Subject Code: BME751	Measurement & Metrology Lab	L T P : 0 0 2	Credits: 1

Course Outcome : Student will be able to		Bloom Taxonomy
CO1	Understand the basic principles of instrumentation for measurement of surface finish, strain, temperature, pressure and flow.	K2
CO2	Understand the principle and operation of Coordinate Measuring Machine (CMM).	K2
CO3	Apply Sine Bar, Slip Gauges, Bevel Protractor, Stroboscope, Dial Indicator etc. for measurement of different attributes.	K3
CO4	Apply the basic concepts of limits, fits & tolerances for selective assembly.	K3

List of Experiments

Minimum 08 experiments out of following (or such experiment) are to be performed:

1. Measurement of effective diameter of a screw thread using 3 wire method.
2. Measurement of angle using sine bar & slip gauges.
3. Study of limit gauges.
4. Study & angular measurement using Bevel protector.
5. Study of different types of Comparators.
6. Study of important parameters of surface finish.
7. Study of principle and operation of coordinate-measuring machine (CMM).
8. Use of dial indicator and V Block to check the circularity and plot the polar Graph.
9. Study and understanding of limits, fits & tolerances in assembly of machine components.
10. Study and understanding of different methods of measurement of pressure.
11. Study and understanding of different methods of measurement of temperature.
12. Study and understanding of measurement of strain using strain gauges.
13. Study and understanding of different methods of measurement of flow.
14. Study and understanding of different methods of measurement of vibration/power.
15. Study and understanding of measurement of displacement using LVDT.

EXPERIMENT NO. - 1

Micrometer:

Principle:- It works on the principle of movement of a nut and a screw both of which have accurately cut threads.

Description:

- It consists of an accurate screw with about 10 or 20 threads per cm and revolves in a fixed nut.
- The accuracy of micrometer depends on the accuracy of the spindle screw threads.

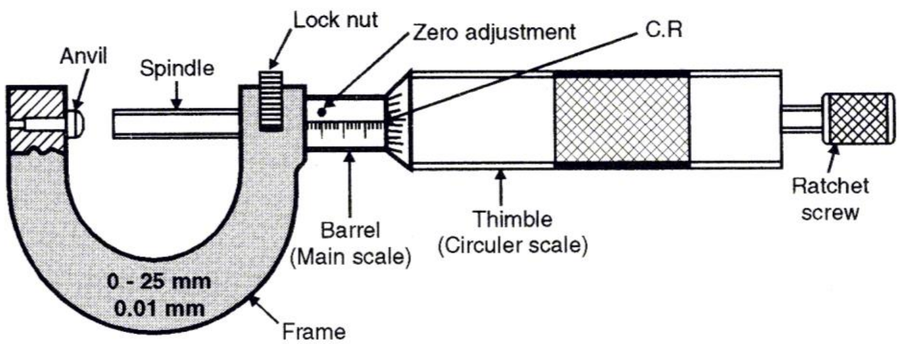


Fig. 11.2.10 : Simple micrometer

As shown in Fig. 11.2.10, the parts of micrometer are as follows:

Screw thread micrometer:

- The working principle is similar to simple micrometer. The only difference is that it is used for accurate measurement of the pitch diameter of screw threads.
- It can measure to an accuracy of 0.01 mm.
- As shown in Fig. 11.2.15.

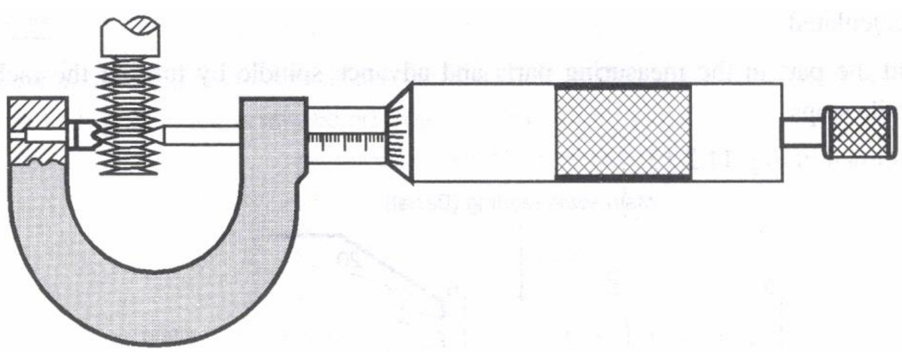


Fig. 11.2.15 : Screw thread micrometer

- The anvil has an internal V which fits over the thread.
- The anvil is free to rotate so as to accommodate to any helix angle of thread.
- It helps to find the pitch diameter or core diameter of the thread.

