-fuel ratio.

Result: The exhaust emission analysis of a given vehicle is performed.

EXPERIMENT-10

DIESEL VEHICLE SMOKE MEASUREMENT

Aim

Determination of smoke levels by free acceleration from road vehicles equipped with compression ignition engines.

Tools required

Diesel vehicle and smoke meter.

Theory

In Diesel engines, smoke is one of visible emissions. Exhaust emissions from diesel engines are usually more visible than those emitted from petrol engines because they contain over ten times more soot particles. In general diesel engines produce less carbon monoxide than petrol engines but more oxides of nitrogen, oxides of sulphur, aldehydes and particulate matter.

Smoke consists of solid and/or liquid particles or droplets that are so small that they tend to remain suspended in air for extended periods of times varying from seconds to years. The smoke of the engine exhaust is a visible indicator of the combustion process in the engine. It is visible products of combustion due to poor combustion.

Smoke density means the light absorption coefficient of the exhaust gases emitted by the vehicle expressed in terms of m-1 or in other units such as Bosch, Hartidge, % opacity, etc.

Opacity is a measure of light reduction/loss over a smoke column path usually expressed as a percentage. An opacity of 10% means that 90% of the source light power remains and 10% has been lost after passing through the measurement path. The 90% (0.9) term (the light remaining) is referred to as Transmittance.

Free acceleration test means the test conducted by abruptly but not violently, accelerating the vehicle from idle to full speed with the vehicle stationary in neutral gear.

Types of Smoke:

Black Smoke: This is the most common one and is really just an imbalance in the air to fuel ratio - too much fuel to not enough air. The black smoke is full of particulates that are basically large diesel particles that normally would be burned as fuel. Most common causes of black smoke are faulty injectors, a faulty injector pump, a bad air filter (causing not enough oxygen to be supplied), a bad EGR valve (causing the valves to clog) or even a bad turbocharger..

White Smoke: White smoke means that the fuel that is being injected into the combustion chamber is not being burned properly. The common causes that produce white smoke range from something as simple as low engine compression or water in the fuel to the fuel pump timing being thrown off because something is starving the fuel from getting to the pump in the manner necessary for the pump to time and work correctly.

Blue Smoke: Blue smoke results from burning engine oil. This is a mechanical problem because engine oil isn't supposed to be getting into areas where it can be burned. There could be a faulty injector pump or lift pump, which would allow oil to mix with fuel and be burned. The valves or valve stem seals could be bad. Worn cylinders and piston rings can help with this problem) allows oil to seep where it shouldn't. having put too much oil in the engine.

How to measure Smoke Density?

Common reporting scales include Hartridge Smoke Unit s (HSU), Bosch Smoke Unit (BSU), Filter Smoke Number (FSN), etc. Smoke Factor (SF) is a term introduced by ESPH to describe its remote sensing measurement of smoke. It represents a ratio of exhaust opacity to the amount of fuel burned at the time of measurement. SF is measured in the UV using frequencies providing the greatest sensitivity to the particulate mass fraction. The amount of fuel burned element of the ratio is formulated by summing measurements of the carbon-based gases of the exhaust. For black diesel smoke, a SF of 1 indicates 1% of fuel by mass is emitted as PM.

Smoke Measurement: Smoke measurement broadly classified into two groups:

1) Comparison Method 2) Obscuration Method

1. Comparison Method: Ringlemann Chart is used in this process. The chart shows four shades of gray as well as pure white and an all-black section .In use, the chart is set up at eye level line with the stack at such distance that the sections appear to be different degrees of uniform gray shades. Ringlemann number ranging from 0 (no smoke) to No. 5 (dense black smoke).

2. Obscuration Method: Divided into 3 types.

i) Light Extinction type: -Intensity of light beam is reduced by smoke which is a measure of smoke intensity. Ex. Hartridge smoke meter.

ii) Continuous Filtering Type: Measurement of smoke intensity is achieved by continuously passing exhaust gas through a moving strip of filter paper and collecting particles. Ex. Van Brand Smoke meter.

iii) Spot Filtering Type: A smoke strain obtained by filtering a given quantity of exhaust gas through a fixed filter paper is used for the measurement of smoke intensity. Ex. Bosch Smoke meter.

Description:

The AVL Smoke Meter uses the filter paper method to determine the soot concentration in the exhaust of diesel and GDI engines. A variable, but exactly defined sampling volume is sampled from the engine exhaust pipe and passed through clean filter paper inside the device. The filtered soot causes blackening of the filter paper, which is measured by a photoelectric measuring head and the result is analyzed by a microprocessor. The value determined is the Filter Smoke Number (FSN).

When determining the soot content, not only the paper blackening (PB) has to be taken into account, also the volume of exhaust drawn through the filter paper is important (effective sampling length Leff).

FSN = PB for Leff = 405 mm (Length of the column of exhaust referred to 1 bar and 25 °C)

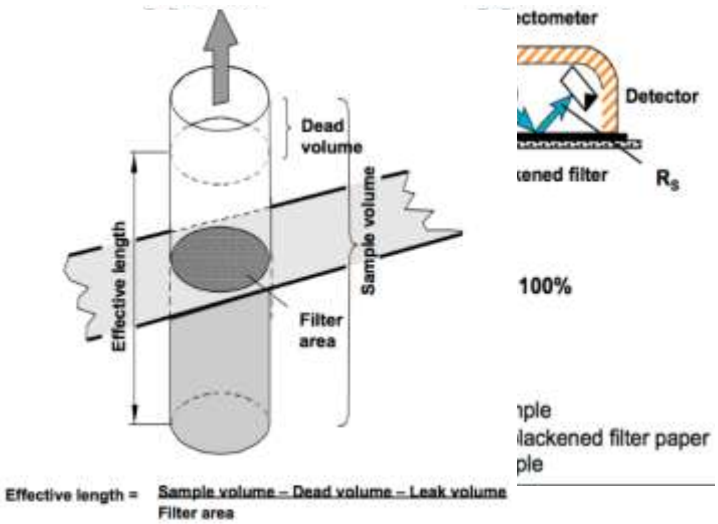


Figure 1: Principle of smoke meter

Procedure

Vehicle Preparation

1. The opacimeter, the Instrument used for the measurement of smoke should be a type approved instrument as given in CMVR -116(3) and meeting the requirements specified in Part-VIII.
2. The pipes connecting the opacimeter shall also be as short as possible. The pipe shall be inclined upwards from the sampling point to the opacimeter and sharp bends where soot might accumulate shall be avoided.
3. In cases where an engine has several exhaust outlets, these shall be connected to a single outlet in which opacity measurement shall be made.
4. The engine of the vehicle shall be warmed-up to attain oil temperature of 60 °C. The test shall be carried out as soon as this engine condition is reached.
5. The vehicle gear change control shall be set in the neutral position and the drive between engine and gearbox engaged. With the engine idling, the accelerator control shall be operated quickly, but not violently, so as to obtain maximum delivery from the injection pump. This position shall be maintained until maximum engine speed is reached and the governor comes into action. As soon as this speed is reached the accelerator shall be released until the engine resumes its idling speed and the opacimeter reverts to the corresponding conditions. Typically the maximum time for acceleration shall be 5s and for the stabilization at maximum no load speed shall be 2s. The time duration between the two free accelerations shall be between 5-20s.
6. The operation described above shall be repeated not less than six times in order to clear the exhaust system and to allow for any necessary adjustments of the apparatus. During this operation the sample probe shall not be inserted in to the vehicle exhaust system.
7. The free acceleration smoke test shall be carried out with sample probe inserted in to the vehicle exhaust system. The maximum no load rpm reached during this operation shall be within + 500 rpm in respect of 3 wheeler vehicles and + 300 rpm for all other categories of vehicles, of the average value obtained in the last four of the six flushing cycles. If for any reason the speed is not within the specified tolerance band the particular smoke reading shall be considered as invalid and shall be discarded. The above operation shall be repeated till the peak smoke values recorded in four successive accelerations are valid and are situated within a bandwidth of 25 % of the arithmetic mean (in m-1 unit) of these values or within a bandwidth of 0.25 K, whichever is higher and do not form a decreasing sequence.

8. The absorption coefficient to be recorded shall be the arithmetic mean of these four valid readings. The vehicle should be considered meeting the requirement if the absorption coefficient thus recorded is less than the prescribed limits.
9. In case the valid readings are not obtained within the 10 free-accelerations, the testing shall be discontinued and the vehicle owner shall be advised to re-submit the vehicle after the same is repaired / serviced.
10. For the purpose of PUC certification if the smoke is not within limits as per 5.0 below, the testing shall be discontinued and the vehicle owner shall be advised to re-submit the vehicle after the same is repaired / serviced.

Technical specification of AVL 437 Smoke Meter

S. No	Particulars	Specifications
1	Accuracy and Reproducibility	± 1% full scale reading.
2	Measuring range	0-100% capacity in % 0-∞ absorption m^{-1}
3	Measurement chamber	effective length 0.430 m ± 0.005 m
4	Heating Time	220 V ....approx. 20 min
5	Light source	Halogen bulb 12 V/ 5W
6	Colour temperature	3000 K ± 150 K
7	Detector	Selenium photocell dia. 45 mm Max. sensitivity in light,
8	In Frequency range	550 to 570nm.Below 430 nm and above 680 nm sensitivity is less than 4% related to the maximum sensitivity
9	Maximum Smoke	210° C Temperature at entrance.

Figure 2: Smoke meter connected to tailpipe of a vehicle to test the smoke level

Measurement

1. Check all electrical connections
2. Install and connect correct probe
3. Switch on main switch and wait till red warning LED for low temperature is off.
4. Connect the oil temperature probe
5. Connect the RPM Module
6. Connect clamp on transducer to the cable
7. Switch off the engine
8. Take out the dipstick

9. Adjust the oil temperature sensor equal to the length of Dipstick
10. Plug the oil temperature sensor into oil sump and other side to smoke meter
11. Check the pressure line size and plug the RPM sensor to fuel line of first cylinder and connect other side to the smoke meter
12. Now switch on the smoke meter by inserting power ON of the smoke meter
13. After switching on the smoke meter shows the value 0.0 and CAL LED glows. Now the equipment is in CAL mode.
14. Press TEST key given on the remote
15. Now press the AUTO key given on the remote
16. Now you will see 1 written on the remote screen
17. This is the band width selection option .you can select band width 1 or 2
18. After selecting the rpm range again press AUTO key
19. Accelerate the vehicle from minimum to maximum smoothly till the AUTOLED starts blinking
20. Press the AUTO key to go to second reading and continue the six flushing cycles
21. Press again AUTO key to start actual test.
22. For the purpose of PUC (Pollution Under Control) certification, if the idling CO and/or HC are not within limits as per table given below.

Method Of Test	**Maximum Smoke Density**	
	Light absorption coefficient (1/m)	Hartidge Units
Free acceleration test for turbo charged engine and naturally aspirated engine for vehicles manufactured as per pre-Bharat Stage IV norms.	2.45	65
Free acceleration test for turbo charged engine and naturally aspirated engine for vehicles manufactured as per Bharat Stage IV norms.	1.62	50

Observations:

Trail No.	**Maximum Smoke Density**	
	Light absorption coefficient (1/m)	Hartidge Units
1.		
2.		

Note: The emissions of visible pollutants from in-service compression ignition (diesel) engine vehicles, when subjected to a free acceleration test as referred in CMVR-115 (2)(b) and for issue of "Pollution under control certificate" to be issued by the authorised agencies under CMVR-115 (7).

Results: The exhaust smoke measurement of a given vehicle is performed.

Pollution Under Control (PUC) Certificate

In India, a valid driving license, insurance coverage and a Pollution Under Control Certificate are legal mandatory requirements for a car. An insurance coverage is mandated by the Motor Vehicles Act, 1988, for all cars plying on Indian roads. Similarly, the Central Motor Vehicle Rule, 1989 mandates the PUC Certification.

Validity and Cost

- When you purchase a new car, a PUC certificate is provided for it and the validity of this certificate is 1 year. Following that your car would need to undergo the PUC test at regular intervals and a new certificate will be issued each time.
- The validity of the new certificate is usually 6 months. In case an adverse reading is observed in the PUC test, the validity of the certificate will be decided on the basis of that reading.
- If cars exhibit higher levels of emission than the prescribed limits, the registration number of the vehicle will be informed to the RTO, Deputy RTO or Assistant RTO by the testing centre within one day.
- The cost of the PUC test is quite minimal. It varies from Rs. 60 to Rs. 100, based on the vehicle that is being tested and its fuel type.

PUC Test Procedure

- In the case of diesel vehicles, the accelerator is fully pressed and the readings of pollution levels are observed. This is repeated five times and the average constitutes the final reading.
- For petrol vehicles, the car is kept idling without pressing the accelerator. Only one reading is taken and this constitutes the final reading.

PUC testing can be done at any authorised petrol pumps or independent testing centres. The certificates are also issued at the location of the tests. The PUC certificate contains the following information,

- The serial number of the issued certificate
- The vehicle’s license plate number
- The date on which the test was conducted
- The expiry date of the PUC certificate
- The readings and observations from the test

Test Criteria and Certificate

All vehicles that are tested for PUC should fall within the following limits.

Vehicle Type	Percentage of CO	Hydrocarbon measured in ppm
2 and 3 wheeled vehicles (2 or 4 stroke) that are manufactured on or before 31st March 2000	4.5	9000
2 and 3 wheeled vehicles (2 stroke) that are manufactured after 31st March 2000	3.5	6000
2 and 3 wheeled vehicles (4 stroke) that are manufactured after 31st March 2000	3.5	4500
4 wheeled vehicles that are manufactured as per the Pre Bharat Stage II Norms	3	1500
4 wheeled vehicles that are manufactured as per the Pre Bharat Stage II, Stage III or subsequent Norms	0.5	750

PUC certificate is an important document that you should carry at all times when you are driving the tested vehicle. When requested by a traffic official, if you are unable to furnish this document, you will have to bear the penalties. You should also ensure that it is renewed as soon as it expires to avoid fines.

If a vehicle does not carry a valid PUC certificate, it is liable for prosecution as per Section 190(2) of the Motor Vehicles Act. The driver will be charged Rs. 1000 if it is a first-time offense, and Rs. 2000 for every subsequent offense.

In case you are carrying a valid PUC certificate, but your vehicle is visibly polluting the environment, the certificate of your vehicle will be cancelled and you will be required to procure a new certificate within 1 week. If you fail to do so, you will be prosecuted under Section 190(2) of the Motor Vehicles Act.

The pollution standards for in use vehicles have been
prescribed under Rule 115(2) of Central Motor vehicles Rules, 1989.

They are :
(I) Petrol/CNG/LPG Vehicles:

S.No	Vehicle Type	CO %	HC (n-hexane equivalent) ppm
1	2&3-Wheelers (2/4-stroke) (Vehicles manufactured on and before 31/3/2000)	4.5	9000
2	2&3-Wheelers (2-stroke) (Vehicles manufactured after 31/3/2000)	3.5	6000
3	2&3-Wheelers (4-stroke) (Vehicles manufactured after 31/3/2000)	3.5	4500
4	4- wheelers manufactured as per pre Bharat Stage II norms	3.0	1500
5	4- wheelers manufactured as per Bharat Stage- II, Bharat Stage III	0.5	750

(Petrol/Compressed Natural Gas/liquefied Petroleum Gas driven vehicles, manufactured

S.No.	Vehicle Type	Idle Emission Limit		High Idle Emission Limited	
(1)	(2)	(3)		(4)	
		CO%	HC(n Hexane Equivalent ppm)	CO%	Lambda(RPM-2500±200)
1.	Compressed Natural Gas/Liquefied Petroleum Gas driven 4 wheelers manufactured as per Bharat Stage IV norms.	0.3%	200ppm	-	-
2.	Petrol driven 4-wheelers manufactured as per Bharat Stage IV norms.	0.3%	200ppm	0.2	1/± 0.03 or as declared by the vehicle manufacturer.

(II) For Diesel Vehicles

S.No.	Method Of Test	Maximum Smoke Density	
(1)	(2)	(3)	
		Light absorption coefficient (1/metre)	Hartidge Units
1.	Free acceleration test for turbo charged engine and naturally aspirated engine for vehicles manufactured as per pre-Bharat Stage IV norms.	2.45	65
2.	Free acceleration test for turbo charged engine and naturally aspirated engine for vehicles manufactured as per Bharat Stage IV norms.	1.62	50"

EXPERIMENT-11

MULTI CAR SCANNING

AIM:

To conduct the multi car scanning on the given vehicle and to find the error memory, display actual values

TOOLS REQUIRED:

System tester

Car

Computer with ESI software

Description:

KTS modules can perform the following functions with ESI[tronic] or ESI[tronic] 2.0:

Controller diagnosis, with e.g.

Read error memory

Display actual values

Initiate actuators

Use of other controller-specific functions

Multimeter measurements (not with KTS 525) for

Voltage measurement

Resistance measurement

Current measurement (only with special accessory current measuring clips or shunt)

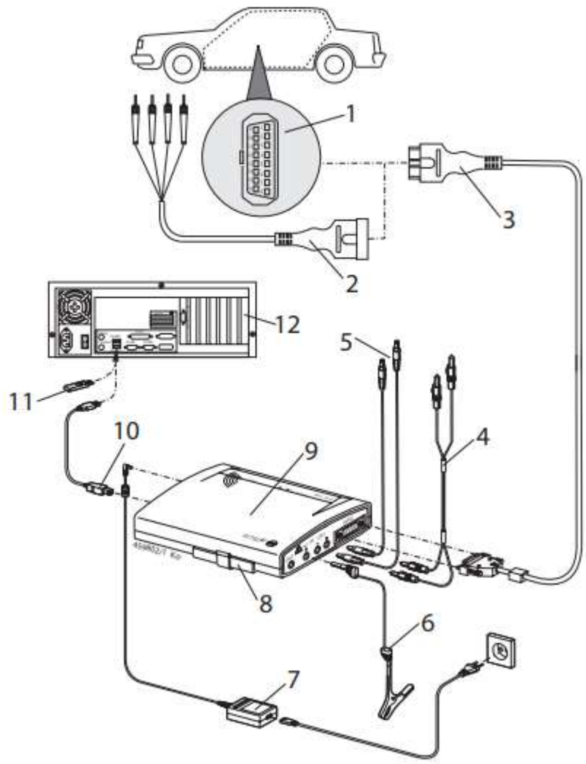
Requirements

Hardware PC/Laptop with at least one free USB interface

Operation

KTS 530 can only be connected with the PC/Laptop via the USB interface. KTS 525 / 540 / 570 can be linked with the PC/Laptop via wireless connection (Bluetooth) or via the USB interface. Insert the Bluetooth USB adapter in the PC/Laptop for a wireless connection

Connection diagram.



1 OBD interface in vehicle

2 UNI connection cable

3 OBD diagnosis cable

4 Measurement cables (KTS 570)

5 Measurement cables (KTS 530, KTS 540)

6 GND lead

7 Power pack

8 Adapter insert (IBOX 01)

9 KTS 570

10 USB connecting cable

11 Bluetooth USB adapter

12 PC (Laptop)

Notes concerning controller diagnosis

KTS modules are either powered via the power supply that is delivered or through the OBD interface of the vehicle.

The connection to the diagnosis interface in the vehicle is made via

- the OBD diagnostics cable (Fig. 3, item 3) or
- the OBD diagnostics cable and the UNI connecting cable (Fig. 3, item 2)
- the OBD diagnostics cable and a vehicle-specific adapter line (special accessories).

Notes concerning the multimeter and oscilloscope

Danger from high voltage! If measurements are taken without a ground lead, potentially deadly voltages can be generated.

- If no diagnosis cable is connected, a ground connection is to be made from the KTS modules before making any V-, R- or I-measurements (Fig. 1, Item 2) made connection to vehicle ground with the ground cable provided.
- Connect the ground cable as close as possible to the measurement object.
- Use KTS modules only on the vehicle and not for measuring voltages > 60 VDC, 30 VAC or 42 VACpeak! Do not perform any measurements on ignition systems.
- Only use the accompanying measuring cables with touch protection.
- Always insert measuring cables in the KTS modules first and then into the vehicle.
- Do not route unshielded measuring cables close to high-power sources of interference, such as e.g. ignition cables.

Connection

1. Connect the KTS module with the power supply included with the delivery.

2. Connect the KTS module with the PC/Laptop using the USB connection cable.

Test Procedure

1. Click ESI tronic software
2. Connect OBD cable and USB cable

3. Fill description
4. Click on diagram
5. Continue
6. Locate connections
7. Connect OBD
8. System Overview
9. Swith on ignition
10. See the error
11. Erase the error
12. Global OBD for unknown model/vehicle
13. Show all
14. Direct selection with global OBD
15. Switch ON ignition not engine
16. System found continue
17. OBD review
18. Double click option
19. Return
20. Start engine in actual
21. Select read fault memory

Trouble shooting

If Bluetooth is not working

1. Main menu→Hardware settings→OK→start DDC
2. KTS 525 USB #319→ok
3. KYS 525 BTB→OK
4. Test for connections

Result

STATIC & DYNAMIC BALANCING APPARATUS

STATIC & DYNAMIC BALANCING APPARATUS

1. AIM:

To balance the masses Statically & Dynamically of a simple rotating mass system.

2. APPARATUS:

Static and Dynamic Balancing Apparatus.

3. INTRODUCTION:

A system of rotating masses is said to be in static balance if the combined mass centre of the system lies on the axis of rotation. When several masses rotate in different planes, the centrifugal forces, in addition to being out of balance, also form couples. A system of rotating masses is in dynamic balance when there does not exist any resultant centrifugal force as well as resultant couple.

4. THEORY:

4.1 CONDITIONS FOR STATIC AND DYNAMIC BALANCING:

4.1.1 If a shaft carries a number of unbalanced masses such that the center of mass of the system lies on the axis of rotation, the system is said to statically balance.

4.1.2 The resultant couple due to all the inertia forces during rotation must be zero.

These two conditions together will give complete dynamic balancing. It is obvious that a dynamically – balanced system is also statically balanced, but the statically balanced system is not dynamically balanced.

4.2 BALANCING OF SEVERAL MASSES ROTATING IN DIFFERENT PLANES:

When several masses revolve in different planes, they may be transferred to a reference plane (written as RP), which may be defined as the plane passing through a point on the axis of rotation and perpendicular to it. The effect of transferring a revolving mass (in one plane) to a reference plane is to cause a force of magnitude equal to centrifugal force of the revolving mass to act in the reference plane, together with a couple of magnitude equal to the product of the force and the distance between the plane of rotation and the reference plane. In order to have a complete balance of the several revolving masses in different planes, the following conditions must be satisfied:

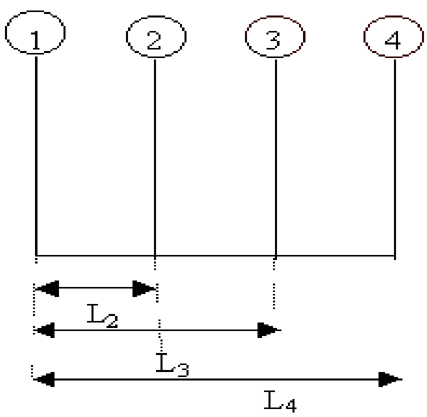
4.2.1 The forces in the reference plane must balance, i.e. the resultant force must be zero.

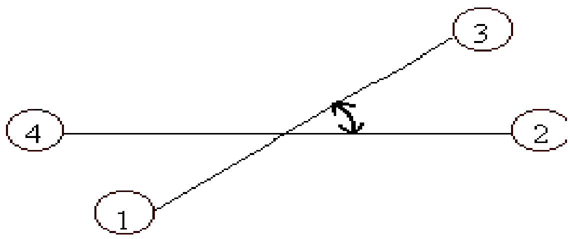
4.2.2 The couple about the reference plane must be balance, i.e. the resultant couple must be zero.

Let us now consider four masses m_1, m_2, m_3 and m_4 revolving in planes 1, 2, 3 and 4 shown in fig. The relative angular positions of these masses are shown in the end view Fig. The magnitude, angular position and position of the balancing mass $m_1$in plane 1may be obtained as discussed below:

- Take one of the planes, say 1as the reference plane (R.P.). The distance of all the other planes to the left of the reference plane may be regarded as negative, and those to the right as positive.
- Tabulate the data as in table. The planes are tabulated in the same order i.e. 1, 2, 3.

RP





Plane	Weight No.	Mass (m)	Radius (r)	Angle θ	Mass moment mr	Distance from plane 1 (L)	Couple mrL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1(R.P.)	4	m_1	r_1	θ_1	$m_1\ r_1$	0	0
2	1	m_2	r_2	$\theta_2=0^0$	$m_2\ r_2$	L_2	$m_2\, r_2\, L_2$
3	2	m_3	r_3	θ_3	$m_3\ r_3$	L_3	$m_3\, r_3\, L_3$
4	3	m_4	r_4	θ_4	$m_4\ r_4$	L_4	$m_4\, r_4\, L_4$

1. The position of plane 4 from plane 2 may be obtained by drawing the couple polygon with the help of data given in column no. 8.