Digital micrometer:

- It is used where high accuracy is required.
- It is based on electronic technology.
- It can be zeroed at any position, which greatly speeds the process of inspection.

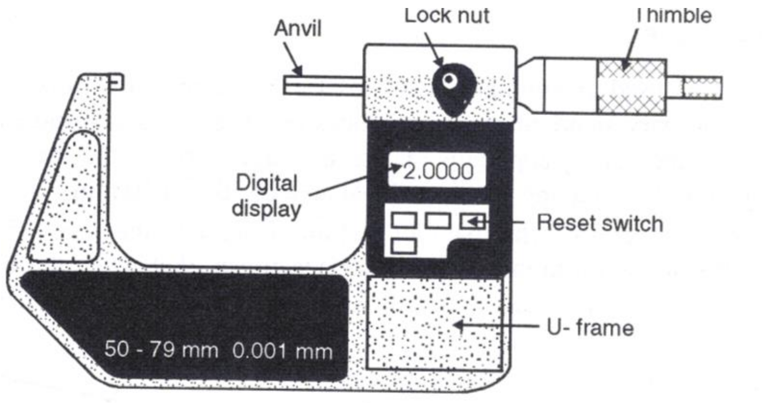


Fig. 11.2.16 : Digital micrometer

Depth micrometer:

• Depth micrometer is used for measuring depths of holes, slots, etc. Its principle is similar to micrometer.
• It consists of one shoulder that acts as the reference while measurement is carried out.
• Extension rods can be used for large ranges of measurement e.g.
Rod-1: Range 0 - 25
Rod-2: Range 25 - 50
Rod-3: Range 50 – 75
Rod-4: Range 75 - 100
• If extension rods are used, the reading is to be calculated as
• Total Reading = [MSR + (CSR x LC)] + [Lower range of extension rod.]
• Very important point to be noted is that, its scale is calibrated in reverse direction.

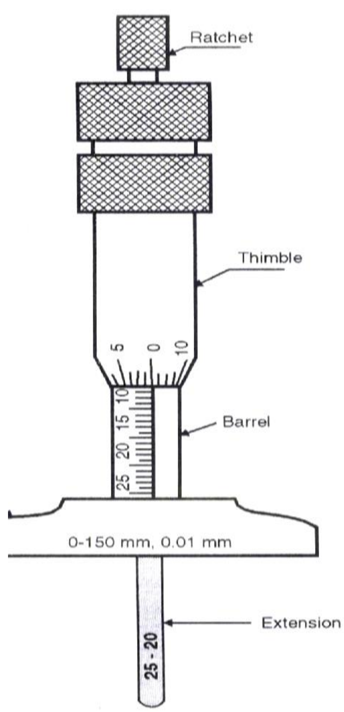


Fig. 11.2.17 : Depth micrometer

• **Ratcher :** It controls the pressure applied on the workpiece for accurate measurement. It is the small extension of thimble.
• **Thimble :** The spindle movement either in forward or backward direction is controlled by the rotation of thimble.
• **Barrel :** It has fixed graduations, which are clearly engraved on it and blackened for reading.
• **Anvil :** It is made up of hardened steel and is rigidly fixed to the one end of the frame. When the spindle touches the anvil, then thimble cannot be rotated further in forward direction.

Least count:
• The thimble which is the movable or circular scale, is divided into 50 equal parts.
• Every fifth graduation is numbered from 0 to 50.

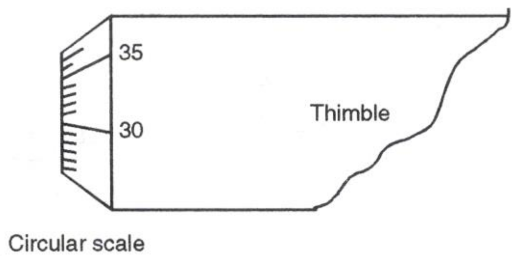


Fig. 11.2.11 : Bevelled edge of thimble

• The barrel which is the main scale has fixed graduations as shown in Fig. 11.2.12.

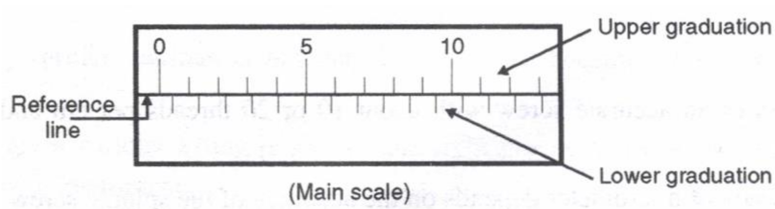


Fig. 11.2.12 : Barrel

• The graduations are above and below the reference line. The upper graduations are of 1 mm each are 0, 5, 10,15,20 and 25.
• The lower graduations are at 1 mm interval, but are placed at the middle of two successive upper graduation so as to read upto 0.5 mm.
• The spindle has a fine thread of pitch 0.5 mm and one full rotation of the thimble moves the spindle by 0.5 mm.
• The thimble has 50 divisions on its circumference.
Therefore one division on the circular scale moves the spindle by
1
x0.5 = 0.01mm
This is called as the least count of micrometer.

$$\therefore \text{ Least count} = \frac{\text{Smallest division on main scale (Barrel)}}{\text{Total number of division on circular scale (Thimble)}}$$

$$= \frac{0.5}{50} \text{ mm}$$

$$= 0.01 \text{ mm}$$

Reading:

• Before using the instrument, it must be checked to zero error and the least count should be calculated.

• Hold the part in the measuring parts and advance spindle by turning the rachet unitil spindle stops.

• As shown inFig. 11.2.13.

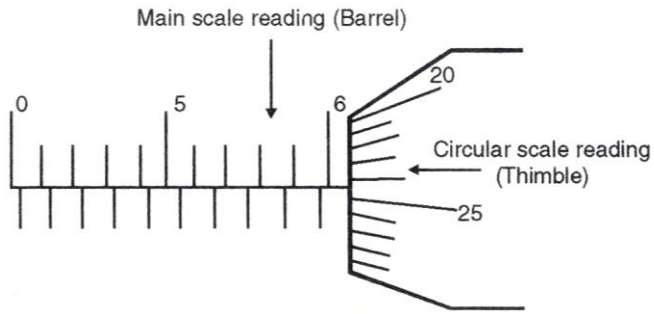


Fig. 11.2.13

$$\therefore \text{ Total reading} = \text{Main scale reading} + (\text{circular scale reading}) \times \text{Least count}$$

$$\therefore \text{ Total reading} = 6 + (23 \times 0.01)$$

$$= 6.23 \text{ mm}$$

• Consider another example, as shown in Fig. 11.2.14.

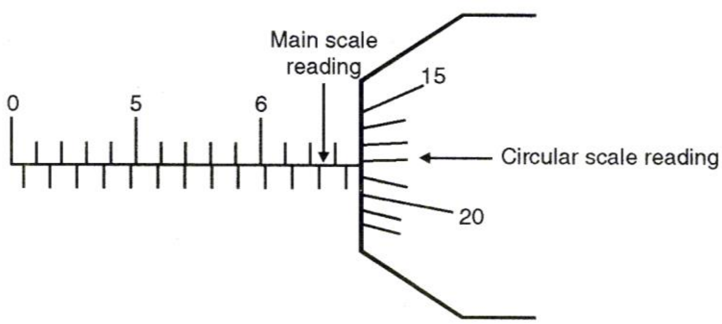


Fig. 11.2.14

Main scale reading = 6.35 mm.