2. The magnitude and angular position of mass m1 may be determined by drawing the force polygon from the given data of column no.5 & column no.6 to some suitable scale. Since the masses are to be completely balanced, therefore the force polygon must be closed figure. The closing side of force polygon is proportional to the m1 r1.

The angular position of mass m_1 must be equal to the angle in anticlockwise measured from the R.P. to the line drawn on the fig. parallel to the closing side of force polygon

5. DESCRIPTION:

The apparatus consists of a steel shaft mounted in ball bearings in a stiff rectangular main frame. A set of four blocks of different weights is provided and may be detached from the shaft.

A disc carrying a circular protractor scale is fitted to one side of the rectangular frame. A scale is provided with the apparatus to adjust the longitudinal distance of the blocks on the shaft. The circular protractor scale is provided to determine the exact angular position of each adjustable block.

The shaft is driven by electric motor mounted under the main frame, through a belt. For static balancing of weights the main frame is suspended to support frame by chains then rotate the shaft manually after fixing the blocks at their proper angles. It should be completely balanced. In this position, the motor driving belt should be removed.

For dynamic balancing of the rotating mass system, the main frame is suspended from the support frame by two short links such that the main frame and the supporting frame are in the same plane. Rotate the statically balanced weights with the help of motor. If they rotate smoothly and without vibrations, they are dynamically balanced.

6. EXPERIMENTAL PROCEDURE:

- Insert all the weights in sequence 1- 2- 3 - 4 from pulley side.
- Fix the pointer and pulley on shaft.
- Fix the pointer on 0^o (θ_2) on the circular protractor scale.
- Fix the weight no. 1 in horizontal position with help of acrylic section.
- Rotate the shaft after loosening previous position of pointer and fix it on θ_3.
- Fix the weight no. 2 in horizontal position.
- Loose the pointer and rotate the shaft to fix pointer on θ_4.
- Fix the weight no. 3 in horizontal position.
- Loose the pointer and rotate the shaft to fix pointer on θ_1.
- Fix the weight no.4 in horizontal position.
- Now the weights are mounted in correct position.
- For static balancing, the system will remain steady in any angular position.
- Now put the belt on the pulleys of shaft and motor.
- Supply the main power to the motor through dimmerstat.
- Gradually increase the speed of the motor. If the system runs smoothly and without vibrations, it shows that the system is dynamically balanced.
- Gradually reduce the speed to minimum and then switch off the main supply to stop the system.

7. OBSERVATION & CALCULATION:

7.1 OBSERVATION TABLE:

S. No.	Plane	Mass, m (gm)	Angle from reference line, θ (degree)	Distance, L (mm)
1	1(R.P)			
2	2			
3	3			
4	4			

7.2 CALCULATION TABLE:

Plane	Mass, m (gm)	Radius of rotation, r (mm)	Mass moment (m x r)	Couple (m x r x L)
1				
2				
3				
4				

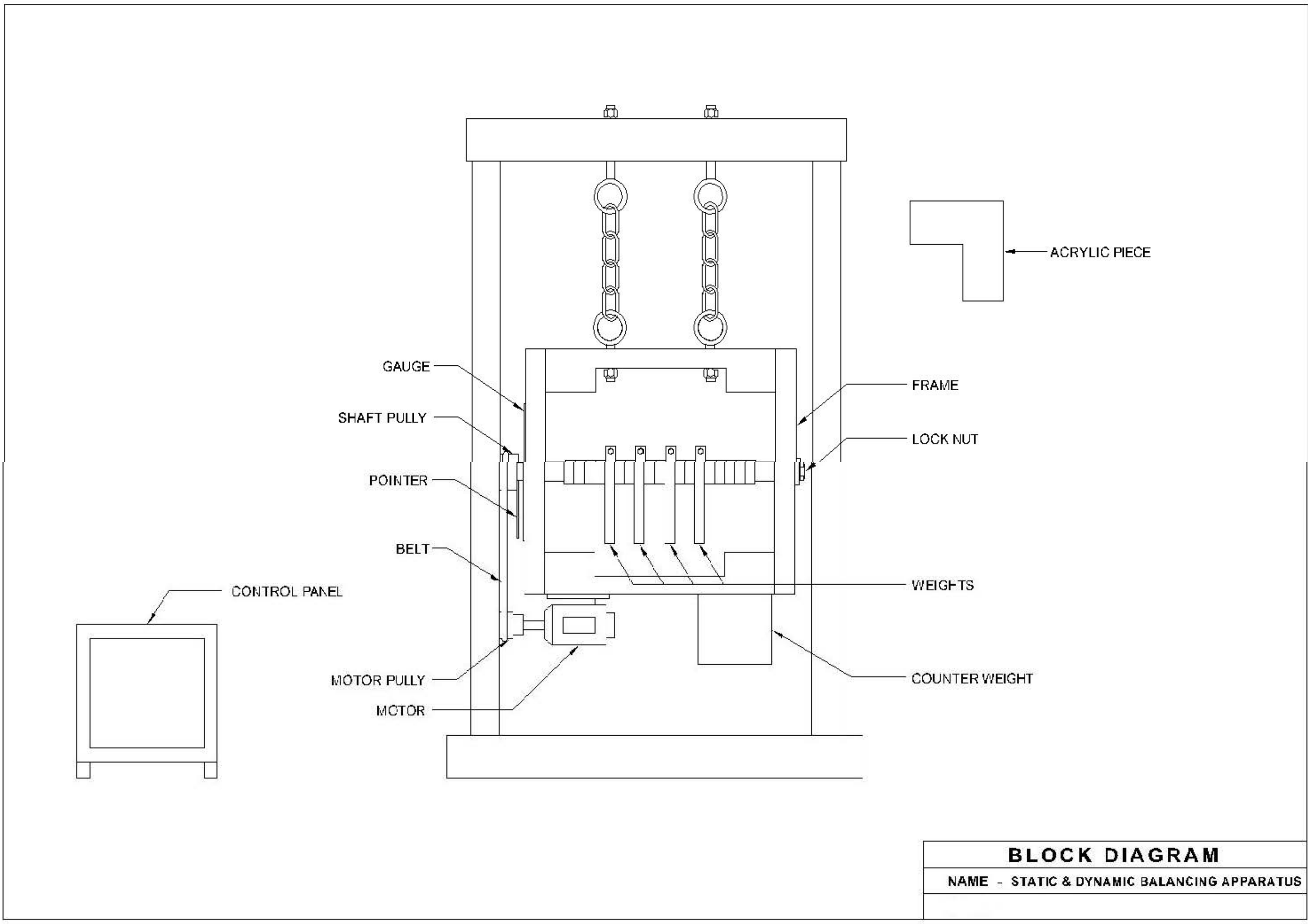
8. NOMENCLATURE:

Nom	Column Heading	Units	Type
L	Distance between particular weight from reference plane	mm	Measured
m	Mass of given weight	gm	Measured
r	Radius of rotation of particular weight	mm	Given
θ	Angle of particular weight from w.r.t. to reference plane	degree	Measured

9. PRECAUTION & MAINTENANCE INSTRUCTIONS:

1. Never run the apparatus if power supply is less than 200 Volts & above than 230 Volts.
2. Increase the motor speed gradually.
3. Experimental set up should be tight properly before conducting experiment.
4. Before starting the rotary switch, dimmer stat should be at zero position.

10. BLOCK DIAGRAM:



RESULT:

MOTORISED GYROSCOPE APPARATUS

MOTORISED GYROSCOPE APPARATUS

1. AIM:

To study the gyroscopic effect of a rotating disc and Experimental justification of the Gyroscopic Couple equation $T = I.\omega.\omega p$.

2. APPARATUS:

1. Motorised Gyroscope
2. Weights
3. Stop watch

3. INTRODUCTION:

3.1 AXIS OF SPIN:

If a body is revolving about an axis, the latter is known as axis of spin (Refer Fig.1, where OX is the axis of spin).

3.2 PRECESSION:

Precession means the rotation about the third axis OZ (Refer Fig. 1) that is perpendicular to both the axis of spin OX and that of couple OY.

3.3 AXIS OF PRECESSION:

The third axis OZ is perpendicular to both the axis of spin OX and that of couple OY is known as axis of precession.

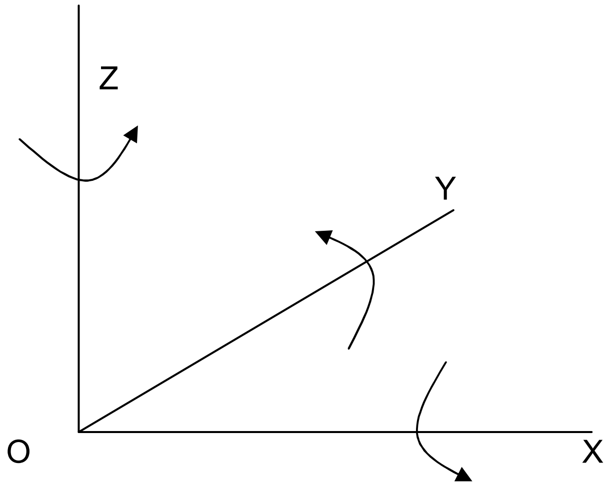
3.4 GYROSCOPIC EFFECT:

To a body revolving (or spinning) about an axis say OX, (Refer Fig.1) if a couple represented by a vector OY perpendicular to OX is applied, then the body tries to process about an axis OZ which is perpendicular both to OX and OY. Thus, the couple is mutually perpendicular.

The above combined effect is known as processional or gyroscopic effect.

3.5 GYROSCOPE:

It is a body while spinning about an axis is free to rotate in other directions under the action of external forces.



OX – Axis of spin, OY – Axis of Couple, OZ – Axis of Precession

Figure 1

4. THEORY:

4.1 GYROSCOPIC COUPLE OF A PLANE DISC:

Let a disc of weight 'W' having a moment of inertia I be spinning at an angular velocity ω about axis OX in anticlockwise direction viewing from front (Refer Fig.2). Therefore, the angular momentum of disc is $I\omega$. Applying right–hand screw rule the sense of vector representing the angular momentum of disc which is also a vector quantity will be in the direction OX as shown.

A couple whose axis is OY perpendicular to OX and is in the plane Z, is now applied to prices the axis OX.

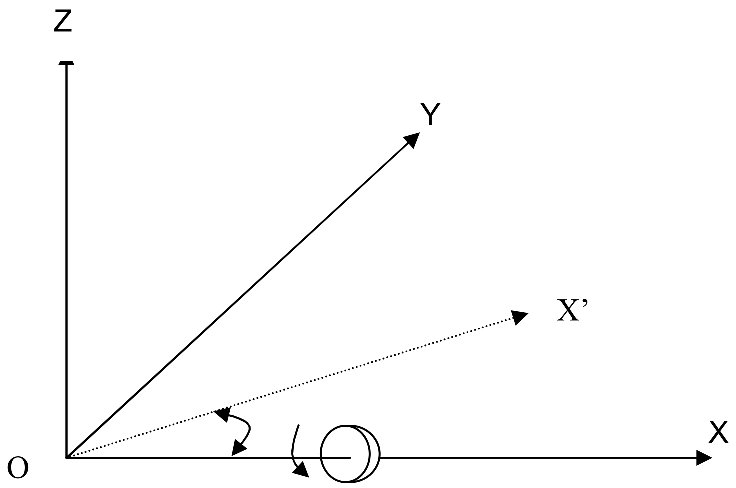


Figure: 2

Let axis OX turn through a small angular displacement from OX to OX' in time δt. The couple applied produces a change in the direction of angular velocity, the magnitude remains constant. This change is due to the velocity of precession.

Therefore, 'OX' represents the angular momentum after time dt.

Change of angular momentum = $\overrightarrow{OX'} - \overrightarrow{OX} = \overrightarrow{XX'}$

Angular desplacement $= \frac{XX'}{dt} = \frac{OX \times d\theta}{dt}$

As, XX' = OX × d θ in direction of XX' Now

as rate of change of angular momentum Couple

applied = C =T

We get $T = OX \frac{d\theta}{dt}$

But OX = I ω

Where

I = Moment of Inertia of disc

ω = Angular Velocity of disc.

$$T = I.\omega \frac{d\theta}{dt}$$

And in the limit dt is very small

We have $\frac{d\theta}{dt} = \omega_P$

Where ω_P = Angular velocity of precession of yoke about vertical axis.

Thus, we get T = I × ω × ω_p

The direction of the couple applied on the body is clockwise when looking in the direction XX' and in the limit this is perpendicular to the axis of ω and of ω_p.

The reaction couple exerted by the body on its frame is equal in magnitude to that of 'C', but opposite in direction.

5. DESCRIPTION:

The set up consists of heavy disc mounted on a horizontal shaft, rotated by a variable speed motor. The rotor shaft is coupled to a motor mounted on a trunion frame having bearings in a yoke frame, which is free to rotate about vertical axis. A weight pan on other side of disc balances the weight of motor. Rotor disc can be move about three axis. Weight can be applied at a particular distance from the center of rotor to calculate the applied torque. The gyroscopic couple can be determined with the help of moment of inertia, angular speed of disc and angular speed of precession.

6. EXPERIMENTAL PROCEDURE:

7.1 Set the rotor at zero position.
7.2 Start the motor with the help of rotary switch.
7.3 Increase the speed of rotor with dimmer stat & let it run for 10 minutes.
7.4 Measure the R.P.M. with the help of tachometer.
7.5 Put the weight on weight pan then yoke rotate at anticlockwise direction.
7.6 Note down the time for any rotating angle (e.g. 30o,40o).
7.7 Repeat the experiment for the different speeds.
7.8 Repeat the experiment for different loads.

8. OBSERVATION & CALCULATION:

8.1 DATA:

Acceleration due to gravity g	= 9.81 m/sec^2
Distance of weight for the center of disc L	= ……… m
Radius of disc r	= 0.15 m
Weight of rotor disc W	= 5.42 kg

8.2 OBSERVATION TABLE:

Sr. No.	N (RPM)	W_1 (kg)	$d\theta$ (degree)	dt (sec)
1				
2				
3				
4				
5				

8.3 CALCULATIONS:

$$I = \frac{W}{g} \times \frac{r^2}{2} \text{ (kg-m-s}^2\text{)}$$

$$\omega = \frac{2 \times \pi \times N}{60} \text{ (rad/s)}$$

$$\omega_p = \frac{d\theta}{dt} \times \frac{\pi}{180} \text{ (rad/s)}$$

$$T_{the} = I\ \omega\ \omega_p \text{ (kg-m)}$$

$$T_{act} = W_1 \times L \text{ (kg-m)}$$

9. NOMENCLATURE:

Nom.	Column Heading	Units	Type
dt	Time required for the precessions	s	Measured
d	Angle of precession	degree	Measured
g	Acceleration due to gravity	m/s^2	Given
I	Moment of inertia of disc	$Kg\text{-}m\text{-}s^2$	Calculated
L	Distance of weight from the center of disc	m	Measured
N	RPM of Disc spin	RPM	Measured
r	Radius of disc	m	Given
Tact	Actual Gyroscopic couple	kg-m	Calculated
Tthe	Theoretical Gyroscopic couple	kg-m	Calculated
W	Weight of rotor disc	kg	Given
W1	Weight on pan	kg	Measured
ω	Angular velocity of disc	rad/s	Calculated
ωp	Angular velocity of precession of yoke about vertical axis	rad/s	Calculated

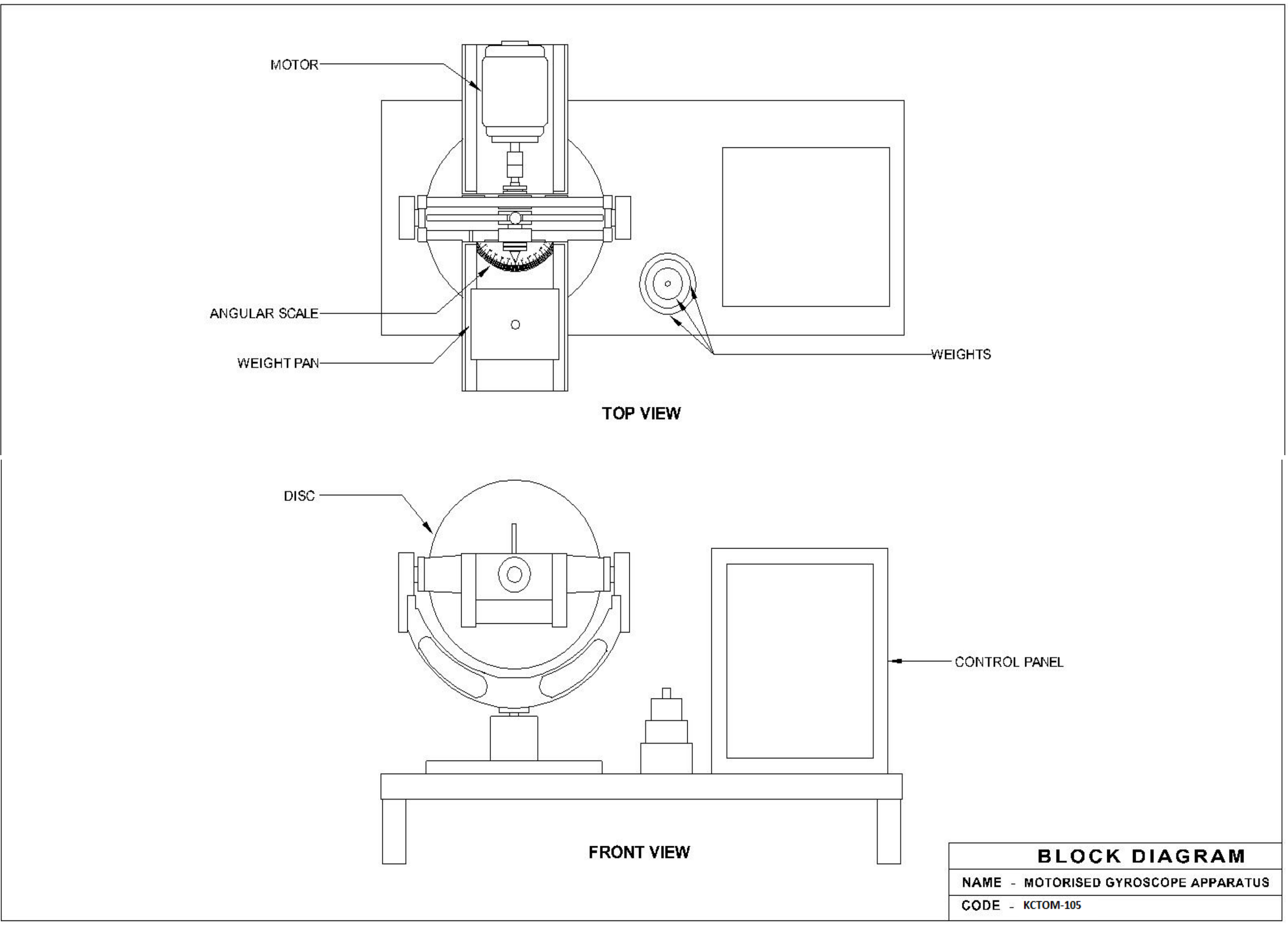
10. PRECAUTION & MAINTENANCE INSTRUCTIONS:

10.1 Never run the apparatus if power supply is less than 200 Volts and above than 230 Volts.

10.2 Before start the motor set dimmer stat at zero position.

10.3 Increase the speed gradually.

11. BLOCK DIAGRAM



RESULTS:

WHIRLING OF SHAFT DEMONSTRATOR

WHIRLING OF SHAFT DEMONSTRATOR

1. AIM:

To study the modes of vibration and to measure the frequency in each case.

2. APPARATUS:

> Whirling of shaft apparatus.

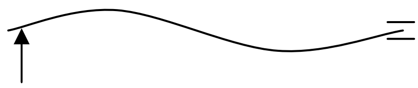
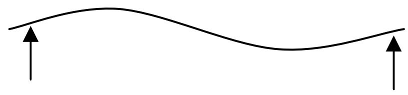
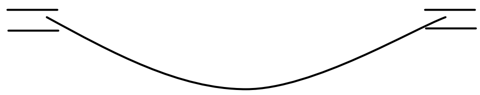
3. INTRODUCTION:

A rotating shaft tends to bow out with large amplitude at a certain speed of rotation. This phenomenon is known as the whirling of the shaft. The speed at which it occurs is called the critical speed.

4. THEORY:

In actual practice, a rotating shaft carries different mountings and accessories in the form of gears, pulleys etc. when the gears or pulleys are put on the shaft, the center of gravity of the pulley or gear does not coincide with the center line of the bearings or with the axis of the shaft, when the shaft is stationary. This means that the center of gravity of the pulley or gear is at a certain distance from the axis of rotation and due to this, the shaft is subjected to centrifugal force. This force will bend the shaft, which will further increase the distance of center of gravity of the pulley or gear from the axis of rotation. The bending of shaft not only depends upon the value of eccentricity (distance between center of gravity of the pulley and axis of rotation) but also depends upon the speed at which the shaft rotates.
The speed, at which the shaft runs so that the additional deflection of the shaft from the axis of rotation becomes infinite, is known as critical or whirling speed.

Possible Experiments with Elastic Rods

Exp. No.	End Fixing	Mode of Whirl
1	One supported other fixed	1^{st} Mode 
2	One supported other fixed	2^{nd} Mode 
3	Both end Supported	1^{st} Mode 
4.	Both end Supported	2^{nd} Mode 
5	Both end fixed	1^{st} Mode 

5. DESCRIPTION:

The apparatus consists of a DC motor as the driving unit, which drives the shaft supported in bearings. Fixing ends can slide and adjust according to the requirement on the guiding pipes. Motor is connected to the shaft through flexible coupling. The shafts of the different diameters can be replaced easily. A dimmerstat is provided to increase or decrease the rpm of the motor. The whole arrangement is fixed on M.S frame. Guards are provided to protect the user from accident.

6. EXPERIMENTAL PROCEDURE:

1 Fix the shaft to be tested in the bearings.

2 Supply the main power to the motor through dimmerstat.

3 Gradually increase the speed of motor until the first mode of vibration is not arrived.

4 Study the first mode of vibration and note down the corresponding speed of the shaft with the help of hand tachometer.

5 Gradually increase the speed of motor again, until the second mode of vibration is not arrived.

6 Study the second mode of vibration and note down the corresponding speed of the shaft with the help of hand tachometer.

7 Now do same procedure for other conditions.

8 Reduce the speed gradually and when shaft stop rotating, cut off the main power supply.

9 Repeat the experiment for the shafts of different diameters.

10 Repeat the experiment for different bearing conditions.

7. OBSERVATION & CALCULATION:

7.1 DATA:

Acceleration due to gravity g	= 9.81 m/s^2
Density of shaft material ρ	= 7800 kg/m^3
Young's Modulus of elasticity E	= 2 x 10^{11} N/m^2
Diameter of shaft d1	= 3.2 x 10^{-3} m
Diameter of shaft d2	= 4.8 x 10^{-3} m
Diameter of shaft d3	= 6.4 x 10^{-3} m
Length of shaft L_1	= 1 m
Length of shaft L_2	= 1 m
Length of shaft L_3	= 1 m

7.2 OBSERVATION TABLE:

When both the ends are fixed:		When both the ends are supported			When one end is fix and other end is supported		
Sr. No.	N_a	Sr. No.	N_a		Sr. No.	N_a	
1		1	1st Mode	2nd Mode	1	1st Mode	2nd Mode
2		2			2		
3		3			3		
4		4			4		
5		5			5		

7.3 CALCULATIONS:

$d = d_1$ (if shaft 1 is used)

$d = d_2$ (if shaft 2 is used)

$d = d_3$ (if shaft 3 is used)

$L = L_1$ (if shaft 1 is used)

$L = L_2$ (if shaft 2 is used)

$L = L_3$ (if shaft 3 is used)

$$I = \frac{\pi}{64} d^4 \ (\text{m}^4)$$

$$A = \frac{\pi}{4} d^2 \ (\text{m}^2)$$

$$m_S = A \times \rho \ (\text{kg/m})$$

$$W = m_S \times g \ (\text{N/m})$$

When Both The Ends Are Fixed:

$$\delta_S = \frac{WL^4}{384EI} \ (\text{m})$$

$$f_n = \frac{0.4985}{\sqrt{\left(\frac{\delta_S}{1.27}\right)}} \text{ (Hz)}$$

$$N_t = 60 \times f_n \text{ (RPM)}$$

When Both The Ends Are Supported:

$$\delta_S = \frac{5W L^4}{384EI} \text{ (m)}$$

$$f_n = \frac{0.4985}{\sqrt{\left(\frac{\delta_S}{1.27}\right)}} \text{ (Hz)}$$

$$N_t = 60 \times f_n \text{ (RPM)}$$

When One End Is Fix And Other Is Supported:

$$\delta_S = \frac{W L^4}{185EI} \text{ (m)}$$

$$f_n = \frac{0.4985}{\sqrt{\left(\frac{\delta_S}{1.27}\right)}} \text{ (Hz)}$$

$$N_t = 60 \times f_n \text{ (RPM)}$$

8. NOMENCLATURE:

Nom	Column Heading	Units	Type
A	Area of shaft	m^2	Calculated
d	Diameter of shaft	m	Given
d_1	Diameter of shaft 1	m	Given
d_2	Diameter of shaft 2	m	Given
d_3	Diameter of shaft 3	m	Given
E	Young's Modulus of elasticity	kg/cm^2	Given
f_n	Frequency of transverse vibration	Hz	Calculated
g	Acceleration due to gravity	m/s^2	Given

I	Moment of inertia of shaft	m^4	Calculated
L	Length of shaft	m	Given
L_1	Length of shaft 1	m	Given
L_2	Length of shaft 2	m	Given
L_3	Length of shaft 3	m	Given
m_S	Mass of the shaft	kg/m	Calculated
N_a	Actual whirling speed	RPM	Measured
N_t	Theoretical whirling speed	RPM	Calculated
ρ	Density of shaft material	kg/m^3	Given
W	Weight of the shaft	N/m	Calculated
δ_S	Static deflection of shaft due to mass of shaft	m	Calculated

* Symbols represents unitless quantity

9. PRECAUTION & MAINTENANCE INSTRUCTIONS:

10.1 Never run the apparatus if power supply is less than 180 volts & above than 230 volts.

10.2 Deflecting in a single bow and whirling round like a skipping rope. If this speed is maintained the deflection will become so large that the shaft will be fractured.

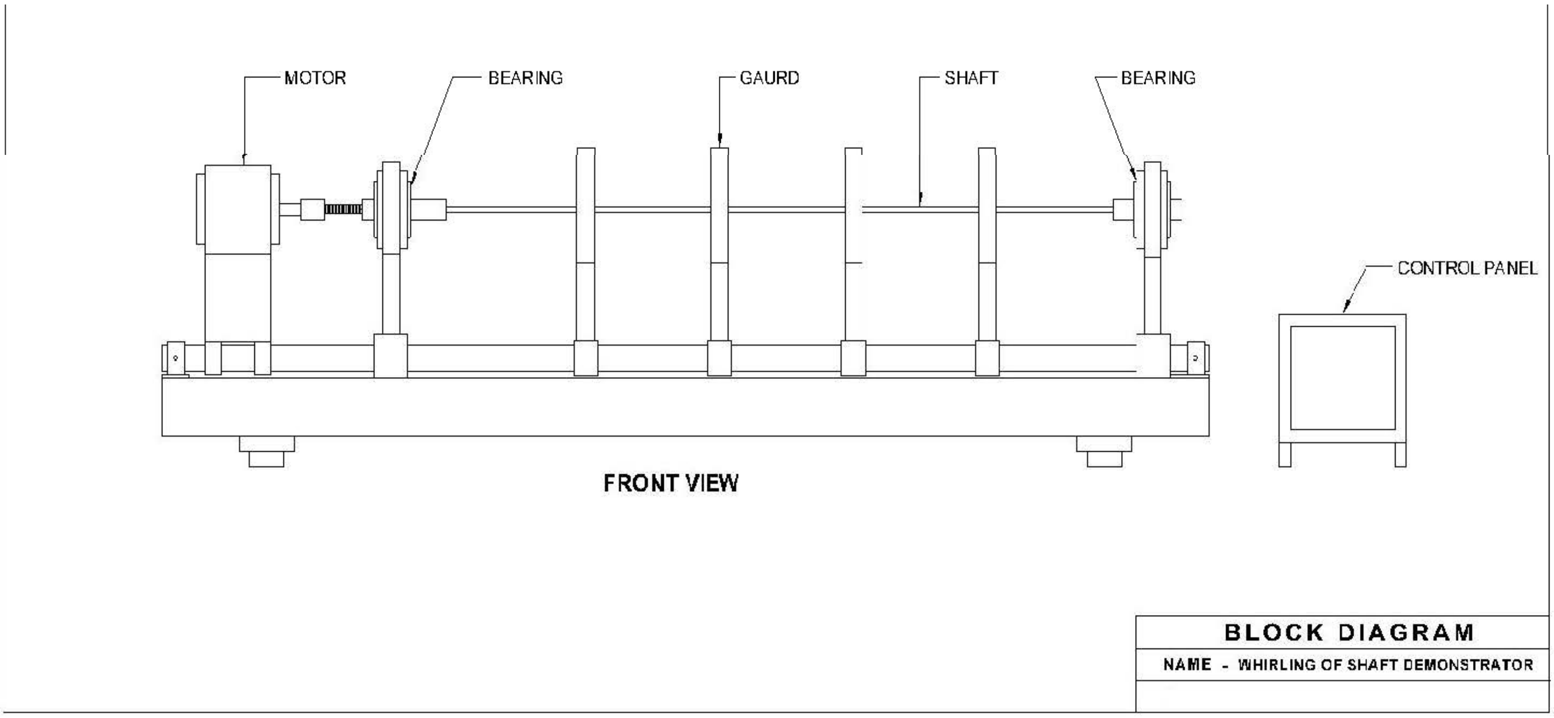
10.3 It is advisable to increase the speed of shaft rapidly and pass through the critical speeds first rather than observing the 1st critical speed which increases the speed of rotation slowly. In this process, there is a possibility that the amplitude of vibration will increase suddenly bringing the failure of the shaft.

10.4 If the shaft speed is taken to maximum first and then reduce slowly (thus not allowing time to build up the amplitude of vibration), higher mode will be observed first and note the corresponding speed and then by reducing the speed further the next mode of lower frequency can be observed without any danger of rise in amplitude as the speed is being decreased and the inertia forces are smaller in comparison with the bending spring forces hence possibility of build up of dangerous amplitudes are avoided.

10.5 It is a destructive test of shafts and it is observed that the elastic behavior of the shaft material changes a little after testing it for a few times and it is advisable to use fresh shafts afterwards.

10.6 Fix the apparatus firmly on the suitable foundation.

10. BLOCK DIAGRAM:



RESULTS:

UNIVERSAL VIBRATION
APPARATUS

Undamped Torsional Vibration of Single rotor shaft system

1. Aim:

To study the free vibration of Single Rotor System and to determine the natural frequency of vibration theoretically & experimentally.

2. Description:

In this experiment, one end of the shaft is gripped in the chuck & heavy flywheel free to rotate in ball bearing is fixed at the other end of the shaft. The bracket with fixed end of the shaft can be clamped at any convenient position along lower beam. Thus, length of the shaft can be varied during the experiments. The ball bearing support to the flywheel offers negligible damping during the experiment. The bearing housing is fixed to side member of the main frame.

3. Experimental Procedure:

3.1 Fix the bracket at convenient position along the lower beam.

3.2 Grip one end of the shaft at the bracket by chuck.

3.3 Fix the rotor on the other end of shaft.

3.4 Twist the rotor through some angle & release.

3.5 Note down the time required for 'n' oscillations.

3.6 Repeat the procedure for the different length of shaft.

3.7 Complete the observation table given below

4. Observation & Calculation:

4.1 Data:

Acceleration due to gravity g	= 9.81 m/s^2
Modulus of rigidity G	= 0.8 X 10^{11} N/m^2
Diameter of disc D	= 0.19 m
Diameter of shaft d	= 0.003 m
Weight of disc W	= ______ kg

4.2 Observation Table:

S. No.	L (m)	n	t (s)
1			
2			
3			

4.3 Calculations:

$$I_p = \frac{\pi}{32} d^4, \text{ (m}^4\text{)}$$

$$I = \frac{W \times D^2}{8} \text{ (kg m}^2\text{)}$$

$$K_t = \frac{G \times I_p}{L} \text{ (Nm)}$$

$$T_{theo} = 2\pi \sqrt{\frac{I}{K_t}}, \text{ (s)}$$

$$T_{act} = \frac{t}{n} \text{ (s)}$$

$$f_{theo} = \frac{1}{T_{theo}}, \text{ (Hz)}$$

$$f_{act} = \frac{1}{T_{act}}, \text{ (Hz)}$$

Calculation Table

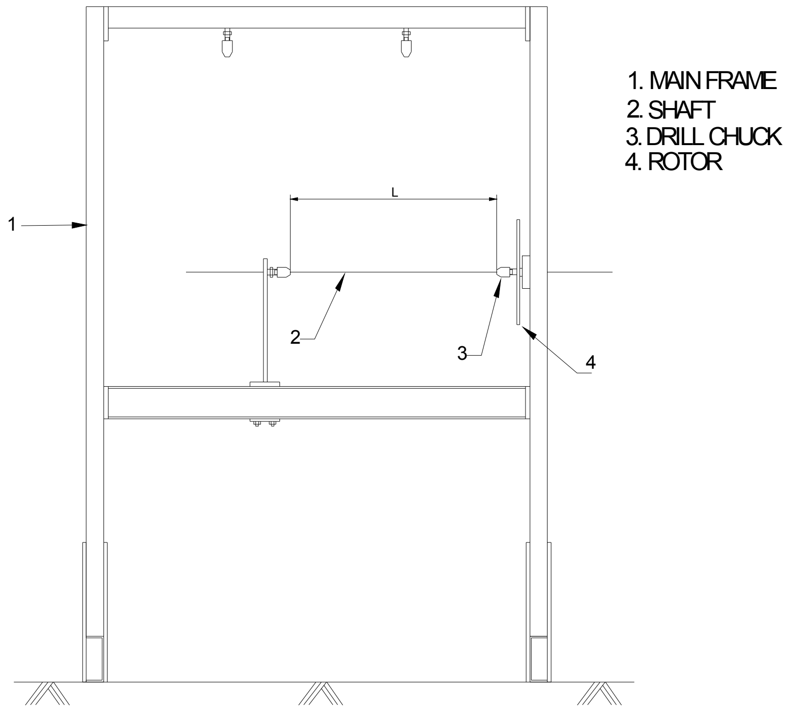
S. No.	L (m)	T_{theo} (S)	T_{act} (S)	F_{theo} (Hz)	F_{act} (Hz)
1					
2					
3					

5. NOMENCLATURE:

Nom	Column Heading	Units	Type
D	Diameter of disc	m	Given
d	Diameter of shaft	m	Given
f_{act}	Actual frequency	Hz	Calculated
f_{theo}	Theoretical frequency	Hz	Calculated
G	Modulus of rigidity	N/m^2	Given
g	Acceleration due gravity	m/s^2	Given
I	Moment of inertia of disc	$Kg\ m^2$	Calculated
I_p	Polar Moment of inertia of shaft	m^4	Calculated
k_t	Torsional Stiffness	Nm	Calculated
L	Length of shaft	m	Measured
n	Number of oscillations	*	Measured
T_{act}	Actual time period	s	Calculated
T_{theo}	Theoretical time period	s	Calculated
t	Time required for n oscillations	s	Measured
W	Weight of disc	kg	Given

* Symbol represents unitless quantity

7. BLOCK DIAGRAM:



UNDAMPED VIBRATION OF SINGLE ROTOR SYSTEM

Undamped Torsional Vibration of Two rotor shaft system

1. Aim:

To study the Free Vibration of Two Rotor System and to determine the Natural Frequency of Vibration Theoretically & Experimentally.

2. Description:

In this experiment, two discs having different mass moments of inertia are clamped one at each of the shaft by means of collect and chucks. Attaching the cross lever weights can change Mass moment of inertia of any disc. Both discs are free to oscillate in ball bearing. This provides negligible damping during experiment.

3. Experimental Procedure:

3.1 Fix the shaft b/w the two rotors.

3.2 Rotate the rotors in opposite direction w.r.t each other.

3.3 Note down the time for 'n' oscillation.

3.4 Repeat the procedure with different equal masses attached to the ends of cross arm.

3.5 Complete the observation table given below.

4. Observation & Calculation:

4.1 Data:

Dia of disc A, D_A	= 0.225 m
Dia of disc B, D_B	= 0.190 m
Wt. of disc A, W_A	= _______ kg
Wt. of disc B, W_B	= _______ kg
Radius of fixation of the weight on the arm, R	= _______ m
Dia of shaft, d	= 0.003 m
Modulus of rigidity of shaft ,G	= 0.8×10^{11} N/m^2

4.2 Observation Table:

S. No.	n	t (s)	W_1 (Kg)	R (m)
1				
2				
3				

4.3 Calculations:

$$T_{act} = \frac{t}{n} \text{ , (s)}$$

$$I_p = \frac{\pi * d^4}{32} \text{ (m}^4\text{)}$$

$$k_t = \frac{G * I_p}{L} \text{ (Nm)}$$

$$I_A = \frac{W_A * D_A^{\ 2}}{8} \text{ (kgm}^2\text{)}$$

$$I_B = \frac{W_B * D_B^{\ 2}}{8} + \frac{2W_1 * R^2}{8} \text{ (kgm}^2\text{)}$$

$$T_{theo} = 2 * \pi \sqrt{\frac{I_A * I_B}{k_t (I_A + I_B)}} \text{ (s)}$$

$$f_{Theo} = \frac{1}{T_{theo}} \text{ (Hz)}$$

$$f_{act} = \frac{1}{T_{act}} \text{ (Hz)}$$

Calculation Table

S. No.	$T_{theo.}$ (s)	F_{theo} (Hz)	T_{act} (s)	F_{act} (Hz)
1				
2				
3				

5. NOMENCLATURE:

Nom	Column Heading	Units	Type
D_A	diameter of disc A	m	Given
D_B	Diameter of disc B	m	Given
d	Diameter of shaft	m	Given
f_{act}	Actual frequency	Hz	Calculated
f_{theo}	Theoretical frequency	Hz	Calculated
G	Modulus of rigidity of shaft	N/m^2	Given
g	Acceleration due gravity	m/s^2	Given
I_A	Moment of .Inertia of disc A	kgm^2	Calculated
I_B	Moment of .Inertia of disc B (With weight on cross arm)	kgm^2	Calculated
I_p	Polar moment of inertia	m^4	Calculated
k_t	Torsional Stiffness	Nm	Calculated
L	Length of shaft	m	Measured
n	number of oscillations	*	Measured
R	Radius of fixation of the weight on the arm.	m	Given
T_{act}	Actual time period	s	Calculated
T_{theo}	Theoretical time period	s	Calculated
t	Time required for n oscillation	s	Measured
W_1	Weight attached to the cross arm.	kg	Measured
W_A	weight of disc A	kg	Given
W_B	weight of disc B	kg	Given

* Symbol represents unitless quantity

Undamped Free Vibration of Equivalent Spring mass system

1. AIM:

To study the undamped force vibration of equivalent spring mass system, and find the frequency of undamped force vibration of equivalent spring mass system.

2. DESCRIPTION:

The equipment is designed to study free damped vibration. It consists of rectangular beam supported at one end by a trunion pivoted in ball bearing. The bearing housing is fixed to the side member of the frame. The other end of beam is supported by the lower end of helical spring; upper end of the spring is attached to screw, which engages with screwed hand wheel. The screw can be adjusted vertically in any convenient position and can be clamped with the help of lock nut.

The exciter unit can be mounted at any position along the beam. Additional known weights may be added to the weight platform under side exciter.

3. EXPERIMENTAL PROCEDURE:

3.1 Support one end of beam in the slot of trunion and clamp it by means of screw.

3.2 Attach the other end of the beam to lower end of spring.

3.3 Adjust the screw to which the spring is attached with the help of hand wheel such that beam is horizontal in position.

3.4 Weight the exciter assembly along with discs, and weights platform.

3.5 Clamp the assembly at any convenient position.

3.6 Measure the distance L1 of the assembly from pivot. Allow system to vibrate freely.

3.7 Adjust the pen holder so that it makes contact with graph paper.

3.8 Switch on the motor.

3.9 Switch on the graph recorder.

3.10 Note down the oscillations for particular time e.g.10 s.

3.11 Repeat the experiment for different weights.

3.12 Repeat the experiment varying L_1.

4. OBSERVATION & CALCULATION:

4.1 DATA:

Acceleration due to gravity g	= 9.81 m/s^2
Weight of exciter assembly along with wt. platform W	= ______ kg
Length of beam L	= ______ m
Stiffness of Spring , K	= 9123 N/m

4.2 OBSERVATIONS:

S. No.	w (kg)	L_1 (m)	n	t (s)
1				
2				
3				

4.3 CALCULATIONS:

$$m = W + w \text{ (kg)}$$

$$m_e = m\left[\frac{L_1^2}{L^2}\right] \text{ (kg)}$$

$$T_{theo} = 2\pi\sqrt{\frac{m_e}{K}}, \text{ (s)}$$

$$T_{act} = \frac{t}{n}, \text{ (s)}$$

$$f_{theo} = \frac{1}{T_{theo}}, \text{ (Hz)}$$

$$f_{act} = \frac{1}{T_{act}}, \text{ (Hz)}$$

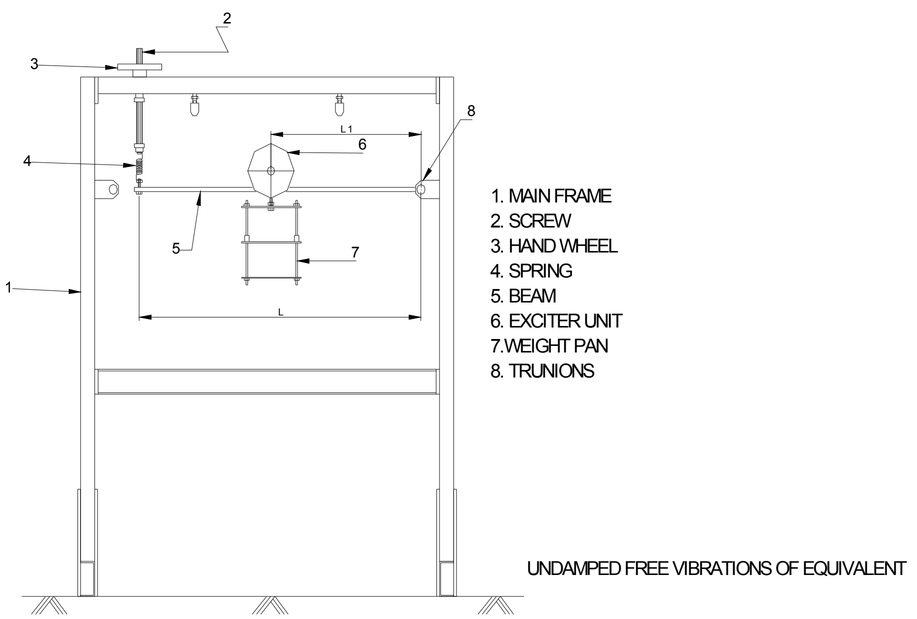
CALCULATION TABLE:				
S. No.	T_{act} (s)	f_{act} (Hz)	T_{theo} (s)	f_{theo} (Hz)
1				
2				
3				

5. NOMENCLATURE:

Nom	Column Heading	Units	Type
f_{act}	Actual frequency of equivalent spring mass system	Hz	Calculated
f_{theo}	Theo. frequency of equivalent spring mass system	Hz	Calculated
g	Acceleration due to gravity	m/s^2	Given
k	Stiffness of spring.	kg/m	Calculated
L_1	Distance of exciter from pivot.	m	Measured
L	Length of beam.	m	Measured
m	Total mass of exciter assembly	kg	Calculated
m_e	Equivalent mass exciter assembly	kg	Calculated
n	No. of oscillations as from graph	*	Measured
T_{act}	Actual time period	s	Calculated
T_{theo}	Theoretical time period	s	Calculated
t	Time taken for 'n' oscillations	s	Measured
W	Weight of exciter assembly along with wt. platform	kg	Given
w	Weight attached on exciter assembly	kg	Measured

* Symbol represents unitless quantity

6. BLOCK DIAGRAM:



Forced damped Vibration of Equivalent Spring Mass System

1. AIM:

To study the Forced damped Vibration of Equivalent Spring Mass System. And find the frequency of forced damped equivalent spring mass system.

2. DESCRIPTION:

It is similar to that described for expt. No. 9. The exciter unit is coupled to D.C. variable speed motor. RPM of motor can be varied with the speed control unit. Speed of rotation can known from the RPM indicator on control panel. It is necessary to connect the damper unit to the exciter. Amplitude of vibration can be recorded on strip chart recorder.

3. DAMPING ARRANGEMENT:

3.1 Close the one hole of damper for light damping.

3.2 Close the two holes of damper for medium damping.

3.3 Close all the three holes of damper for heavy damping.

4. EXPERIMENTAL PROCEDURE:

4.1 Arrange the set-up as shown in the fig.10.

4.2 Start the motor and allow the system to vibrate.

4.3 Wait for 1 to 2 minutes for amplitude to build the particular forcing frequency.

4.4 Adjust the position of strip chart recorder. In that way that the pen should be in contact with graph paper.

4.5 Press the graph recorder button.

4.6 Note down the no. of oscillation for a specific time.

4.7 Repeat the experiment by changing damping.

4.8 Repeat the experiment for different RPM.

5. OBSERVATION & CALCULATION:

OBSERVATIONS:

N=________RPM

5.1 OBSERVATION TABLE:

S. No.	n	t (s)
1		
2		
3		

5.2 CALCULATIONS:

$$T_{act} = \frac{t}{n}, \text{ (s)}$$

$$f_{act} = \frac{1}{T_{act}}, \text{ (Hz)}$$

CALCULATION TABLE:

Sr. No.	f_a (Hz)	A (mm)
1		
2		
3		

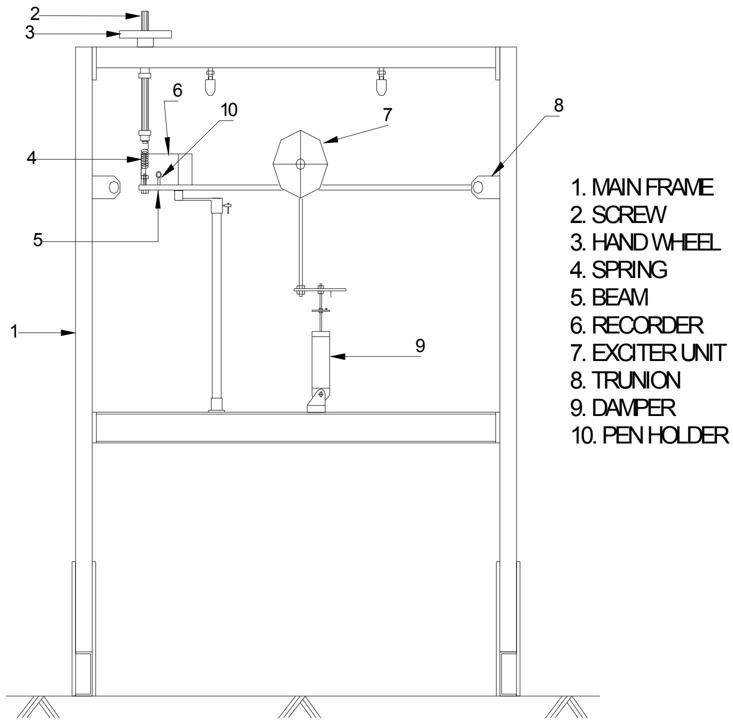
Plot the graph b/w Amplitude and frequency for different damping.

6. NOMENCLATURE:

Nom	Column Heading	Units	Type
A	Amplitude of oscillations	mm	Measured
f_a	Frequency.	Hz	Calculated
N	Speed of motor	RPM	Measured
n	No. of oscillations from graph.	*	Measured
t	Time for ‘n’ oscillations.	s	Measured

* Symbol represents unitless quantity

7. BLOCK DIAGRAM:



FORCED DAMPED VIBRATION OF
EQUIVALENT MASS SYSTEM
FIG. 10

JOURNAL BEARING APPARATUS

Journal Bearing Apparatus

1. Objective:

To study the pressure profile of lubricating oil at various conditions of load and speed.

2. Aim:

To plot the Cartesian pressure curve.

3. Introduction:

This apparatus helps to demonstrate and study the effect of important variables such as speed, viscosity and load, on the pressure distribution in a Journal bearing.

The portion of a shaft, which revolves in the bearing and is subjected to load at right angle to the axis of shaft, is known as Journal. The whole unit consisting of journal and its supporting part is known as Bearing. The whole arrangement is known as Journal bearing.

4. Theory:

Journal Bearing Apparatus is designed on the basis of hydrodynamic bearing action used in practice. In a simple journal bearing the bearing surface is bored out to a slightly larger diameter than that of the journal. Thus, when the journal is at rest, it makes contact with the bearing surface along a line, the position of which is determined by the line of action of the external load. If the load is vertical as in fig. 3. The line of contact is parallel to the axis of the journal and directly below that axis. The crescent shaped space between the journal and the bearing will be filled with lubricant. When rotation begins the first tendency is for the line of contact to move up the bearing surface in the opposite direction to that of rotation as shown at Fig 2. When the journal slides over the bearing, the true reaction of the bearing on the journal is inclined to the normal to the two surfaces at the friction angle θ and this reaction must be in line with the load. The layer of lubricant immediately adjacent to the journal tends to be carried round with it, but is scraped off by the bearing, so that a condition of boundary lubrication exists between the high spots on the journal and bearing surfaces which are actually in contact.

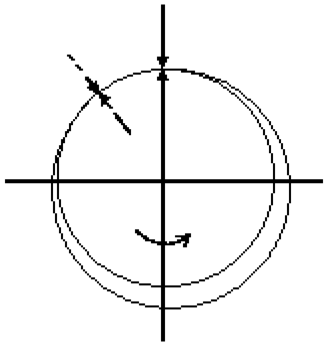


Fig 1

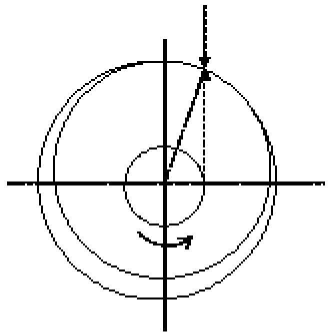


Fig 2

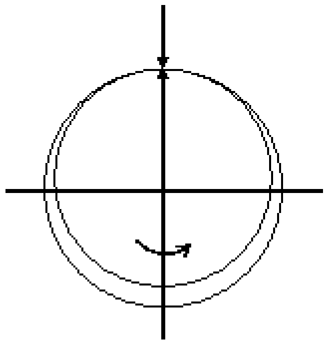


Fig 3

As the speed of rotation of the journal increases, the viscous force which tends to drag the oil between the surfaces also increases, and more and more of the load is taken by the oil film in the convergent space between the journal and bearing. This gradually shifts the line of contact round the bearing in the direction of motion of the journal. Due to this two surfaces are completely separated and the load is transmitted from the journal to the bearing by the oil. The film will only break through if it is possible for the resultant oil pressure to be equal to the load, and to have same line of action. The pressure of the oil in the divergent part of the film may fall below that of the atmosphere, in which case air will leak in from the ends of the bearing. Assuming that the necessary conditions are fulfilled and that the complete film is formed, the point of nearest approach of journal to the bearing will by this time have moved to the position shown Figure 1.

5. Description:

The apparatus consists of a M.S. bearing mounted freely on a steel journal shaft. This journal shaft is coupled to a DC motor. Speed regulator is provided with the set-up to control the speed of journal shaft. The journal bearing has Compound pressure gauge measure pressure at different point. The weight is hanged on the centre of the bearing. One oil inlet mounted on journal to supply lubricating oil. One ball valve is also provided to release the trap air. An oil reservoir accompanies the set-up to store the sufficient oil for experiment. This reservoir supplies oil to the bearing.

6. Experimental Procedure:

1 Close both the valve V_1 and V_2.

2 Fill the lubricating oil in the fuel tank.

3 Open the valve V_1.

4 . Switch on the main supply.

5 . Start the motor.

6 . Set some speed of motor with help of variac.

7 . Open the valve V_2 for removing air.

8 . When the air bubbles are removed from pipe close the valve V_2.

9 Apply load on the journal shaft.

10 Note the readings of pressure at different rotation(angle) of the journal.

11 Repeat the experiment for different load.

12 Repeat the experiment for difference RPM.

7. Observation & Calculation:

Observation Table:	
Total vertical load on the journal W	= ________ kg
Revolutions per minute N	= ______ RPM

Sr. No.	θ (Deg)	P (kg/cm^2)
1		
2		
3		
4		
5		

Plot a graph between θ vs. P

8. NOMENCLATURE:

Nom	Column Heading	Units	Type
N	Revolutions per minute	RPM	Measured
P	Nominal bearing pressure	kg/cm^2	Measured
W	Total vertical load on the journal	kg	Measured
θ	Angle	Degree	Measured

9. PRECAUTION & MAINTENANCE INSTRUCTIONS:

.1 Never run the apparatus if power supply is less than 200 volts & above than 230 volts.

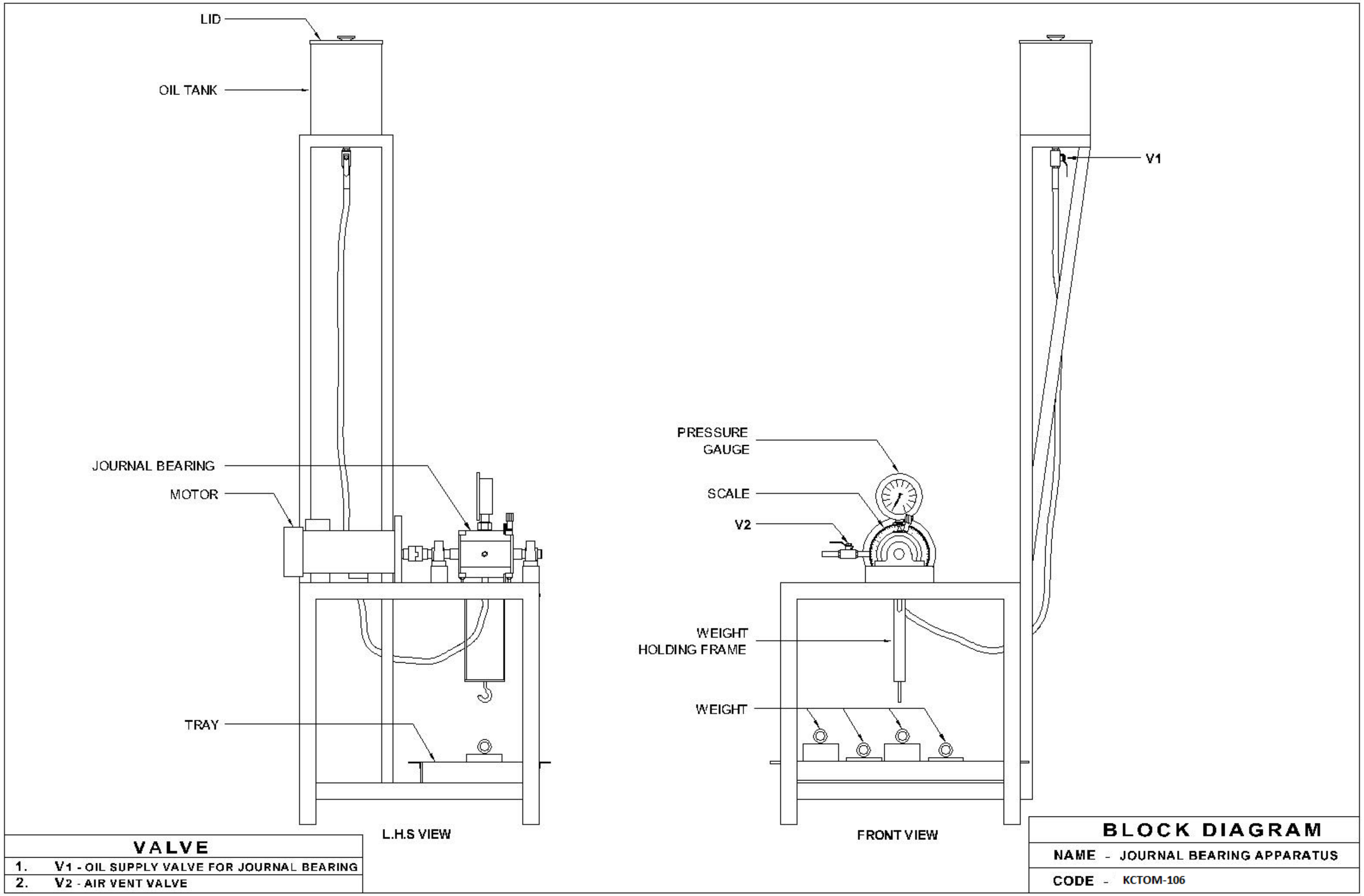
.2 Increase the speed gradually.

3 Do not run the journal & bearing without lubricant oil.

4 Use clean lubricant oil.

5 Always keep apparatus free from dust.

BLOCK DIAGRAM:



UNIVERSAL GOVERNOR APPARATUS

1. AIM:

1.1 Determination of characteristics curves of sleeve position against speed for all governors.

1.2 Determination of characteristics curves of radius of rotation against controlling force for all governors.

2. Introduction

The function of a governor is to regulate the mean speed of an engine, when there are variations in loads e.g. when load on an engine increase or decrease, obviously its speed will, respectively decrease or increase to the extent of variation of load. This variation of speed has to be controlled by the governor, within small limits of mean speed. This necessitates that when the load increase and consequently the speed decreases, the supply of fuel to the engine has to be increased accordingly to compensate for the loss of the speed, so as to bring back the speed to the mean speed. Conversely, when the load decreases and speed increases, the supply of fuel has to be reduced.

3. THEORY:

The function of the governor is to maintain the speed of an engine within specific limit whenever there is a variation of load. The governor should have its mechanism working in such a way, that the supply of fuel is automatically regulated according to the load requirement for maintaining approximately a constant speed. This is achieved by the principle of centrifugal force. The centrifugal type governors are based on the balancing of centrifugal force on the rotating balls by an equal and opposite radial force, known as the controlling force.

4. Description:

The apparatus is designed to perform experiments on following governors:-

5.1 Watt Governor

5.2 Porter Governor

5.3 Proell Governor

5.4 Hartnell Governor

The drive unit consists of a DC motor connected to the shaft through V belt. Motor and shaft are mounted on a rigid MS base frame in vertical position. The spindle is supported in ball bearing.

The optional governor mechanism can be mounted on spindle. The speed control unit controls the precise speed and speed of the shaft is measured with the help of tachometer. A counter sunk has been provided at the topmost bolt of the spindle. A graduated scale is fixed to measure the sleeve lift.

6. Experimental Procedure:

6.1 Starting Procedure:

1 Assemble the governor to be tested.

2 Complete the electrical connections.

3 Switch ON the main power.

4 Note down the initial reading of pointer on the scale.

5 Switch ON the rotary switch.

6 Slowly increase the speed of governor with help of variac until the sleeve is lifted from its initial position.

7 Let it run for 2 minutes so that lift of governor stabilized.

8 Note down the sleeve’s height.

9 Note down the RPM.

10 Increase the speed of governor in steps to get the different positions of sleeve lift at different RPM.

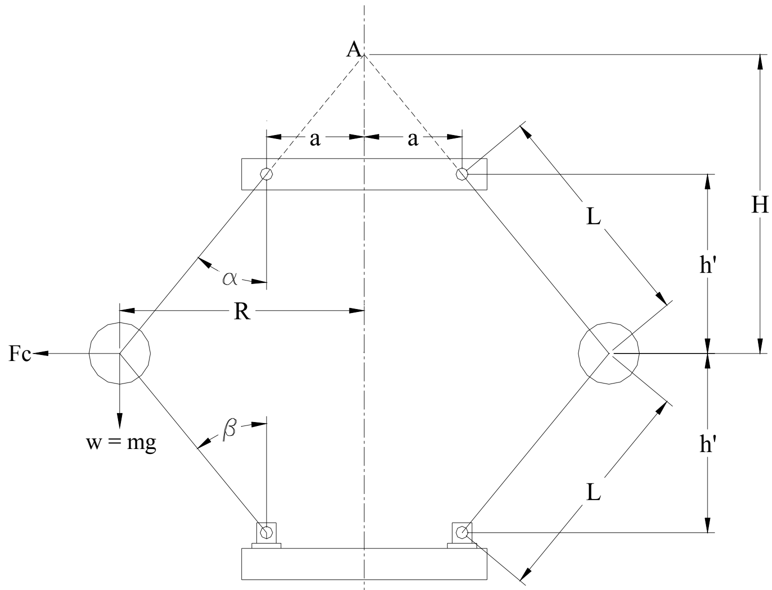
6.2 Closing Procedure:

1 Decrease the speed of governor gradually by bringing the variac to zero position and then switch off the motor.

2 Switch OFF the motor.

WATT GOVERNOR

It is assumed that mass of the arms; links & sleeve are negligible in comparison with the mass of the balls and are neglected in the analysis.



WATT GOVERNOR

Figure 1

In Figure 1, taking moments about point A

$$F_c * H = m * g * R$$

i.e. $m * \omega^{2*} * R * H = m * g * R$

Therefore, $H = \dfrac{g}{\omega^2}$

Also $\omega = \dfrac{2\pi N}{60}\, radian / \text{sec}$

Therefore, $H = \dfrac{g}{\left(\dfrac{2\pi N}{60}\right)^2}$

$$N = \sqrt{\frac{91.2g}{H}}$$

Observation & Calculation:

8.A.1 Data:	
Length of link L	= 106 mm
Initial height h'	= 95 mm
Weight of balls on one side, w	= 1.5 kg
Acceleration due to gravity g	= 9.81m/sec^2
Distance of pivot to center of spindle a	= 50 mm

Observation:

X'' = ______ mm

Observation Table:

S.No	X' (mm)	N_{act} (RPM)
1		
2		
3		
4		

Calculations:

$$X = (X' - X'') \text{ (mm)}$$

$$\omega = \frac{2 \times \pi \times N_{act}}{60} \text{ (rad/s)}$$

$$h = \left\{ h' - \left(\frac{X}{2} \right) \right\} \text{ (mm)}$$

$$\alpha = \cos^{-1}\left(\frac{h}{L} \right)$$

$$H = \left\{ \left(\frac{a}{\tan \alpha} \right) + h \right\} \text{ (mm)}$$

$$N_{theo} = \frac{60}{2\pi} \sqrt{\frac{g \times 1000}{H}} \text{ (RPM)}$$

$$R = \{a + (L \sin \alpha)\} \text{(mm)}$$

$$F_{act} = \frac{w \times R \times \omega^2}{g \times 1000} \text{(kg)}$$

$$F_{theo} = \frac{w \times R}{H} \text{(kg)}$$

Plot The Graph For Following Curves:-

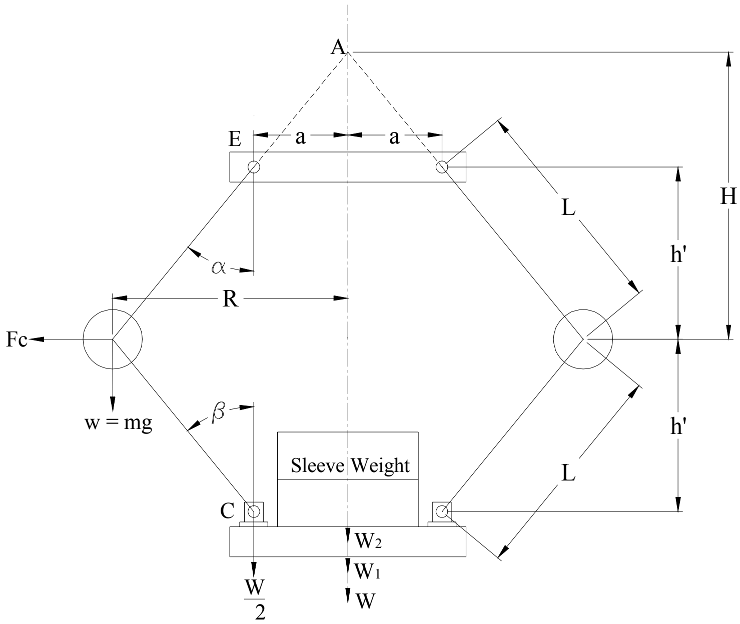
1. R/H vs N_{theo}
2. R/H vs N_{act}
3. X vs N_{theo}
4. X vs N_{act}

Nomenclature:

Nom	Column Heading	Units	Type
a	Distance of pivot to center of spindle	mm	Given
F_{theo}	Theoretical centrifugal force	kg	Calculated
F_{act}	Actual centrifugal force	kg	Calculated
g	Acceleration due to gravity	m/s^2	Given
H	Height of governor	mm	Calculated
h	Final height of governor	mm	Calculated
h'	Initial height of governor	mm	Given
L	Length of link	mm	Given
N_{theo}	Theoretical speed of governor	RPM	Calculated
N_{act}	Actual speed of governor	RPM	Measured
R	Radius of rotation	mm	Calculated
w	Weight of balls on one side	kg	Given
X	Lift of Sleeve	mm	Calculated
X'	Height of sleeve at N rpm	mm	Measured
X''	Initial reading of pointer on sleeve	mm	Measured
ω	Angular velocity	rad/sec	Calculated
α	Angle of inclination of upper link to vertical	Degree	Calculated

PORTER GOVERNOR

Porter Governor differs from Watt's Governor only in extra sleeve weight, else is similar to Watt Governor.



PORTER GOVERNOR
Figure 2

OBSERVATION & CALCULATION:

DATA:	
Length of link L	= 106 mm
Initial height $h^{'}$	= 95 mm
Weight of balls on one side, w	=1.5 kg
Acceleration due to gravity g	= 9.81m/s^2
Distance of pivot to center of spindle a	= 50 mm
Weight of cast iron sleeve W_1	= 2.120 kg
Weight of arms on one side W_3	= 0.177 kg

OBSERVATION:

X'' = ______ mm

W_2 = ______ kg

OBSERVATION TABLE:

S.No.	X' (mm)	N_{act} (RPM)
1		
2		
3		
4		

CALCULATIONS:

$$X = (X' - X'') \text{ (mm)}$$

$$\omega = \frac{2 \times \pi \times N}{60} \text{ (rad/s)}$$

$$h = \left\{ h' - \left(\frac{X}{2} \right) \right\} \text{(mm)}$$

$$\alpha = \cos^{-1}\left(\frac{h}{L} \right)$$

$$H = \left\{ \left(\frac{a}{\tan \alpha} \right) + h \right\} \text{ (mm)}$$

$$W = W_1 + W_2 + W_3 \text{ (kg)}$$

$$N_{theo} = \frac{60}{2\pi} \sqrt{\left(\frac{w + W}{w} \times \frac{g\,x\,1000}{H} \right)} \text{ (RPM)}$$

$$R = \{a + (L \sin \alpha)\} \text{(mm)}$$

$$F_{act} = \frac{w \times R \times \omega^2}{g \times 1000} \text{ (kg)}$$

$$F_{theo} = [(w + W \quad) \times \tan \alpha \quad] \text{(kg)}$$

Plot The Graph For Following Curves:-

1 R/H vs N_{theo}

2 R/H vs N_{act}

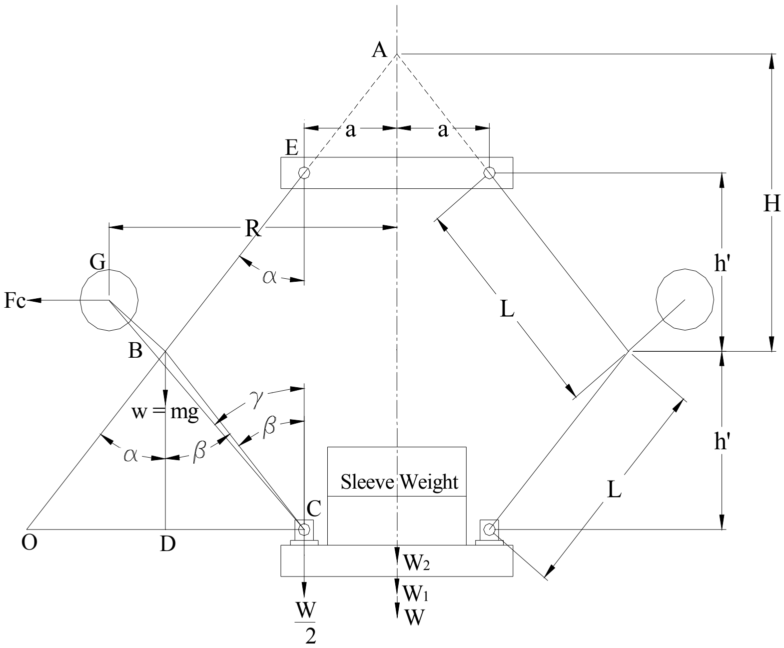
3 X vs N_{theo}

4 X vs N_{act}

Nomenclature:

Nom	Column Heading	Units	Type
a	Distance of pivot to center of spindle	mm	Given
F_{act}	Actual centrifugal force	kg	Calculated
F_{theo}	Theoretical centrifugal force	kg	Calculated
g	Acceleration due to gravity	m/s^2	Given
H	Height of governor	mm	Calculated
h	Final height	mm	Calculated
h’	Initial height	mm	Given
L	Length of link	mm	Given
N_{act}	Actual speed of governor	RPM	Measured
N_{theo}	Theoretical speed of governor	RPM	Calculated
R	Radius of rotation	mm	Calculated
w	Weight of balls on one side	kg	Given
W_1	Weight of cast iron sleeve	kg	Given
W_2	Dead weight applied on sleeve	kg	Measured
W_3	Weight of arms on one side	kg	Given
W	Total dead weight on sleeve	kg	Calculated
X	Lift of Sleeve	mm	Calculated
X’	Height of sleeve at N rpm	mm	Measured
X’’	Initial reading of pointer on sleeve	mm	Measured
ω	Angular velocity	rad/s	Calculated
α	Angle of inclination of upper link to vertical	Degree	Calculated

Proell Governor



PROELL GOVERNOR
Figure 3

Observation & Calculation:

8.C.1Data:	
Length of link L	= 106 mm
Initial height h'	= 100 mm
Initial Angle α'	= 17.753°
Initial Angle γ'	= 23.611°
Weight of balls on one side,w	= 1 kg
Acceleration due to gravity g	= 9.81m/s^2
Distance of pivot to center of spindle a	= 50 mm
Displacement between points G & C of lower link GC	= 155.33 mm
Weight of cast iron sleeve W_1	= 2.120 kg
Weight of arms on one side W_3	= 0.156 kg

Observation:

X'' = ______ mm

W_2 = _______kg

OBSERVATION TABLE:

S.No.	X' (mm)	N_{act} (RPM)
1		
2		
3		
4		

CALCULATIONS:

$$X = (X' - X'')\ \text{(mm)}$$

$$\omega = \frac{2 \times \pi \times N}{60}\text{, rad/sec}$$

$$h = \left\{h' - \left(\frac{X}{2}\right)\right\}\text{(mm)}$$

$$\alpha = \cos^{-1}\left(\frac{h}{L}\right)$$

$$H = \left\{\left(\frac{a}{\tan\alpha}\right) + h\right\}\ \text{(mm)}$$

$$\gamma = [(\alpha - \alpha') + \gamma']$$

$$R = \{a + (GC \sin\gamma\ )\ \}\text{(mm)}$$

$$F_{act} = \frac{w \times R \times \omega^2}{g \times 1000}\text{(kg)}$$

$$DG = (GC \cos\gamma)\quad \text{(mm)}$$

$$W = W_1 + W_2 + W_3\ \text{(kg)}$$

$$F_{theo} = \left(\frac{h}{DG} \times \frac{\tan\alpha}{\cos\gamma}\right) \times (W + w) - (w \times \tan\alpha)$$

$$N_{theo} = \frac{60}{2\pi} \times \sqrt{\left(\frac{F_{theo} \times g \times 1000}{w \times R}\right)}\ \text{(RPM)}$$

Plot The Graph For Following Curves: -

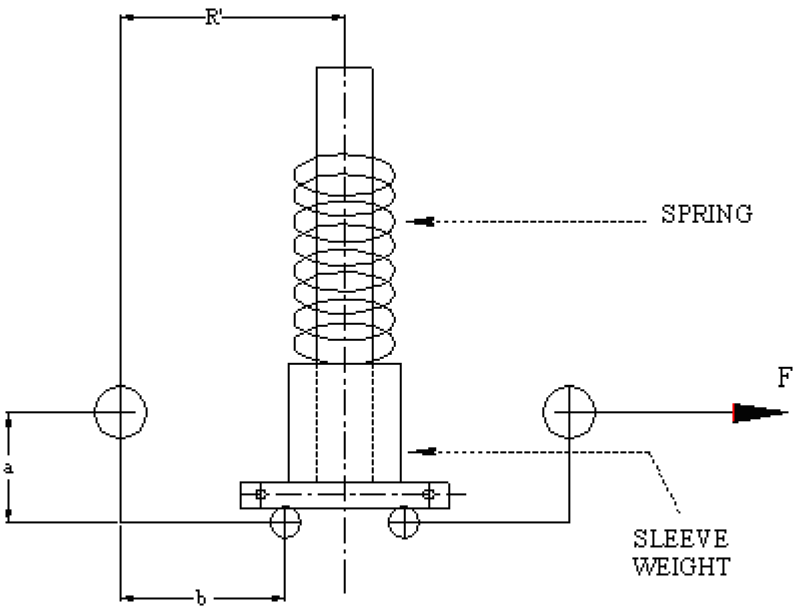
1. R/H vs N_{theo}
2. R/H vs N_{act}
3. Sleeve (X) vs N_{theo}
4. Sleeve (X) vs N_{act}

Nomenclature:

Nom	Column Heading	Units	Type
a	Distance of pivot to center of spindle	mm	Given
F_{act}	Actual centrifugal force	kg	Calculated
F_{theo}	Theoretical centrifugal force	kg	Calculated
GC	Displacement between points G & C of lower link	mm	Given
g	Acceleration due to gravity	m/s^2	Given
H	Height of governor	mm	Calculated
h	Final height	mm	Calculated
h'	Initial height	mm	Given
L	Length of link	mm	Given
N_{act}	Actual speed of governor	RPM	Measured
N_{theo}	Theoretical speed of governor	RPM	Calculated
R	Radius of rotation	mm	Calculated
W	Total weight on governor	kg	Calculated
W_1	Weight of cast iron sleeve	kg	Given
W_2	Dead weight applied on sleeve	kg	Measured
W_3	Weight of arms on one side	kg	Given
w	Weight of balls on one side	kg	Given
X	Lift of Sleeve	mm	Calculated
X'	Height of sleeve at N rpm	mm	Measured
X''	Initial reading of pointer on sleeve	mm	Measured
ω	Angular velocity	rad/s	Calculated
α'	Initial Angle of inclination of upper link to vertical	Degree	Given
γ'	Initial Angle of inclination of lower link to vertical	Degree	Given

α	Angle of inclination of upper link to vertical	Degree	Calculated
γ	Angle of inclination of lower link to vertical	Degree	Calculated
DG	Vertical distance b/w G and line OC	mm	Calculated

HARTNELL GOVERNOR



HARTNELL GOVERNOR
Figure 4

OBSERVATION & CALCULATION:

8.D.1DATA:	
Length of horizontal arm b	= 130 mm
Initial radius of rotation R'	= 186 mm
Weight of balls on one side w	= 0.74 kg
Acceleration due to gravity g	= 9.81m/sec^2
Length of vertical arm	= 75 mm
Weight of cast iron sleeve W_1	= 2.120 kg

OBSERVATION:

X'' = ______ mm

W_2 = ______kg

Observation Table:		
S.No.	**X' (mm)**	**N_{act} (RPM)**
1		
2		
3		
4		

Calculations:

$$X = (X' - X'')\ \text{(mm)}$$

$$R = \left(R' + X \times \frac{a}{b}\right)\ \text{(mm)}$$

$$\omega = \frac{2\pi N_{act}}{60}\ \text{(rad/sec)}$$

$$F_c = \frac{w \times \omega^2 \times R}{g \times 1000}\ \text{(kg)}$$

$$W = W_1 + W_2\ \text{(kg)}$$

$$F_S = \left(2 \times F_c \times \frac{a}{b}\right) - W\ \text{(kg)}$$

$$s = 2 \times \left(\frac{a}{b}\right)^2 \times \left(\frac{F_c}{R - R'}\right)\ \text{(kg/mm)}$$

Plot Graph For Following Curve: -

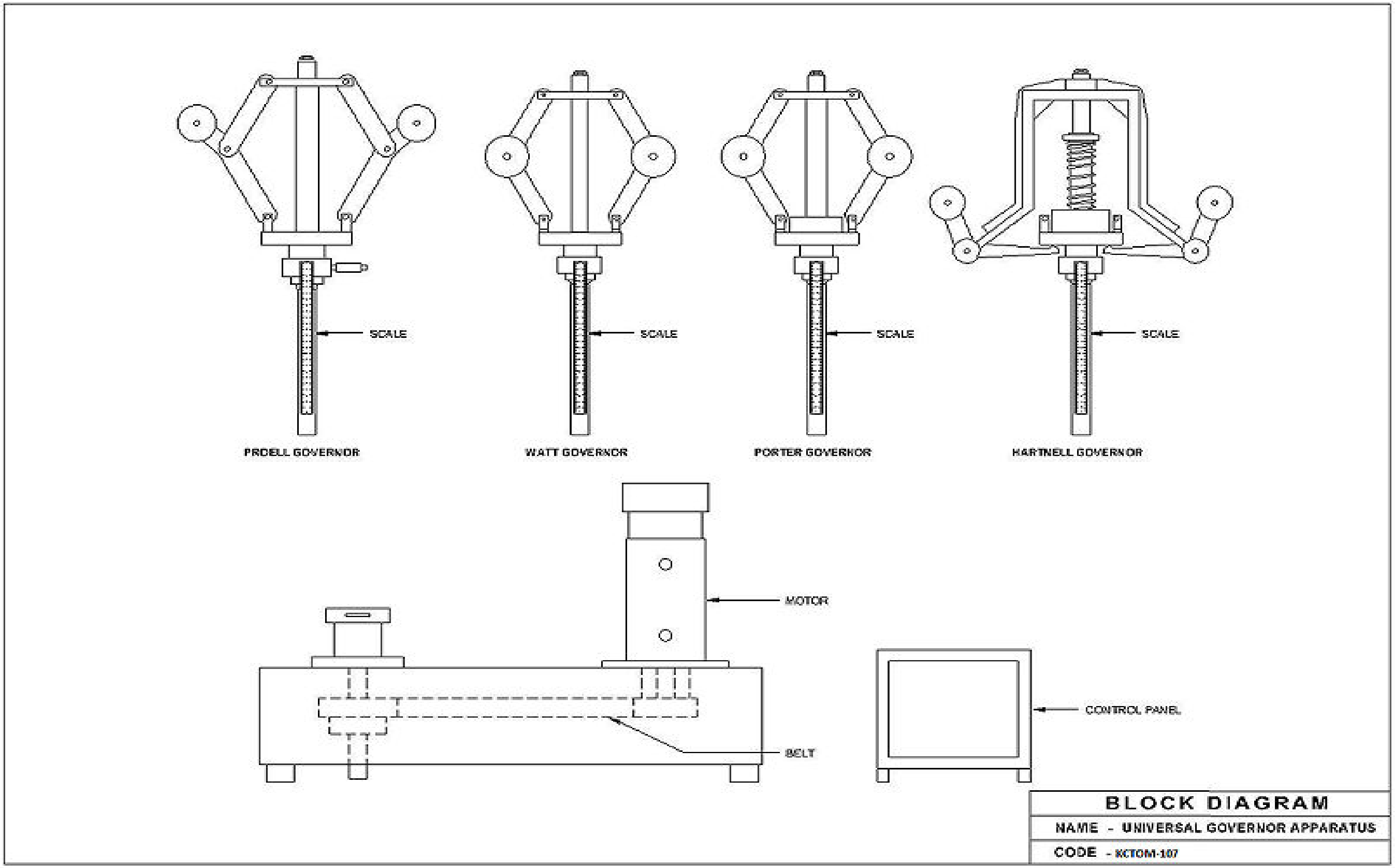
X vs. N_{act}

Nomenclature:

Nom	Column Heading	Units	Type
a	Length of vertical arm	mm	Given
b	Length of horizontal arm	mm	Given
F_c	Centrifugal force	kg	Calculated
F_S	Force exerted by spring	kg	Calculated

g	Acceleration due to gravity	m/sec^2	Given
N_{act}	Actual speed of governor	RPM	Measured
R	Radius of rotation	mm	Calculated
R'	Initial radius of rotation	mm	Given
s	Stiffness of spring	kg/mm	Calculated
W	Total dead weight on sleeve	kg	Calculated
W_1	Weight of cast iron sleeve	kg	Given
W_2	Dead weight applied on sleeve	kg	Measured
w	Weight of balls on one side	kg	Given
X	Lift of Sleeve	mm	Calculated
X'	Height of sleeve at N rpm	mm	Measured
X''	Initial reading of pointer on sleeve	mm	Measured
ω	Angular velocity	rad/sec	Calculated

Block Diagram:



CAM ANALYSIS APPARATUS

CAM ANALYSIS APPARATUS

1. OBJECTIVE:

1.1 To study the various cam and follower pairs.

1.2 To study the effect of follower weight on bounce.

1.3 To study the effect of spring compression on bounce.

2. AIM:

2.1 To find out the angular displacement of various cam follower pairs.

2.2 To plot the n - θ (follower displacement vs. angle of cam rotation) curves for different cam follower pairs.

2.3 To study the effect on cam by changing compression of spring, follower weights, & cam speed.

3. INTRODUCTION:

A cam may be defined as a rotating or a reciprocating element of a mechanism which imparts a rotating, reciprocating or oscillating motion to another element termed as follower.

4. THEORY:

CAM MECHANISM AND ITS USES:

In most of the cases the cam is connected to a frame, forming a turning pair and the follower is connected to the frame to form a sliding pair. The cam and the follower form a three- link mechanism of the higher pair type. The three links of the mechanism are:-

(a) The cam, which is the driving link and has a curved or a straight contact surface

(b) The follower, which is the driven link, and it gets motion by contact with the surface of the cam.

(c) The frame, which is used to support the cam and guide the follower.

The cam mechanism is used in clocks, printing machines, automatic screw cutting machines, internal combustion engines for operating valves, shoe-making machinery etc.

5. DESCRIPTION:

The machine is a motorized unit a camshaft is driven by a D.C. Motor. The shaft runs in a double ball bearing. At the end of the cam shaft a cam can be easily mounted the type of the follower can be changed to suit the cam under test. A graduated circular protractor is fitted coaxial with the shaft and a dial gauge can be fitted to note the follower displacement for the angle of cam rotation. A spring is used to provide controlling force to the system. Weights on the follower rod can be adjusted as per the requirements. An arrangement is provided to vary the speed of camshaft. The machine is particularly very useful for testing the cam performance for jump phenomenon during operation. The machine clearly shows the effect of change of inertia forces on jump action of cam follower during the operation. It is used for testing various cam and follower pairs, i.e.

5.1 An eccentric arc cam with Knife edge follower.

5.2 Tangent cam with roller follower.

5.3 Circular cam with Mushroom follower.

6. UTILITIES REQUIRED:

6.1 Electricity Supply: Single phase, 220 V AC, 50 Hz, 5-15 Amp. combined socket with earth connection. Earth voltage should be less than 5 volts.

6.2 Stroboscope.

6.3 Bench Area Required: 0.6 m x 0.33 m.

7. EXPERIMENTAL PROCEDURE:

7.1 Fix the required cam & follower assembly on the apparatus.

7.2 Fix the dial gauge at top of follower shaft to get the follower displacement.

7.3 To find out the angular displacement, rotate the cam manually.

7.4 Note the angular displacement of cam and vertical displacement of the follower with the help of protractor & dial gauge respectively.

7.5 Draw the n - θ (follower displacement Vs rotation of cam) curve.

7.6 Now remove the dial gauge from the follower shaft.

7.7 Switch on the main power supply.

7.8 Slowly increase the rpm of the motor with the help of dimmerstat provided at the control panel & check the jump of the follower with the help of stroboscope.

7.9 If jump of the follower is not appears then again adjust the speed of the motor. At certain speed jump of the follower will occur. When jump occurs the follower makes a good thumbing sound on cam surface. This speed is the jump speed.

7.10 Decrease the speed of the motor to the minimum value.

7.11 Put some weight on the follower shaft plate and keep the spring tension constant.

7.12 Increase the speed of the motor and find out the jump speed.

7.13 Now vary the weight on the follower shaft plate and get the two or three jump speeds of the follower at constant spring tension.

7.14 Plot the curve for follower weight Vs jump speed.

7.15 Now get the jump speed by varying the spring tension and keeping the follower weight constant.

7.16 Repeat the procedure for other two cam & follower assemblies.

8. Observation & Calculation:

Observation Table:1

Sr. No.	Eccentric Cam with Knife Edge Follower		Tangent Cam with Roller Follower		Circular Cam with Mushroom Follower	
	θ (Degree)	n (mm)	θ (Degree)	n (mm)	θ (Degree)	n (mm)
1						
2						
3						
4						
5						

Plot the curve n vs θ for Eccentric Cam with knife Edge follower.

Plot the curve n vs θ for Tangent cam with Roller follower.

Plot the curve n vs θ for Circular cam with Mushroom follower.

OBSERVATION TABLE:2						
Sr. No.	**Eccentric Cam with Knife Edge Follower**		**Tangent Cam with Roller Follower**		**Circular Cam with Mushroom Follower**	
	W (kg)	**N (RPM)**	**W (kg)**	**N (RPM)**	**W (kg)**	**N (RPM)**
1						
2						
3						
4						
5						

Plot the curve W vs N for Eccentric Cam with knife Edge follower.

Plot the curve W vs N for Tangent cam with Roller follower.

Plot the curve W vs N for Circular cam with Mushroom follower.

9. NOMENCLATURE:

Nom	Column Heading	Units	Type
N	Revolution per minute	RPM	Measured
n	Displacement	mm	Measured
W	Applied weight	kg	Measured
θ	Cam Angle	Degree	Measured

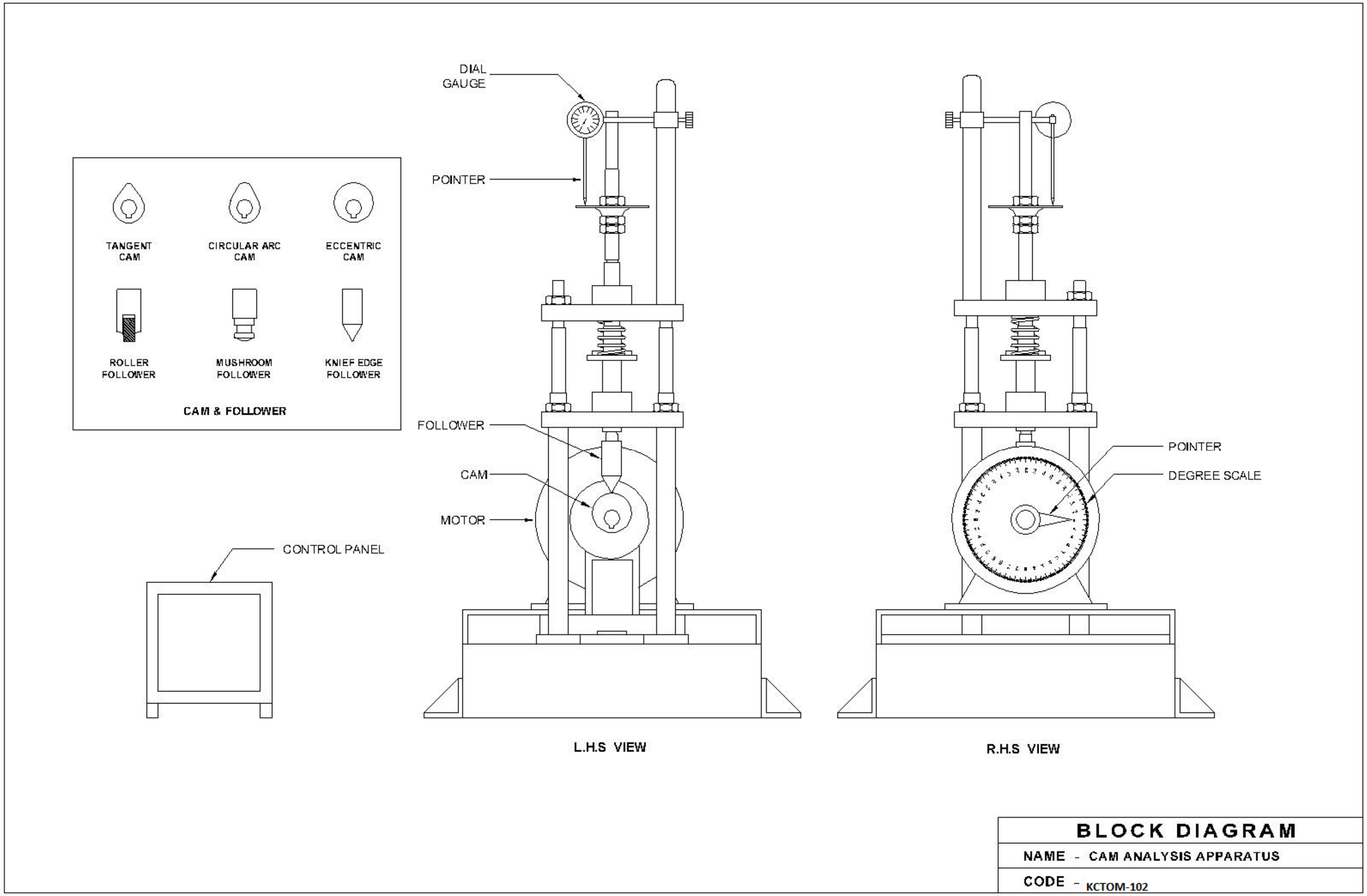
10. PRECAUTION & MAINTENANCE INSTRUCTIONS:

10.1 Always lubricate the cam before starting the apparatus.

10.2 Tighten all the nuts properly before starting the apparatus.

10.3 Increase the speed of the motor slowly.

BLOCK DIAGRAM:



CORIOLLI'S COMPONENT OF ACCELRATION APPARATUS

CORIOLLI'S COMPONENT OF ACCELERATION APPARATUS

1. AIM:

To determine the Coriolli's Component of Acceleration at various speeds of rotation and water flow rates.

2. INTRODUCTION:

The total acceleration of a point with respect to another point in a rigid link is the vector sum of its centripetal and tangential components. This holds true when the distance between two points is fixed and the relative acceleration of the two points on a moving rigid link has been considered. If the distance between two points varies, that is the second point which was stationary, now slides; the total acceleration will contain one additional component, known as Coriolli's component of acceleration.

3. THEORY:

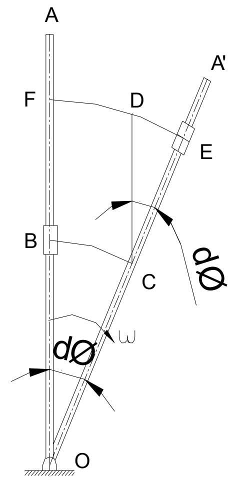
Mechanism (shown in fig) consisting translating pair i.e. blocks B, which is free to slide in straight path fixed in direction. If the translating pair itself revolves, its acceleration will include the Coriolli's component of acceleration due to change in relative distance between two points.

Let link OA oscillate about the fixed center O with constant angular velocityω, from OA to OA' in time dt, angle between OA and OA' being $d\theta$. The link consists of a slider B that moves outward along the link OA with velocity ν from position B to E during the same interval of time. Now the slider can be considered to have moved from B to E as follows:

From B to C due to rotation of link i.e. angular velocity ω of the link.

C to D due to outward velocity ν of the slider.

D to E due to acceleration perpendicular to the rod.



The third movement of the slider is due to Coriolli's acceleration which can be analyzed as under:-

$$arc\,DE = arc\,EF - arc\,FD$$

$$= arc\,EF - arc\,BC$$

$$= FO \times d\theta - BO \times d\theta$$

$$= (FO - BO)d\theta = BF \times d\theta = CD \times d\theta$$

Now linear displacement

$$CD = v \times dt$$

and angular displacement

$$d\theta = \omega \times dt$$

$$Arc\ DE = (v \times dt)(\omega \times dt)$$

$$= v \times \omega (dt)^2$$

but $DE = 1/2 f^{cc} (dt)^2$ (If f^{cc} the acceleration of the particle is constant)

$\therefore$ $1/2 f^{cc} (dt)^2 = v \times \omega (dt)^2$

or $f^{cc} = 2 \times v \times \omega$

This is the required Coriolli's component of acceleration and is always perpendicular to the link.

HYDRAULIC ANALOGY:

Consider a short column of the fluid of length δr at distance r from the axis of rotation of the tube. Then if the velocity of the fluid relative to the tube is ν and the angular velocity of the tube is ω the Coriolli's component of acceleration of the column is $2\nu\omega$ in a direction perpendicular to, in the plane of rotation of the tube. The torque δT applied by the tube to produce this acceleration is then-

$$\frac{\delta w}{g} 2 \times v \times \omega$$

Where δw is the weight of fluid of the short column. If (w) is the specific weight of the fluid and (a) is the cross-section area of the tube outlet, then:

$$\delta w = w\, a\, \delta r$$

$$\delta T = 2 \times v \times \omega \frac{w}{g} \times a \times \delta \times L$$

and the complete torque applied to a column of length L is given by

$$T = 2 \times v \times \omega \times a \times \frac{w \times L^2}{2 \times g}$$

$$T = \frac{C_c \times w \times a \times L^2}{2 \times g}$$

or Coriolli's Component of acceleration

$$C_c = \frac{2 \times g \times T}{w \times a \times L^2}$$ (Considering both tubes)

5. DESCRIPTION:

The Apparatus consists of two stainless steel tubes, projecting radially from a central Perspex tube, are rotated by a DC swinging field motor, mounted vertically in a pillow blocks and bearings. A spring balance attached to this fixed swinging field motor with a fixed armed length measures the torque supplied by the motor.

A digital rpm indicator is provided to measure the speed of the motor. Water from the pump flows to the Perspex tube through the control valve. The water flow rate is measured with the help of rotameter .The water leaving the radial tubes circulate continuously by the water pump. The splash tank and all the accessories are mounted on a fabricated M.S. frame.

6. Utilities Required:

6.1 Electricity Supply: Single phase, 220 V AC, 50 Hz, 5-15 Amp. combined socket with earth connection. Earth voltage should be less than 5 volts.

6.2 Water Supply (Initial Fill).

6.3 Floor Drain Required.

6.4 Floor Area Required: 1.0 m x 1.5 m.

7. Experimental Procedure:

7.1 Open the valve V_2 Partially.

7.2 Switch on the main supply.

7.3 Switch on the motor.

7.4 Set speed of motor with help of variac.

7.5 Switch on the pump.

7.6 Maintain a constant water level in the vertical perspex tube with help of valve V_1 and V_3.

7.7 When constant water level maintained, note the reading of spring balance.

7.8 Note down the rotameter reading.

7.9 Note down the RPM.

7.10 Repeat the procedure for different speeds.

7.11 Repeat the procedure for different flow rates.

7.12 After the experiment, open the valve V_4 to drain out the water.

8. OBSERVATION & CALCULATION:

8.1 DATA:

Acceleration due to gravity g	= 9.81 m/s^2
Swinging field arm length R	= 0.137 m
Density of water ρw	= 1000 kg/m^3
Length of pipe L	= 0.3 m
Internal diameter of pipe d	= 0.006 m

8.2 OBSERVATION TABLE:

Sr. No.	N (RPM)	Q (LPH)	F (Kg)
1			
2			
3			
4			
5			

8.3 CALCULATIONS:

$$T = F \times R \text{ (kg-m)}$$

$$a = \frac{\pi}{4} d^2 \text{ (m}^2\text{)}$$

$$A_{act} = \frac{T \times g}{\rho_W \times a \times L^2} \text{ (m/s}^2\text{)}$$

$$\omega = \frac{2 \times \pi \times N}{60} \text{ (rad/s)}$$

$$v = \frac{Q}{2a \times 1000 \times 3600} \text{ (m/s)}$$

$$A_{theo} = 2 \times \omega \times v \text{ (m/s}^2\text{)}$$

9. NOMENCLATURE:

Nom	Column Heading	Units	Type
A_{act}	Actual Coriolli's Component of acceleration	m/s^2	Calculated
A_{theo}	Theoretical Coriolli's Component of acceleration	m/s^2	Calculated
a	Cross sectional area of pipe	m^2	Calculated
d	Internal diameter of pipe	m	Given
F	Actual force	kg	Measured
g	Acceleration due to gravity	m/s^2	Given
L	Length of pipe	m	Given
N	Number of rpm of motor	RPM	Measured
Q	Discharge	LPH	Measured
R	Swinging field arm length	m	Given
T	Torque	kg	Calculated
v	Velocity	m/s	Calculated
ρ_w	Density of water	kg/m^3	Given
ω	Angular velocity	rad/s	Calculated

10. PRECAUTION & MAINTENANCE INSTRUCTIONS:

10.1 To control the overflow in the central tube, increase the speed of the motor as the discharge increases.

10.2 By pass valve should fully open before the experiment.

10.3 Variac should be at zero position before starting the experiment.

EPICYCLIC GEAR TRAIN APPARATUS

EPICYCLIC GEAR TRAIN APPARATUS

1. OBJECTIVE:

To study the internal type epicyclic gear train.

2. AIM:

To measure epicyclic gear ratio.

To measure input torque, holding torque and output torque.

3. INTRODUCTION:

Any combination of gear wheels by means of which motion is transmitted from one shaft to another shaft is called a gear train. In case of epicyclic gear train, the axis of the shaft on which the gears are mounted may move relatively to a fixed axis.

The gear trains are useful for transmitting high velocity ratios with gears of moderate size in a comparatively lesser space. The epicyclic gear train is used in the back gear of lathe, differential gears of automobiles, wristwatches etc.

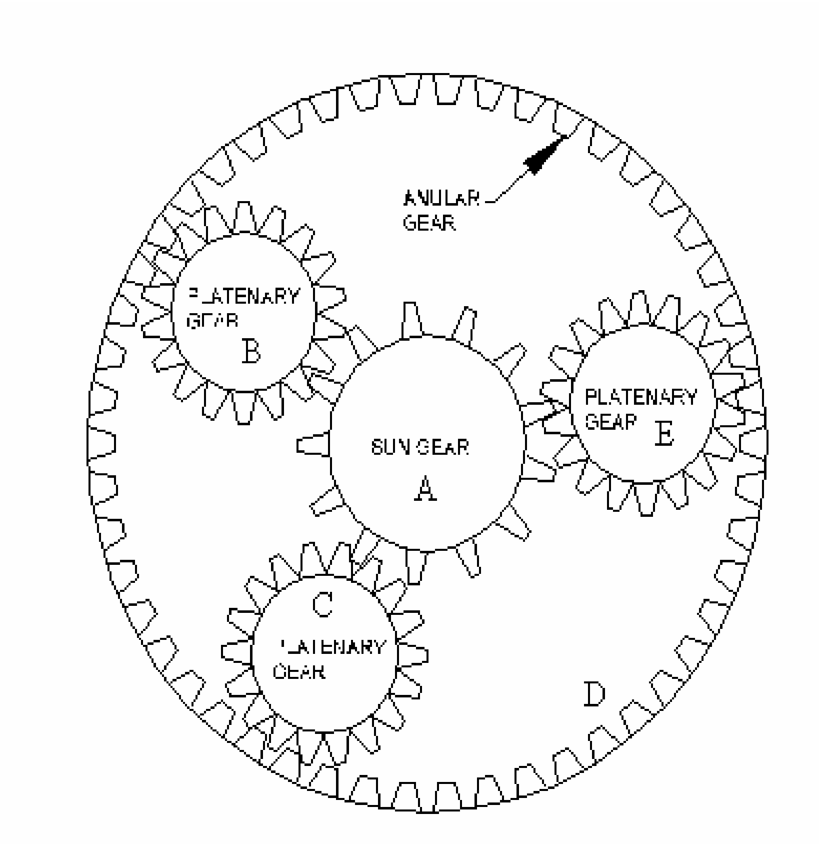
4. THEORY:

GEAR RATIO OF EPICYCLIC GEAR-TRAIN:

A compound epicyclic gear train (internal type) consists of two co–axial shafts. One sun gear (A), three planetary gears (B, C, and E) and an annular gear (D) arrange internally as shown in Fig.1. Wheel A has 13 external teeth. B, C and E have 18 external teeth. The annular gear has 50 internal teeth. The sun gear A is fixed on the input shaft. Three planetary or compound gears B, C, E are mesh with sun gear A and annular gear D.

The ratio of the speed of driver wheel to the speed of the driven wheel is called the speed ratio or velocity ratio.

$$Gear\ Ratio = \frac{Speed\ of\ Driver}{Speed\ of\ Driven}$$



EPICYCLIC GEAR TRAIN

Torque In Epicyclic Gear Train (Internal Type):

If the parts of an epicyclic gear train are all moving at uniform speeds, so that no angular acceleration are involved, the algebraic sum of all external torque applied to the train must be zero. These external torques are: -

Ti = The input torque on the driving member, Arm.

To = The resisting, or load, torque on the driven member.

Th = The holding, or braking torque on the fixed member.

If there is no acceleration,

$T_i + T_o + T_h = 0$ or

$T_o = -(T_i + T_h)$

5. Description:

The set up consists of an epicyclic gear train (internal type) in which sun gear is mounted on input shaft. Three planet gears are mounted on the arm that rotate freely on the fixed pins and mesh with the sun gear and internal teethes of the annular gear. A DC motor is provided for the variable RPM of input shaft controlled by dimmerstat. Digital voltmeter & ammeter is provided to measure input power and hence input torque. To measure the holding torque and output torque, rope brake dynamometer with spring balances is provided. Digital RPM indicator with selector switch is provided to measure the speed of input and output shafts.

6. Utilities Required:

6.1 Electricity Supply: Single Phase, 220 V AC, 50 Hz, 5-15 Amp. Combined socket with earth connection. Earth voltage should be less than 5 volts.

6.2 Floor Area Required: 2 m x 1 m.

7. Experimental Procedure:

7.1 Starting Procedure:

7.1.1 Ensure that ON/OFF switch provided on the panel is at OFF position.

7.1.2 Set the dimmerstat to zero.

7.1.3 Switch ON the mains power supply and switch ON the motor.

7.1.4 Set the speed of input shaft by dimmerstat.

7.1.5 Apply load on holding brake drum by spring balances just to stop its rotation.

7.1.6 Note the reading of voltmeter and ampere meter.

7.1.7 Note the readings of spring balances of the holding drum & output drum.

7.1.8 Note the RPM of the input and output shaft from RPM indicator and selector switch.

7.1.9 Apply load on output brake drum by spring balances just to stop its rotation.

7.1.10 Repeat steps 5-9 for different load on holding brake drum.

7.1.11 Repeat steps 4-10 for different speed of input shaft.

7.2 Closing Procedure:

7.2.1 Reduce the load on holding and output brake drum to zero.

7.2.2 Reduce the speed of input shaft by dimmerstat to zero.

7.2.3 Switch OFF the motor and mains ON/OFF switch.

8. Observation & Calculation:

8.1 Data:

Acceleration due to gravity g	= 9.81 m/s^2
Diameter of the holding brake drum D_{BH}	= 0.2 m
Diameter of the output brake drum D_{BO}	= 0.2 m
Diameter of rope of holding brake drum D_{RH}	= 0.012 m
Diameter of rope of output brake drum D_{RO}	= 0.012 m
Efficiency of motor η	= 0.8

8.2 Observation Table:

Sr. No.	V (Volts)	I (Amp)	N_1 (RPM)	N_2 (RPM)	W_1 (kg)	W_2 (kg)	W_3 (kg)	W_4 (kg)

8.3 Calculations:

$$G_R = \frac{N_1}{N_2}$$

$$T_I = \frac{V \times I \times \eta \times 60}{2 \times \pi \times N_1} \text{ (N-m)}$$

$$R_{EH} = \frac{D_{BH} + (2 \times D_{RH})}{2} \text{ (m)}$$

$$T_H = (W_1 - W_2) \times g \times R_{EH} \text{ (N-m)}$$

$$R_{EO} = \frac{D_{BO} + (2 \times D_{RO})}{2} \text{ (m)}$$

$$T_O = (W_3 - W_4) \times g \times R_{EO} \text{ (N-m)}$$

Calculation Table:							
S. No.	N_1 (RPM)	N_2 (RPM)	G_R	T_I (N-m)	T_H (N-m)	T_O (N-m)	$(T_I + T_H)$ (N-m)

9. Nomenclature:

Nom	Column Heading	Units	Type
D_{BH}	Diameter of the holding brake drum	m	Given
D_{BO}	Diameter of the output brake drum.	m	Given
D_{RH}	Diameter of rope of holding brake drum.	m	Given
D_{RO}	Diameter of rope of output brake drum.	m	Given
g	Acceleration due to gravity	m/s^2	Given
G_R	Gear ratio.	*	Calculated
I	Ampere meter reading	Amp.	Measured
N_1	Speed of driver shaft	RPM	Measured
N_2	Speed of driven shaft	RPM	Measured
R_{EH}	Mean effective radius of holding brake drum	m	Calculated
R_{EO}	Mean effective radius of output brake drum	m	Calculated
T_I	Input torque	N-m	Calculated
T_O	Output torque	N-m	Calculated
T_H	Holding torque	N-m	Calculated
V	Voltmeter reading	Volts	Measured
W_1	Applied weight of holding brake drum	kg	Measured
W_2	Dead weight of holding brake drum	kg	Measured
W_3	Applied weight of holding out put brake drum	kg	Measured
W_4	Dead weight of holding out put brake drum	Kg	Measured

η	Efficiency of motor.	*	Given

* Symbol represents unitless quantity

10. Precaution & Maintenance Instructions:

10.1 Never run the apparatus if power supply is less than 180 and above 230 volts.

10.2 Before starting the experiment ensures that there is no load on the holding and output brake drum.

10.3 Before starting the motor with rotary switch ensure that dimmerstat is at zero position.

10.4 Increase speed gradually.

Elements of Automobile Engineering Laboratory Manual

Lab In-Charge

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Elements of Automobile Engineering Laboratory Manual

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Name of the Lab: Elements of Automobile Engineering

Lab Code: 22SD5AE101

Index

SAFETY REGULATIONS

Users of Thermal Engineering Lab Must comply with the following safety Instructions.

1. Wear always pants and safety shoes when you operate any machines. Sandals are not allowed at all.
2. There should be no overcrowding.
3. Consult the instructor for safety precautions to be followed.
4. Do not run inside the lab and concentrate on the present task.
5. Always use the right tools for the given task.
6. Handle the tools and equipment's with extreme care and place the tools in their properplaces (tool cabinets) once operation is finished.
7. For cleaning tools or equipment, use only the proper cleaner.

Preparation of Lab Practical Report

General principles:

The lab Practical report should be written in simple past tease as passive voice. All observations and sample calculations should be written on left hand side of white paper. The units of various parameters must be shown in the observation table, result table as well as in modelcalculations. Use SI units unless stated otherwise.

- At the end of the results, write discussions/ comments above the results obtained.
- Understand the importance of conducting the experiment.
- Consult the faculty to know the working principle and operation of the machine.
- Take all safety precautions while working on the machines.

Preparation of lab Practical Report:

The lab practical Report should be written in the flowing order,

1. Aim of Experiment
2. Apparatus required.
3. Theory and description of experimental Setup
4. Procedure
5. Observations
6. Sample calculations
7. Results and discussion on results

Experiment No 1

Measurement of Length and Diameter by Vernier Calipers and Micrometer

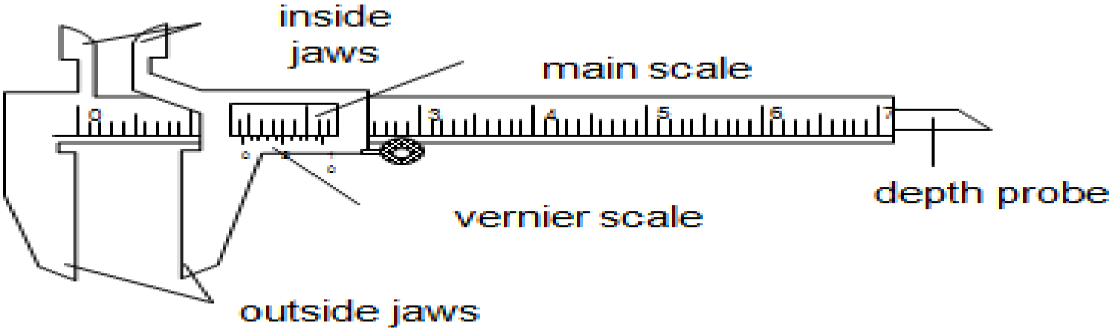
Aim:

To measure dimensions of given object using vernier calipers and micrometer

Instruments Used:

Vernier caliper, Micrometer, and specimen

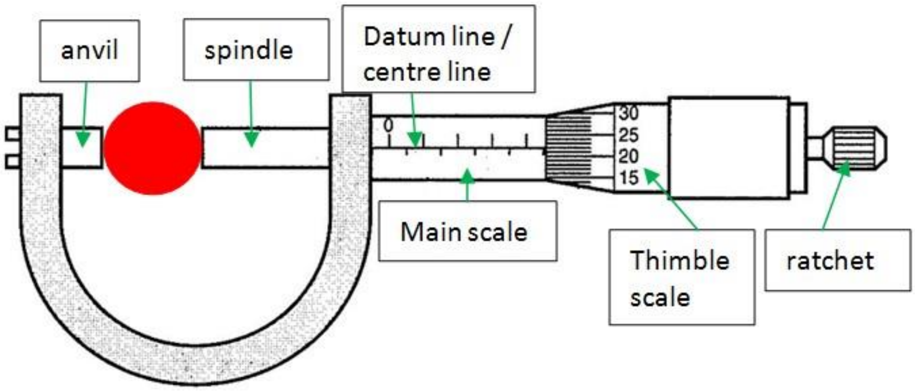
Theory:



Vernier Caliper

Least Count is the smallest division in the instruments' scale. The Least Count is a measure of the accuracy of a measuring instrument. A vernier caliper consists of a rule with a main engraved scale and a movable jaw with an engraved vernier scale. The main scale is calibrated in centimeters (cm) with a millimeter (mm) least count, and the movable vernier scale that divides the least count on the main scale into 50 equal sub-divisions. The span of the upper jaw is used to measure the inside diameter of an object such as hollow cylinders or holes. The leftmost mark on the vernier scale is the zero mark, which is often unlabeled. A measurement is made by closing the jaws on the object to be measured and reading where the zero mark on the vernier scale falls on the main scale. The first two significant figures are read directly from the main scale. This is known as the main scale reading. The next significant figure is the fractional part of the smallest subdivision on the main scale (in this case, mm). If a vernier mark coincides with a mark on the main scale, then the mark number is the fractional part of the main scale division. Before making a measurement, the zero of the vernier caliper should be checked with the jaws completely closed. It is possible that the caliper not being properly will produce systematic error. In this case, zero corrections must be made for each reading. The least of the vernier caliper is calculated by equation (1).

$$\text{Least Count} = \frac{\text{Value of the smallest division on main scale}}{\text{Number of divisions on vernier scale}} \ldots\ldots\ldots\ldots.. 1$$



Micrometer

Least Count is the smallest division in the instruments' scale. A **micrometer** consists of a movable spindle (jaw) that advances toward another parallel-faced jaw, called an anvil, by rotating the thimble. The thimble rotates over an engraved sleeve or barrel that is mounted on a solid frame. Most micrometers are equipped with a ratchet, at the far right in figure, which allows slippage of the screw mechanism when a small constant force is exerted on the jaw. This permits the jaw to be tightened on an object with the same amount of force each time. The axial main scale on the sleeve is calibrated in mm and the thimble scale is the vernier scale and is usually divided into increments of 0.01mm. The **pitch** of a screw is the distance between two consecutive screw threads and is the lateral linear distance the screw moves when turned through one rotation. The axial line on the sleeve main scale serves as a reading line. If a micrometer does not have 0.5 mm divisions on the main scale, you must determine whether the thimble is in its first rotation or second. If it has 50 divisions on the thimble and completes 1 mm in two rotations, each division on the thimble gives 0.01 mm. Measurements are taken by noting the reading x on the main scale of the sleeve. Note the position of the edge of the thimble on the main scale and the position of the reading line on the thimble scale. Multiply this reading with 0.01 mm and add to x. The Least Count is a measure of the accuracy of a measuring instrument. The least of the vernier caliper is calculated by equation.

$$\text{Least Count} = \frac{\text{Pitch (Distance between two consecutive threads of screw)}}{\text{Number of divisions on tumble scale}}$$

Measurements – Vernier Calipers

S. No	Part Name	MSR	VSR	Measurement = MSR+ (VSR X LC)

Measurements - Micrometer

S. No	Part Name	MSR	HSR	Measurement = MSR+ (HSR X LC)

Results

The specifications of the given component are measured with vernier caliper and micrometer.

S. No	Diameter	Trial 1	Trial 2	Average
1				
2				
3				

Experiment 2

Measurement of Angle by Sine Bar

Aim: -

To measure the angle of the given wedge using Since bar

Instruments Used: -

1. Since bar 2. Work piece 3. Dial Gauge

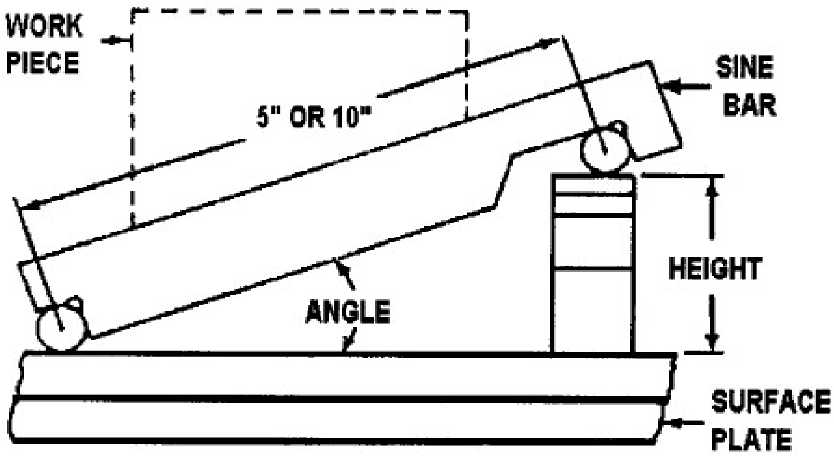
Theory: -

The sine principle uses the ratio of the length of two sides of a right triangle in deriving a given angle. The accuracy with which the sine principle can be used is dependent in practice, on some form of linear measurement. The sine bar is not a complete measuring instrument. Sine bars in conjunction with slip gauges constitute a very good device for the precise measurement of angles. The arrangement is since for any angle θ the sides of a right-angled triangle will have precise ratio, i.e,

$$\mathbf{Sin\theta = h/l}$$

If **h** and **l** could be measured accurately, θ can be obtained accurately. The value of h is built-up by slip gauges and value 'l' is constant for a given sine bar.

Sine bars are used either to measure angles very accurately or for locating any work to a given angle within very close limits. Sine bars are made from high carbon, high chromium, corrosion resistant steel, hardened, ground, and stabilized. Two cylinders of equal diameter are attached at the ends. The axes of these two cylinders are mutually parallel to each other and parallel to and at equal distance from the upper surface of the sine bar. The distance between the axes of the two cylinders is exactly 100, 200 and 300 mm in metric system.



Sine Bar

Procedure

1. Place the work piece/wedge above the sine bar and make it horizontal with the base.
2. The dial gauge is then set at one end of the work moved along the upper surface of the component.
3. If there is any variation in parallelism of the upper surface of the component and the surface plate, it is indicated by the dial gauge.
4. The combination of the slip gauges is so adjusted that the upper surface is truly parallel with the surface plate.
5. Note down the values of the slip gauges.
6. Calculate the angle using the formula.

   $\theta = Sin^{-1}(h/l)$
7. Repeat the procedure 3 or 4 times and take the average.

Observations:

S.No.	Height (h) mm	Length (l) mm	Angle (θ)

Result:

The angle of the given specimen measured with the sine bar is.

The angle of the given specimen measured with the Bevel Protractor is.

Experiment No 3

Determination of Time Period and Natural Frequency of Simple Pendulum

Aim:

To determine the time period and natural frequency of simple pendulum.

Apparatus Required:

Support stands with a string clamp, Stopwatch, Long metal bar.

Theory:

Period means the time it takes to complete one oscillation. Time period of oscillation of a wave refers to the time taken by any bar element to complete one such oscillation. For example, if the pendulum is swinging then time taken in moving maximum back then moving forward and finally returning to the mean position is counted as a period of time. Time period denoted by 'T', whereas second (s) is the SI unit of time period. A simple pendulum is an ideal pendulum composed of a point mass (m) suspended by a weightless, inextensible, soft thread and free to vibrate without friction. There is a reciprocal relationship between Period and Frequency, and these can be expressed mathematically as:

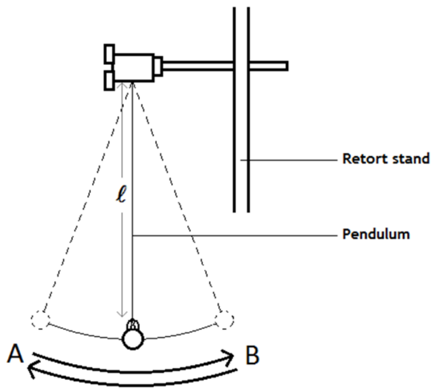
$$\text{Period} = \text{Total time} / \text{Cycles.}$$

Period of a wave decreases whereas the frequency of waves increases. A particle of medium completes one vibration within the time period of a wave. Each complete oscillation is known as a period and is constant. The formula for determining the period of a pendulum is $T = 2\pi \sqrt{L/g}$, where L is the length of the pendulum and g is the acceleration due to gravity. Successive cycles are called periods. The period of pendulum is the time it takes the pendulum to make one full back and forth swing.

A simple pendulum can be defined as a device where its point mass is attached to a light inextensible bar and suspended from a fixed support. Equilibrium position is subjected to a restoring force when a pendulum is displaced sideways from its resting due to its gravity that will accelerate it back toward the equilibrium position.

Sequence of operation:

A simple pendulum consists of long metal bar from a rigid support by a mass less and inextensible bar, such that the metal bar is free to swing back and forth. When the bar from its mean position is dragged to one side and then released, the pendulum is set to motion and the bar moves oppositely on both side of its mean position and when the pendulum bar is displaced it oscillates on a plane about the vertical line through the support. Frequency of a simple pendulum depends on its length and acceleration due to gravity.



Simple Pendulum

The equations are-

Frequency , $f=1/2\pi\sqrt{g/L}$.

Period (T) of a simple pendulum is $T=2\pi\sqrt{L/g}$.

A simple pendulum consists of a mass (m) hanging from a bar of length (L) and fixed at a pivot point (P). When it is displaced to an initial angle and then it is released, the pendulum will swing back and forth with a periodic motion.

Observation Table: -

S. No	Mass (g)	Length of bar (L)	No of Oscillations 'n'	Time taken in sec	Time Period $T= 2\pi (\sqrt{L/g}.)$	Frequency $F= 1/T$

Result

The natural frequency of simple pendulum is.

Experiment- 4

Determination of Time Period and Natural Frequency of Compound Pendulum.

Aim:

To determine the time period and natural frequency of the compound pendulum.

Apparatus Required:

A bar pendulum, a knife–edge with a platform, a spirit level, a precision stopwatch, a meter scale

Theory: -

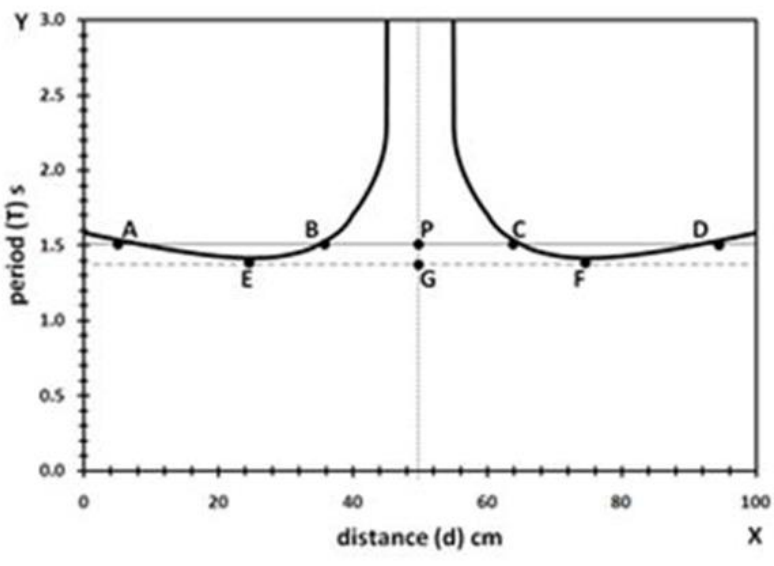
The compound bar pendulum AB is suspended by passing a knife edge through the first hole at the end A. The pendulum is pulled aside through a small angle and released, whereupon it oscillates in a vertical plane with a small amplitude. The time for 10 oscillations is measured. From this the period T of oscillation of the pendulum is determined.

In a similar manner, periods of oscillation are determined by suspending the pendulum through the remaining holes on the same side of the centre of mass G of the bar. The bar is then inverted, and periods of oscillation are determined by suspending the pendulum through all the holes on the opposite side of G. The distances d of the top edges of different holes from the end A of the bar are measured for each hole. The position of the centre of mass of the bar is found by balancing the bar horizontally on a knife edge. The mass M of the pendulum is determined by weighing the bar with an accurate scale or balance.

A graph is drawn with the distance d of the various holes from the end A along the X-axis and the period T of the pendulum at these holes along the Y-axis. The graph has two branches, which are symmetrical about G. To determine the length of the equivalent simple pendulum corresponding to any period, a straight line is drawn parallel to the X- axis from a given period T on the Y- axis, cutting the graph at four points A, B, C, D. The distances AC and BD, determined from the graph, are equal to the corresponding length l. The average length l = (AC+BD)/2 and l/T^2 are calculated. In a similar way, l/T^2 is calculated for different periods by drawing lines parallel to the X-axis from the corresponding values of T along the Y-axis. l/T^2 should be constant over all periods T, so the average overall suspension points is taken. Finally, the acceleration due to gravity is calculated from the equation $g = 4\pi^2(l/T^2)$.

T_{min} is where the tangent EF to the two branches of the graph crosses the Y-axis. At T_{min}, the distance EF = l = $2k_G$ can be determined, which gives us k_G, the radius of gyration of the pendulum about its centre of mass, and one more value of g, from $g = 4\pi^2(2k_G/T_{min}^2)$.

k_G can also be determined as follows. A line is drawn parallel to the Y -axis from the point G corresponding to the centre of mass on the X-axis, crossing the line ABCD at P. The distances AP = PD = AD/2 = h and BP = PC = BC/2 = h' are obtained from the graph. The radius of gyration k_G about the centre of mass of the bar is then determined by equation (4). The average value of k_G over the different measured periods T is taken, and the moment of inertia of the bar about a perpendicular axis through its centre of mass is calculated using the equation $I_G = Mk_G^2$.



Procedure: -

Suspend the pendulum in the first hole by choosing the length 5 cm on the length slider.

Click on the lower end of the pendulum, drag it to one side through a small angle and release it. The pendulum will begin to oscillate from side to side.

Repeat the process by suspending the pendulum from the remaining holes by choosing the corresponding lengths on the length slider.

Draw a graph by plotting distance d along the X-axis and time period T along the Y-axis. (A spreadsheet like Excel can be very helpful here.)

Calculate the average value of l/T2 for the various choices of T, and then calculate g as in step 2 above.

Determine kG and IG as outlined in steps 3 and 4 above.

Repeat the experiment in different gravitational environments by selecting an environment from the drop-down environment menu. If the pendulum has been oscillating, press the Stop button to activate the environment menu.

Observations:

To draw a graph:

<table>
<tr><th>No of holes from A</th><th>Distance of knife edge from A</th><th colspan="3">Time for Oscillations (sec)</th><th>Time Period T (sec)</th></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td>1</td><td>2</td><td>Mean</td><td rowspan="2"></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

Results:

Average acceleration of gravity, g= $4\pi^2(l/T^2)$ = ... m/s^2

Mass of the pendulum M = ... Kg

Experiment No 5

The Experimental Determination of The Moment of Inertia of Flywheel

Aim:

To determine the moment of inertia of a flywheel.

Apparatus:

Fly wheel, weight hanger, slotted weights, stopwatch, meter scale.

Theory:

The flywheel consists of a heavy circular disc/massive wheel fitted with a strong axle projecting on either side.The axle is mounted on ball bearings on two fixed supports. There is a small peg on the axle. One end of a cord is loosely looped around the peg and its other end carries the weight-hanger.

$$P_{loss} = mgh$$

Let "m" be the mass of the weight hanger and hanging rings (weight assembly). When the mass "m" descends through a height "h", the loss in potential energy is

The resulting gain of kinetic energy in the rotating flywheel assembly(flywheel and axle) is.

$$K_{flywheel} = \frac{1}{2} I \omega^2$$

Where,

I -Moment of inertia of the flywheel assembly. ($kg\text{-}m^2$)

ω- Angular velocity at the instant the weight assembly touches the ground. (rad/s)The gain of kinetic energy in the descending weight assembly is,

$$K_{weight} = \frac{1}{2} m v^2$$

Where v is the velocity at the instant the weight assembly touches the ground. (m/s)

The work done in overcoming the friction of the bearings supporting the flywheel assembly is

$$W_{friction} = nW_f$$

Where,

n - Number of times the cord is wrapped around the axle

W_f - work done to overcome the frictional torque in rotating the flywheel assembly completely once.

Therefore, from the law of conservation of energy we get.

$$P_{loss} = K_{flywheel} + K_{weight} + W_{friction} \quad (1)$$

On substituting the values, we get

$$mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 + nW_f \quad (2)$$

Now the kinetic energy of the flywheel assembly is expended in rotating N times against thesame frictional torque. Therefore

$$NW_f = \frac{1}{2}I\omega^2 \quad W_f = \frac{1}{2N}I\omega^2$$

$$v = \omega r$$

If r is the radius of the axle, then velocity v of the weight assembly is related to r by the equation. Substituting the values of v and W_f we get:

$$mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mr^2\omega^2 + \frac{n}{N}\times\frac{1}{2}I\omega^2 \quad (3)$$

Now solving the above equation for I

$$I = \frac{Nm}{N+n}\left(\frac{2gh}{\omega^2} - r^2\right) \quad (4)$$

Where, I = Moment of inertia of the flywheel assembly ($kg\text{-}m^2$) N = Number of rotations of the flywheel before it stoppedm = mass of the rings (kg)

n = Number of windings of the string on the axle

g = Acceleration due to gravity of the environment. (m/s^2) h = Height of the weight assembly from the ground. (m)

r = Radius of the axle. (m)

Now we begin to count the number of rotations, N until the flywheel stops and note the duration of time t for N rotation. Therefore, we can calculate the average angular velocity in radians per second.

$$\omega_{average} = \frac{2\pi N}{t}$$

Since we are assuming that the torsional friction W_f is constant over time and angularvelocity is simply twice the average angular velocity

$$\omega = \frac{4\pi N}{t} \quad (5)$$

Procedure

1. The length of the cord is carefully adjusted, so that when the weight-hanger just touches the ground, the loop slips off the peg.
2. A suitable weight is placed in the weight hanger.
3. A chalk mark is made on the rim so that it is against the pointer when the weight hanger just touches the ground.
4. The other end of the cord is loosely looped around the peg keeping the weight hanger just touching the ground.
5. The flywheel is given a suitable number (n) of rotation so that the cord is wound round the axle without overlapping.
6. The height (h) of the weight hanger from the ground is measured.
7. The flywheel is released.
8. The weight hanger descends, and the flywheel rotates.
9. The cord slips off from the peg when the weight hanger just touches the ground. By this timethe flywheel would have made no rotations.
10. A stop clock is started just when the weight hanger touches the ground.
11. The time taken by the flywheel to come to a stop is determined as t seconds.
12. The number of rotations (N) made by the flywheel during this interval is counted.
13. The experiment is repeated by changing the value of n and m.
14. From these values the moment of inertia of the flywheel is calculated using equation

$$I = \frac{Nm}{N+n}\left[\frac{2gh}{\omega^2} - r^2\right]$$

Observations

S.No.	**Mass (m) in gms**	**Height hin cm**	**Number of string turns (n)**	**Number of rotations of wheel (N) after mass detached**	**Time (t) in sec**	**Angular velocity (ω) in rad/sec**

Result

Moment of inertia of the fly wheel =. ....kgm^2

Experiment no 6.

Grouping of Batteries for Measurement of Voltage and Current Using Multimeter

Aim: To group the batteries for measurement of voltage and current using multimeter

Apparatus: Batteries and multimeter and clips

Theory

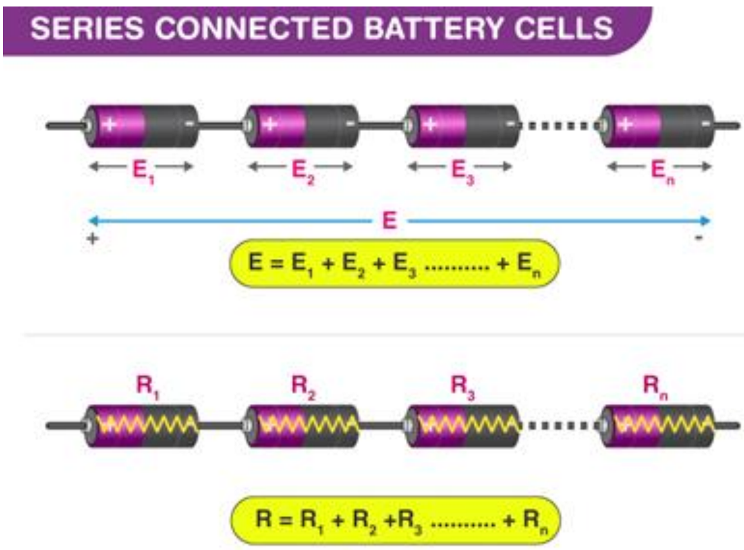
The battery is a device that consists of one or more electrochemical cells with external connections for powering electrical appliances. When there are multiple batteries in each circuit, they are either wired in parallel or series connection. Understanding the difference between series and the parallel connections is crucial as they determine how batteries perform in different applications. In this article, let us look at batteries' series and parallel connection and when each method is appropriate.

Batteries in Series and Parallel Explained

Batteries can either be connected in series, parallel or a combination of both. In a series circuit, electrons travel in one path and in the parallel circuit, they travel through many branches. The following sections will closely examine the series battery configuration and the parallel battery configuration.

Connecting Batteries in Series

A set of batteries is said to be connected in series when the positive terminal of one cell is connected to the negative terminal of the succeeding cell.



The overall emf of the battery is the algebraic sum of all individual cells connected in series.

If $\boldsymbol{E}$ is the overall emf of the battery combined by $\boldsymbol{n}$ number of cells, then.

$$E = E_1 + E_2 + E_3 + E_4 + \ldots\ldots\ldots + E_n$$

Similarly, if r_1, r_2, r_3 are the internal resistances of individual cells, then the internal resistance of the battery will be equal to the sum of the internal resistance of the individual cells.

$$r = r_1 + r_2 + r_3 + \ldots\ldots + r_n.$$

Advantages

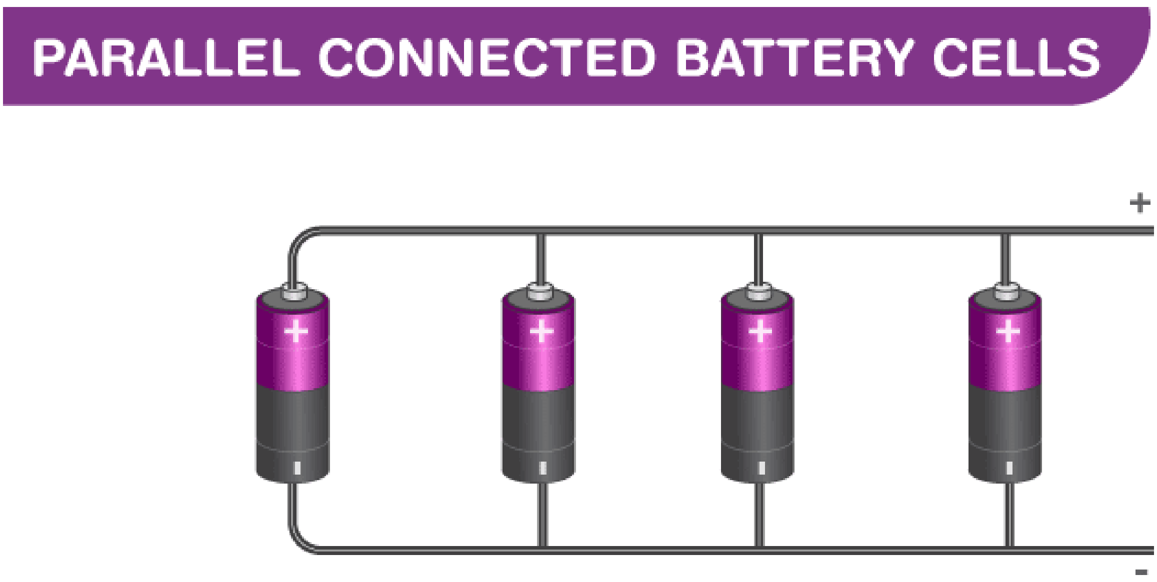
Wiring batteries in series provides a higher system voltage resulting in a lower system current. Low current indicates that you can use thinner wiring and suffer less voltage drop in the system.

Disadvantages

In a series-connected battery system, a converter is needed to achieve low voltages.

Connecting Batteries in Parallel

A set of batteries are said to be connected in parallel when the positive terminals are connected, and similarly, the negative terminals of these cells are connected. These combinations are referred to as parallel batteries.



If the emf of each cell is identical, then the emf of the battery combined by n numbers of cells connected in parallel is equal to the emf of each cell. The resultant internal resistance of the combination is,

$$\left(\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}+\ldots\ldots\ldots\ldots\ldots\ldots+\frac{1}{r_n}\right)^{-1}$$

The current delivered by the battery is the sum of currents delivered by individual cells.

Advantages

One of the prominent advantages of batteries connected in parallel is that if one of the batteries in the system fails to operate, the remaining batteries can still provide power.

Disadvantages

Connecting batteries in parallel results in a higher current draw. This indicates thicker cables and more voltage drop.

Procedure:

To connect a group of batteries in series you connect the negative terminal of one battery to the positive terminal of another and so on until all batteries are connected, you would then connect a link/cable to the negative terminal of the first battery in your string of batteries to your application, then another link/cable to the positive terminal of the last battery in your string to your application

When connecting batteries in parallel the negative terminal of one battery is connected to the negative terminal of the next and so on through the string of batteries, the same is done with positive terminals, ie positive terminal of one battery to the positive terminal of the next. For example, if you needed a 12V 300Ah battery system you will need to connect three 12V 100Ah batteries together in parallel.

Result:

Voltage and Current in series connection

Voltage and Current in parallel connection

Experiment No 7

The Experimental Determination of Mechanical Advantage of Screw Jack

Aim: To determine the mechanical advantage of screw jack

Apparatus required: Simple screw jack, weights.

Theory:

The primary goal of engineering and technology is to make man's life easier. One example of such convenience is the ability to lift a heavy load with minimal effort. One such invention for lifting heavy loads is the screw jack. It is a device with a screw mechanism that can be used to raise or lower loads, and its operation is like that of an inclined plane. The turntable for lifting loads, the pulley for supporting the cord, the effort hanger, the square screw thread, and the base make up the laboratory screw jack.

Screw jacks of three types:

1. Simple screw jack
2. Compound Screw jack
3. Differential Screw jack

A simple screw jack consists of a nut, a screw square threaded, and a handle fitted to the head of the screw. The nut also forms the body of the jack. The load to be lifted is placed on the head of the screw. Here the axial distance between corresponding points on two consecutive threads is known as pitch.

Screw: A screw is a simple machine that is a cylindrical post with a ridge wrapped around it in a helix pattern. When the screw is twisted around once, the screw travels into its target material a distance equal to the distance in between threads.

Pitch: The pitch of a screw is the distance between two threads. Thread measurements are commonly given in units of threads per unit distance (example: 10 threads per centimetre). To calculate the pitch, simply divide the unit distance by the number of threads.

If **p** be the pitch of screw and t is the thickness of thread, then **p = 2t.**

Mechanical advantage = W/P

Where W = Load lifted in N

P = Effort applied to lift the load in N

Procedure:

When we are moving the handle in horizontal direction, the screw is also moved attached to it and load is also lifted by the pitch of screw, in one revolution of handle.

Observation:

S.no	Load (N)	Effort (P_e) in N	Length of Lever (mm)	Pitch of Screw p (mm)	M.A

Result:

Mechanical advantage of screw jack given screw jack is.

Experiment no 8.

Identification And Use of Automotive Garage Tools

Aim:

Identify the various mechanic's tools and to study the applications of each tool.

Introduction:

A good automobile shop must have equipment to undertake all types of faults finding and servicing jobs. The following is a list of tools and equipment's, which are necessary in the auto shop.

1. Screwdriver:

These used to tighten or loose the screw in the machine element. The main parts of screwdrivers are,

1. Handle which is a smooth and shaped properly for good grip. It is usually made of wood on moulded plastics.

2. Blade made of hardened and tempered carbon steel or alloy steel for strength. Blades are rounded, though occasionally square or rectangular sections are also used. The length sizes various from 40 mm to 250 mm or even more. The ends of the blades are formed in to flared tips for turning screw by fitting in to their head slots.

3. Screwdrivers are specified according to the length of the blade and width of the tip. Normally blade length of 45mm and 300mm and tips 3mm to10mm wide are available.

2. Spanners:

These are also called wrenches. These are used for tightening or loosening the nuts. These are made of high tensile or alloy steel and are drop forged & heat-treated. Their size in determined by the nuts or blots is fits. In the unified system used commonly, the spanners are marked with sign A/F followed by a number representing decimal equivalent of the nominal size across the flats of the hexagonal nuts or bolts. The following types of spanners are commonly used.

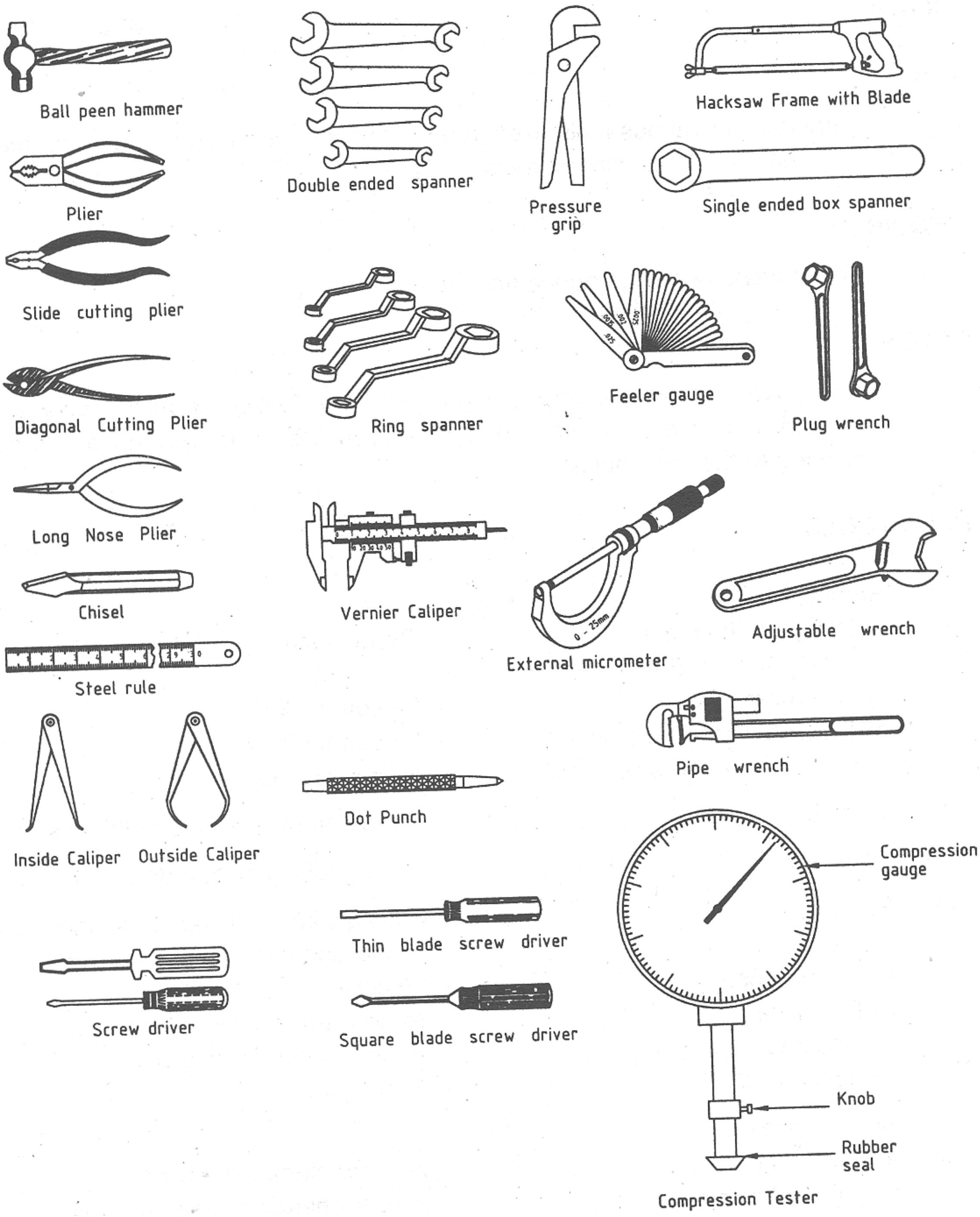
3. Ring Spanners:

The ring spanners also called box spanners. The end openings completely enclosed by the nuts and the bolt heads, for which they cannot slip and cause damage. Further the end holes in some ring spanners are twelve sides, because of which they can be used in restricted spaces. 6 7

4. Open-Ended Spanners:

These are the most used type of the spanners in the garage, although they may not be the best means of tightening or loosening the nuts. Therefore, these are employed where ring spanners or socket wrenches cannot work.

It is observed that spanner opening is kept at an angle with the body axis. This is done to facilitate the turning of the nut in restricted space.



5. Combination Spanners:

These are on one end and have hole on the other end. Thus, they are combination of open-ended and the ring spanners. Initially for loosening jammed nuts more torque is required, and we use ring end, which will not slip. However, after the nut is already loose, it is more convenient to further continue with the open end.

6. Socket Spanner:

These types of spanners are useful in restricted spaces where common types of spanners cannot be used. Both 6&12-point socket should be included in the well-equipped tool kit. This consists of different sizes, which can be used with various types of handles. Apart from handles, both electric and air operated impact wrenches are used to drive socket for speeding up the work.

7. Torque Wrench:

Important nuts and bolts in automobile work have to be tightened with the specified amount of torque because excessive torque may result in their breakage while with lesser torque they will come out loose during use. This is made possible by a torque wrench. It is a specialized form of a socket spanner.

8. Wheel Nut Spanner:

Several different types of spanners are used for tightening or loosening wheel nuts.

9. Allen Wrenches:

Allen keys *are used on Allen screws,* which have hexagonal shaped grooves in their heads.

10. Pliers:

Different types of pliers have been shown in figure. A plier a device mainly used gripping only and should never be used as substitute for spanners that will damage the nut by rounding off its corner.

11. Hammers:

A hammer is a tool used for striking operations such as denting, bending, punching, straightening, riveting, etc. the head and the handle form the two parts of hammers. The head is made of drop forged carbon steel and has a hole for fitting the handle there in. A medium weight ball peen hammer is the one commonly used in automobile work.

12. Chisels:

A common application is the tearing open of corroded nuts and bolts with a flat chisels. The main parts of a chisels are the head the body and the cutting edge or point. These are made of high carbon steel or chrome vanadium steel. Chisels should be kept sharp. These should be sharpened approximately 60 degree included angle.

13. Files:

Files are used for smoothing rough surface and for removing small amount of metal. The cut in file may be classified either as single cut or double cut, depending up on whether they have cuts in one direction or in both directions. Files may also be classified according to the shape of cross section.

14. Hacksaws:

Hacksaws are meant for cutting metals by sawing. A hacksaw consists of an adjustable frame with a handle and replaceable hacksaw blade. The construction of the hacksaw is such that different blade length can be accommodated within limits. The hacksaw blade has a thin harrow strip with teeth on one or both sides and two pin holes at the ends.

15. Drilling Machine:

Drilling machine may be hand operated or electrical ones. The tool used for drilling is called a twist drill. It is main parts are shank, body and the point; shank is fitted in to the drill chuck of the machine, while the points is the conical end, which does the cutting. The cutting edges of the point are called tips.

16. Twist Drill:

The position of the drill between the shank and the point is termed body, which consist of the spiral grooves called flutes. These form the cutting edges and provide passage for the chips to come out and the coolant to flow down to the point. A set of twist drills, from 0.5mm to 6mm is sufficient for automobile work.

17. Reamers:

After drilling the hole, the same can be finished by a reamer. It may be a straight fluted type and spiral fluted type. The initial hole is drilled by a drill 0.3mm smaller than the final finished size required, after which the reamer is turned only in the forward direction till the desired size is obtained.

18. Bench Vice:

Bench vice is used to hold the component while it is worked on. This is permanently fixed on the workbench. While holding the component some soft material is placed in the vice, it is better to place some other wooden or plastic flats between the vice jaws and the components to avoid damage to the later.

19. Steel Rule:

Most simple tool for measurements length is the ordinary steel rule, which is 300 mm long. It is quite satisfactory for measurement with accuracy up to 0.5mm. Besides straight edges of the steel rule or even otherwise unmarked straight edge may be used to measure surface irregularities.

20. Outside Micrometre:

In case of measurements where still greater accuracy is required in that place micrometre is used. External dimension of parts such as thickness, diameter is measured with the help of outside micrometer, whereas internal dimensions are measured with inside micrometer.

21. Lifting Jacks:

Work under the car or to change wheels, it is necessary to lift the car. For, doing this, lifting jack is use which may be mechanically or hydraulically operated. Such a jack is a standard accessory with many cars. It consists of a diamond shaped frame having a nut on one side and a sleeve on the other side.

22. Axle Stand:

It is always necessary to make sure that before start working the car with axle stand. The axle is not suppurated by the jack, or any other support and it is not safe to use bricks, for supporting purpose. So, axle stand is the batter way to support the weight of the vehicle.

23. Vernier Calliper:

Most simple tool for measurements length is the ordinary steel rule, which is 300 mm long. It is quite satisfactory for measurement with accuracy up to 0. 5mm.besides straight edges of the steel rule or even otherwise unmarked straight edge may be used to measure surface irregularities. Used in hole diameter, depth of hole, outer diameter, and inner diameters.

Result:

Thus, the various mechanic’s tools are identified, and the applications were studied.

Experiment 9

Dismantling, Inspection, and Assembly of Multi-Cylinder Petrol Engine

Aim:

To disassemble, inspect and assemble the given multi-cylinder petrol engine.

Tools Required:

Petrol engine, toolbox

Theory:

Engine is the most important system of vehicle that converts heat energy into mechanical energy by fuel consumption. Engine block is the foundation for other parts of the engine and is made of aluminum alloys and cast iron. Engine block is closed by engine head, and the engine head seals the engine cylinder. Engine cylinder heads are usually made of aluminum alloys and cast iron. Provisions for the fuel and air intake and exhaust are provided, in which inlet and outlet valves are fitted. Also provisions for cooling and lubrication are provided. Piston, connecting rod and crankshaft are the parts which fit inside the cylinder block. As the fuel burns inside the cylinder, the energy of fuel makes the piston reciprocate. The connecting rod is connected to the piston and transmits the movement to the crankshaft. The crankshaft converts the reciprocating motion into rotary motion. The rotary motion is transmitted to wheels through transmission system and vehicle propels.

Engine Removal:

Engine removal is disconnecting all the systems attached to it. The process of engine removal and disassembly may vary depending upon the type of engine. The general procedure is as follows.

1. Remove the hood.
2. Disconnect battery cables.
3. Remove air filter.
4. Label all wires and vacuum lines.
5. Drain coolant and oil.
6. Remove the radiator.

7. Remove the distributor and spark plug wiring.
8. Remove the direct current (DC) generator.
9. Remove the heater hoses and ground strap.
10. Remove switches and sensors.
11. Remove the throttle linkage, cable, or wiring.
12. Mark accessory brackets and remove accessories.
13. Remove exhaust components.
14. Remove and plug the fuel line.
15. Separate the engine and transmission/transaxle.
16. Disconnect speedometer cable, transmission shift linkage, and clutch cable.
17. Unbolt the engine mounts.
18. Remove the engine from the vehicle.
19. Roll shop crane until the engine can be lowered safely.

Engine disassembly:

There are some basic rules for dismantle engine irrespective of capacity and type. Engine dismantling should be carried out in a sequence as follows.

1. Document engine information
2. Drain fluids from the engine.
3. Thoroughly clean the engine exterior of dirt, grease, and debris
4. Remove subassemblies like oil filter and engine flywheel.
5. Disconnect spark plug wire and remove the engine from its equipment.
6. Remove the fuel tank and disconnect the fuel line.
7. Remove the muffler.
8. Remove the blower housing, starter assembly and timing chain.
9. Remove the spark plug.
10. Remove the air cleaner.

11. Disconnect linkages and springs from the carburettor; remove the carburettor.
12. Remove the ignition coil or electronic ignition system.
13. Remove the valves, valve springs, and valve spring retainers.
14. Remove the camshaft and valve lifters.
15. Remove the cylinder head.
16. Keep the engine in upside down position.
17. Remove the piston.
18. Remove oil sump.
19. Remove oil strainer and oil pump.
20. Remove the crankcase cover.
21. Disconnect the connecting rod from the crankshaft; remove the piston and connecting rod assembly from the block.
22. Remove the crankshaft.
23. Remove any bearings or seals in the crankcase.

Inspection:

After dismantling the total engine inspect the parts

1. Inspect Timing Belt and Idler Pulleys, check the turning smoothness of the timing belt idler pulleys
2. Inspect Cylinder head for flatness, vertical starches and cracks, Check for any cracking at top due to the thermal and mechanical stress, check also for high temperature corrosion
3. Inspect the valves, valve springs and check for tension
4. Inspect camshaft, cam journal oil clearance and cam lobes
5. Inspect the wear and tear of the rocker arm.
6. Inspect intake and exhaust manifold, check the carbon deposits and for any cracks
7. Check the crankshaft thrust clearance, oil clearance

8. Inspect piston diameter and oil clearance.
9. Inspect piston ring area and Grooves, check for the free movement of the piston rings.
10. Inspect for piston ring end gap.
11. Inspect connecting rods.
12. Inspect crankshaft for run out.
13. Inspect main journals and crank pins.

Result:

The dismantling, inspection and assembly of the given single cylinder petrol engine is done.

Experiment No 10

Dismantling Inspection and Assembly of Multi-Cylinder Diesel Engine

Aim:

To disassemble, inspect and assemble a given multi-cylinder diesel engine.

Tools Required:

Diesel engine, toolbox

Theory:

Engine is the most important system of vehicle that converts heat energy into mechanical energy by fuel consumption. Engine block is the foundation for other parts of the engine and is made of aluminum alloys and cast iron. Engine block is closed by engine head, and the engine head seals the engine cylinder. Engine cylinder heads are usually made of aluminum alloys and cast iron. Provisions for the fuel and air intake and exhaust are provided, in which inlet and outlet valves are fitted. Also provisions for cooling and lubrication are provided. Piston, connecting rod and crankshaft are the parts which fit inside the cylinder block. As the fuel burns inside the cylinder, the energy of fuel makes the piston reciprocate. The connecting rod is connected to the piston and transmits the movement to the crankshaft. The crankshaft converts the reciprocating motion into rotary motion. The rotary motion is transmitted to wheels through transmission system and vehicle propels.

Engine Removal:

Engine removal is disconnecting all the systems attached to it. The process of engine removal and disassembly may vary depending upon the type of engine. The general procedure is as follows.

1. Remove the hood.
2. Disconnect battery cables.
3. Remove air filter.
4. Label all wires and vacuum lines.
5. Drain coolant and oil.
6. Remove the radiator.

7. Remove the direct current (DC) generator.

8. Remove the heater hoses and ground strap.
9. Remove switches and sensors.
10. Remove the throttle linkage, cable, or wiring.
11. Mark accessory brackets and remove accessories.
12. Remove exhaust components.
13. Remove the fuel line.
14. Separate the engine and transmission/transaxle.
15. Disconnect speedometer cable, transmission shift linkage, and clutch cable.
16. Unbolt the engine mounts.
17. Remove the engine from the vehicle.
18. Roll shop crane until the engine can be lowered safely.

Engine disassembly:

There are some basic rules for dismantle engine irrespective of capacity and type. Engine dismantling should be carried out in a sequence as follows.

1. Document engine information
2. Thoroughly clean the engine exterior of dirt, grease, and debris
3. Oil from the engine sump should be drained completely, the fluids should be left overnight to drain to ensure as much as possible.
4. Remove subassemblies like oil filter and engine flywheel.
5. Remove the fuel tank and fuel pipes/hoses.
6. Intake air hose fixed to the intake manifold is to be removed.
7. Remove the blower hose, starter assembly and timing chain
8. After removing timing chain remove clutch assembly

9. Now the cylinder head case has to be detached.

10. Rocker shaft has to be detached.

11. Rocker arm of each cylinders should be dismantled.

12. If the cam shaft is placed on the head of the engine it has to be removed else take out the push rods

13. Now take out the valve springs with this intake and exhaust valves can be removed.

14. Unscrew the bolts and take out the cylinder head.

15. Take out the fuel injectors of each cylinder and remove the distributor.

16. Remove the fuel pump.

17. Keep the engine in upside down position.

18. Remove oil sump.

19. Remove oil strainer and oil pump.

20. Remove connecting rod caps.

21. Remove pistons and connecting rods from topside of cylinder bore.

Inspection:

After dismantling the total engine inspect the parts

1. Inspect Timing Belt and Idler Pulleys, check the turning smoothness of the timing belt idler pulleys

2. Inspect Cylinder Head for Flatness, vertical starches and Cracks, check for any cracking at top due to the thermal and mechanical stress, check also for high temperature corrosion.

3. Inspect the valves, valve springs and check for tension.

4. Inspect camshaft, cam journal oil clearance and cam lobes

5. Inspect the wear and tear of the rocker arm.
6. Inspect intake and exhaust manifold, check the carbon deposits and for any cracks.
7. Check the crankshaft thrust clearance, oil clearance
8. Inspect piston diameter and oil clearance.
9. Inspect piston ring area and grooves, check for the free movement of the piston rings.
10. Inspect for piston ring end gap.
11. Inspect connecting rods.
12. Inspect crankshaft for run out.
13. Inspect main journals and crank pins.

Assembly:

In order to assemble the engine follows the reversal order of the dismantling procedure.

Result:

Disassembly, inspection, and assembly of the given diesel engine are done.

Experiment No 11

Study and Demonstration of Transmission System and Its Components

Aim:

To Study and demonstration of transmission system and its components

Tools:

Gear box

Gearbox study

An automobile requires high torque when climbing hills and when starting, even though they are performed at low speeds. On other hand, when running at high speeds on level roads, high torque is not required because of momentum. So, requirement of a device is occur, which can change the vehicle's torque and its speed according to road condition or when the driver need. This device is known as transmission box.

Main functions:

1. Provide the torque needed to move the vehicle under a variety of road and load conditions. It does this by changing the gear ratio between the engine crankshaft and vehicle drive wheels.
2. Be shifted into reverse so the vehicle can move backward.
3. Be shifted into neutral for starting the engine.

Major components:

1. Counter shaft:

Counter shaft is a shaft which connects with the clutch shaft directly. It contains the gear which connects it to the clutch shaft as well as the main shaft. It may be runs at the engine speed or at lower than engine speed according to gear ratio. It is having fixed gears.

2. Main shaft:

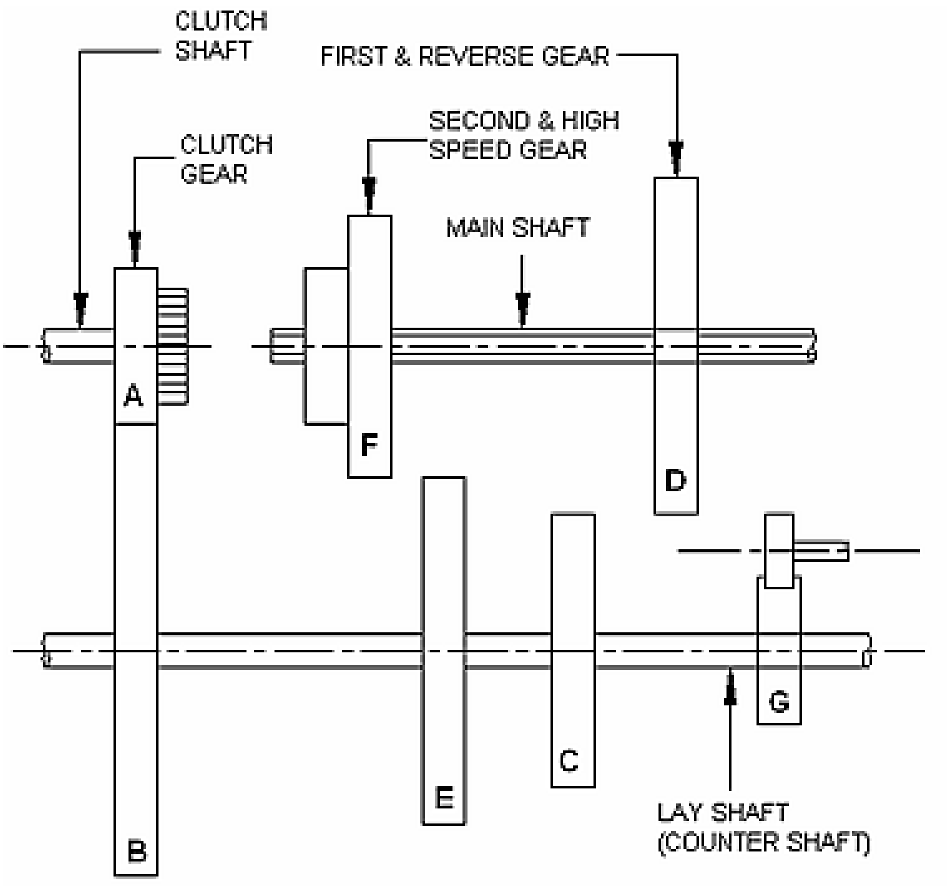
It carries power form the counter shaft by use of gears and according to the gear ratio, it runs at different speed and torque compares to counter shaft. One end of this shaft is connecting with the universal shaft.

3. Gears:

Gears are used to transmit the power form one shaft to another. They are most useful component of transmission box because the variation is torque of counter shaft and main shaft is dependent on the gear ratio. The gear ratio is the ratio of the driven gear teeth to the driving gear teeth. If gear ratio is large than one, the main shaft revolves at lower speed than the counter shaft and the torque of the main shaft is higher than the counter shaft. On other hand if the gear ratio is less than one, than the main shaft revolves at higher speed than the counter shaft and the torque of the main shaft is lower than the counter shaft. A small car gear box contains four speed gear ratio and one reverse gear ratio.

4. Bearings:

Whenever the rotary motion, bearings are required to support the revolving part and reduce the friction. In the gear box both counter and main shaft are supported by the bearing.



Schematic layout of sliding mesh gear box

Working of gear box:

In a gear box, the counter shaft is meshed to the clutch shaft with a use of a couple of gear. So, the counter shaft is always in running condition. When the counter shaft is brought in contact with the main shaft by use of meshing gears, the main shaft starts to rotate according to the gear ratio. When want to change the gear ratio, simply press the clutch pedal which disconnect the counter shaft with engine and connect the main shaft with counter shaft by another gear ratio by use of gearshift lever. In a gear box, the gear teeth and other moving metal must not touch. They must be continuously separated by a thin film of lubricant. This prevents excessive wear and early failure.

Observation Table

S. No	Part name	Quantity	Remarks
1			
2			
3			
4			
5			
6			
7			

Result

Thus, the given gear box is studied and demonstrated of its components.

Experiment No 12

Study And Demonstration of Automotive Wiring Colour Codes and Electrical Symbols

Aim:

To draw general electrical wiring diagram and study of electrical circuits in an automobile.

Theory:

Automotive Wiring

Electrical power and control signals must be delivered to electrical devices reliably and safely so that the electrical system functions are not impaired or converted to hazards. All vehicles are not wired in the same manner; however, once you understand the circuit of one vehicle, should be able to trace an electrical circuit of any vehicle using wiring diagrams and colour codes.

One and Two-Wire Circuits: The branch circuits making up the individual systems have one wire to conduct electricity from the battery to the unit requiring it and ground connections at the battery and the unit to complete the circuit. These are called one-wire circuits or branches of a ground return system. In automotive electrical systems with branch circuits that lead to all parts of the equipment, the ground return system saves installation time and eliminates the need for an additional wiring to complete the circuit. The all-metal construction of the automotive equipment makes it possible to use this system.

The two-wire circuit requires two wires to complete the electrical circuit- one wire from the source of electrical energy to the unit it will operate, and another wire to complete the circuit from the unit back to the source of the electrical power. Two-wire circuits provide positive connection for light and electrical brakes on some trailers. The coupling between the trailer and the equipment, although made of metal and a conductor of electricity, must be jointed to move freely. The rather loose joint or coupling does not provide the positive and continuous connection required to use a ground return system between two vehicles. The two -wire circuit is commonly used on equipment subject to frequent or heavy vibrations. Tracked equipment, off-road vehicles (tactical), and many types of construction equipment are wired in this manner.

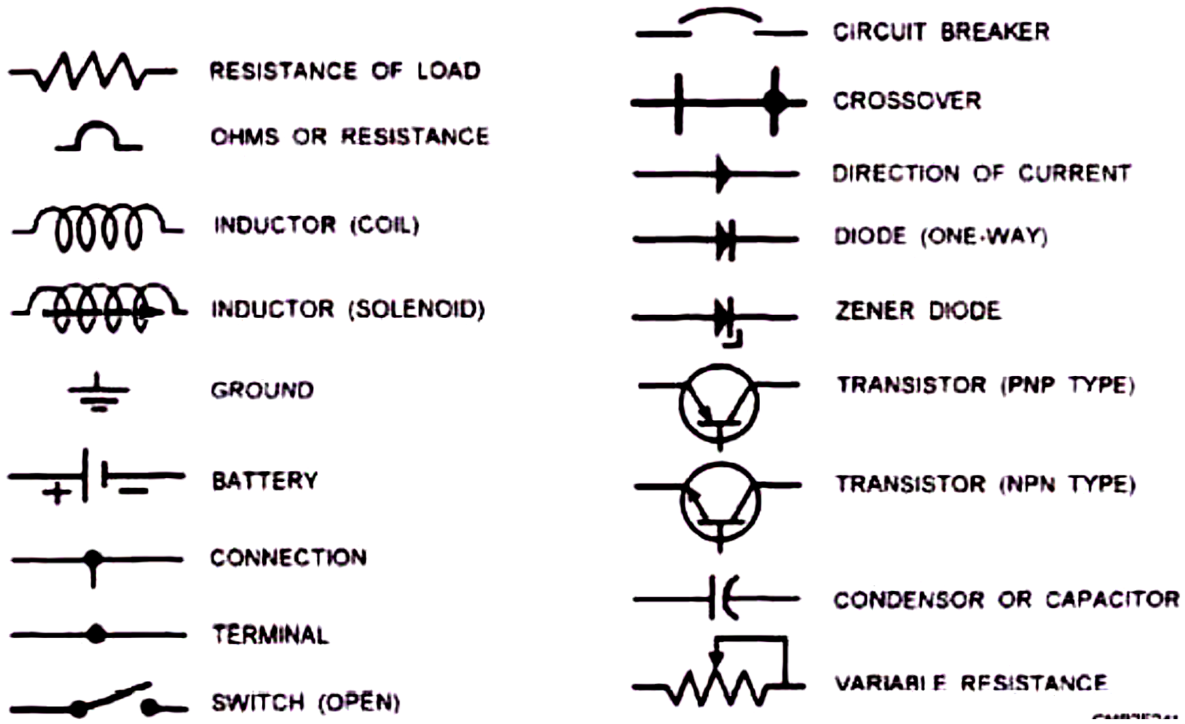


Fig. Electrical symbols

Wiring colour codes

Wires allow electricity to travel from one location to another. Many vital systems in a vehicle won't work if the wiring isn't in place. Copper and aluminium are the most popular types of automotive wire materials. he differences between the two is that copper is more conductive, flexible, and unlikely to corrode than aluminium wire. Wires come in a variety of shapes and sizes and can be found all throughout a vehicle. Some wires merely supply power or ground to specific components, while others carry a range of digital and analog signals to components such as the powertrain control module (PCM). The wire's qualities are mostly determined by its intended function. Wires harness for cars come in a variety of colours. Depending on its function, a wire is usually allocated a colour. This facilitates repairs by allowing the technician to distinguish the function of an individual wire from a group of wires in a wiring harness.

MAIN	***TRACER***	***PURPOSE***
Black		All earth connections
Black	Brown	Tachometer generator to tachometer
Black	Blue	Tachometer generator to tachometer
Black	Red	Electric or electronic speedometer to sensor
Black	Purple	Temperature switch to warning light
Black	Green	Relay to radiator fan motor
Black	Light green	Vacuum brake switch or brake differential pressure valve to warning light and/or buzzer
Black	White	Brake fluid level warning light to switch and handbrake switch, or radio to speakers
Black	yellow	Electric speedometer
Black	Orange	Radiator fan motor to thermal switch

MAIN	***TRACER***	***PURPOSE***
Blue		Lighting switch (head) to dip switch
Blue	Brown	Headlamp relay to headlamp fuse
Blue	Red	Dip switch to headlamp dip beam fuse
		Fuse to right-hand dip headlamp
Blue	Light green	Headlamp wiper motor to headlamp wash pump motor
Blue	White	a) Dip switch to headlamp main beam fuse
		b) Headlamp flasher to main beam fuse
		c) Dip switch main beam warning light
		d) Dip switch to long-range driving light switch
Blue	Yellow	Long-range driving light switch to lamp
Blue	Black	Fuse to right-hand main headlamp
Blue	Pink	Fuse to left-hand dip headlamp
Blue	Slate	Headlamp main beam fuse to left-hand headlamp or inboard headlamps when independently fused
Blue	Orange	Fuse to right-hand dip headlamp

MAIN	***TRACER***	***PURPOSE***
Brown		Main battery lead
Brown	Blue	Control box (compensated voltage control only) to ignition switch and lighting switch (feed)
Brown	Red	Compression ignition starting aid to switch

		Main battery feed to double pole ignition switch
Brown	Purple	Alternator regulator feed
Brown	Green	Dynamo 'F' to control box 'F'
		Alternator field 'F' to control box 'F'
Brown	White	Ammeter to control box
		Ammeter to main alternator terminal
Brown	Yellow	Alternator to 'no charge' warning light
Brown	Black	Alternator battery sensing lead
Brown	Slate	Starter relay contact to starter solenoid
Brown	Orange	Fuel shut-off (diesel stop)

MAIN	***TRACER***	***PURPOSE***
Green		Accessories fused via ignition switch
Green	Brown	Switch to reverse lamp
Green	Blue	Water temperature gauge to temperature unit
Green	Red	Direction indicator switch to left-hand flasher lamps
Green	Purple	Stop lamp switch to stop lamps, or stop lamp switch to lamp failure unit
Green	Light green	Hazard flasher unit to hazard pilot lamp or lamp failure unit to stop lamp bulbs
Green	White	Direction indicator switch to right hand flasher lamps
Green	Yellow	Heater motor to switch single speed (or to 'slow' on tow- or three-speed motor)
Green	Black	Fuel gauge to fuel tank unit or changeover switch or voltage stabilizer to tank units
Green	Pink	Fuse to flasher unit
Green	Slate	a) Heater motor to switch ('fast' on two- or three-speed motor)
		b) Coolant level unit to warning light
Green	Orange	Low fuel level switch to warning light

AIN	***TRACER***	***PURPOSE***
Light green		Instrument voltage stabilizer to instruments
Light green	Brown	Flasher switch to flasher unit
Light green	Blue	a) Flasher switch to left-hand flasher warning light
		b) Coolant level sensor to control unit
		c) Test switch to coolant level control unit

Light green	Red	Fuel tank changeover switch to right-hand tank unit or entry and exit door closed switch to door actuator
Light green	Purple	Flasher unit to flasher warning light
Light green	Green	Start inhibitor relay to change speed switch; or switch to heater blower motor second speed on three-speed unit
Light green	White	Low air pressure switch to buzzer and warning light
Light green	Yellow	Flasher switch to right-hand warning light; or differential lock switch to differential lock warning light
Light green	Black	Front screen jet switch to screen jet motor
Light green	Slate	Fuel tank changeover switch to left-hand tank unit; or entry and exit door open switch to door actuator
Light green	Orange	Rear window wash switch to wash pump; or cab lock-down switch to warning light

MAIN	***TRACER***	***PURPOSE***
Orange		Wiper circuits fused via ignition switch
Orange	Blue	Switch to front screen wiper motor first speed timer or intermittent unit
Orange	Green	Switch to front screen wiper motor second speed
Orange	Black	Switch to front screen wiper motor parking circuit, timer or intermittent unit
Orange	Purple	Timer or intermittent unit to motor parking circuit
Orange	White	Timer or intermittent unit to motor parking circuit
Orange	Yellow	Switch to headlamp or rear window wiper motor feed, timer or relay coil
Orange	Light green	Switch to headlamp or rear window wiper motor parking circuit timer or relay coil
Orange	Pink	Timer or relay to headlamp or rear window wiper motor feed
Orange	Slate	Timer or relay to headlamp or rear window wiper motor parking circuit
Pink	white	Ballast terminal to ignition distributor

MAIN	***TRACER***	***PURPOSE***
Purple		Accessories fed direct from battery via fuse
Purple	Brown	Horn fuse to horn relay when horn is fused separately
Purple	Blue	Fuse to heated rear window relay or switch and warning light
Purple	Red	Switches to map light, under bonnet light, glove box light and boot lamp when fed direct from battery fuse
Purple	Green	Fuse to hazard flasher
Purple	Light green	Fuse to relay for screen demistor

Purple	White	Interior lights to switch (subsidiary circuit door safety lights to switch)
Purple	Yellow	Horn to horn relay
Purple	Black	Horn to horn relay to horn push
Purple	Pink	Rear heated window to switch or relay
Purple	Slate	Aerial lift motor to switch up
Purple	Orange	Aerial lift motor to switch down

MAIN	***TRACER***	***PURPOSE***
Red		Main feed to all circuits mastered by side lamp switch
Red	Brown	Rear fog guard switch to lamps
Red	Blue	Front fog lamp fuse to fog lamp switch
Red	Purple	Switches to map light, under bonnet light, glove box light and boot lamp when side lamp circuit fed
Red	Green	Bulb failure unit to righthand side and rear lamps
Red	White	a) Sidelamp fuse to right-hand side and rear lamps
		b) Sidelamp fuse to panel light rheostat
		c) Fuse to panel light switch or rheostat
		d) Fuse to fibre optic source
Red	Yellow	Fog lamp switch to fog lamp or front fog fuse to fog lamps
Red	Black	Left-hand sidelamp fuse to side and tail lamps and number plate illumination
Red	Pink	Side lamp fuse to lighting relay
Red	Slate	Lamp failure unit to lefthand side and tail lamps
Red	Orange	Fusebox to rear fog guard switch
Slate		Window lift main lead

MAIN	***TRACER***	***PURPOSE***
White		Ignition switch or starter solenoid to ballast resistor
White	Brown	Oil pressure switch to warning light or gauge, or starter relay to oil pressure switch
White	Blue	Choke switch to choke solenoid (unfused) and/or choke to switch to warning light, or electronic ignition distributor to drive resistor
White	Red	Starter switch to starter solenoid or inhibitor switch or starter relay or ignition (start position) to bulb failure unit
White	Purple	Fuel pump no 1 or right-hand to changeover switch
White	Green	Fuel pump no 2 or left-hand to changeover switch
White	Light green	Start switch to starter interlock or oil pressure switch to fuel pump or start inhibitor switch to starter relay or solenoid
White	Yellow	Ballast resistor to coil or starter solenoid to coil

White	Black	Ignition coil contact breaker to distributor contact breaker, or distributor side of coil to voltage impulse tachometer
White	Pink	Ignition switch to radio fuse
White	Slate	Current tachometer to ignition coil
White	Orange	Hazard warning led to switch
Yellow		a) Overdrive
		b) Petrol injection
		c) Door locks
		d) Gear selector switch to start

Result:

The general electrical wiring diagram and electrical systems of an automobile is studied.