Total reading = Main scale reading + (Circular scale reading) x Least count = 6.35 + (18 x 0.01) = 6.53 mm

Observations

Least count (L.C.) = -----------------------------------

Observation Table

Dimension of Specimen	Trial	Main scale reading	Circular scale reading	Size=M.S.R+C.S.R x LC	Remarks
Thickness	1 2 3				
Length	1 2 3				

7. Result
Length of specimen =
Width of specimen =

--------------Viva Questions---------

1. What is the least count of the Instrument?
2. How to measure the least count of the Instrument.
3. How many types of micrometer are there?
4. What is the various range of the micrometer available in the market?
5. What is the linear measurement?
6. What is the accuracy of micrometer?
7. Differentiate accuracy and precision.
8. What is the principle of micrometer?

EXPERIMENT NO.-2

Measurement of Angle using Sine Bar and Slip Gauges

1 Objective- Measurement of angle using Sine bar & Slip gauges.

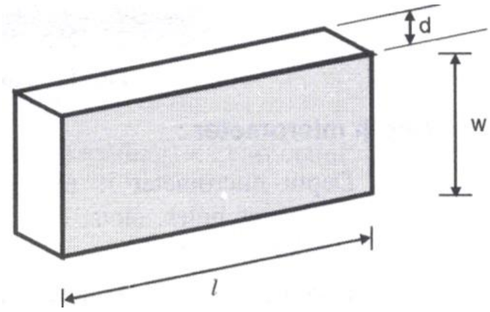
2 Apparatus- Sine Bar, Slip gauge set, Specimen for measurement & Surface plate.

Slip Gauges:

These may be used as reference standards for transferring the dimension of the unit of length from the primary standard to gauge blocks of lower accuracy and for the verification and graduation of measuring apparatus. These are high carbon steel hardened, ground and lapped rectangular blocks, having cross sectional area of 30 mm 10 mm.

Their opposite faces are flat, parallel and are accurately the stated distance apart. The opposite faces are of such a high degree of surface finish, that when the blocks are pressed together with a slight twist by hand, they will wring together. They will remain firmly attached to each other.

They are supplied in sets of 112 pieces down to 32 pieces. Due to properties of slip gauges, they are built up by, wringing into combination which gives size, varying by steps of 0.01 mm and the overall accuracy is of the order of 0.00025mm. Slip gauges with three basic forms are commonly found, these are rectangular, square with center hole, and square without center hole.



The accuracy of individual blocks must be within accepted tolerance limits. The accuracy of gauges can be affected by the dimensional instability of material or by wear in use or damage during storage and handling. The health of slip gauges can be very easily checked by checking it’s wringing quality by wringing the gauge to be tested with an optical flat.

A standard metric set of slip gauge will comprise of 103 pieces made up of as follows

(i) 19 pieces ranging from 1.01 mm to 1.49mm in steps of 0.1 mm.

ii) Fourty nine pieces with a range of 0.5 to 24.5 mm in steps of 0.50 mm.

iii) Four pieces of 25, 50, 75 and 100 mm each.

iv) One piece of 1.005 mm.

Apart from these two extra gauges of 2.5 mm each are supplied as protective slips.

Smaller size metric sets are also available with 76, 56, 48 and 31 pieces. The english slip gauge sets are available with 81, 49, 41, 35 or 28 slips.

According to IS-2984-1966, there are five grades of accuracy such as grade I, Grade II, Grade 0, Grade 00 and calibration grade. Grade I is used for precise work in tool room, for setting sine bars, checking gap of gauges and setting dial indicators to zero.

Grade II is a workshop grade and is used in setting up machine tools, checking mechanical widths. Grade 0 is an inspection grade. Grade 00 is used for highly precision work and the calibration grade is a special grade used for calibrating dial gauges, comparators and other accurate instruments.

According to the method of manufacture, the slip gauges are classified as cohesive and wring together type. The cohesive type is machine lapped with high precision so as to obtain a mirror like polished surface. The wring type has a surface with a scratch pattern finish, due to circular motion in lapping. The cohesive type of gauges is more accurate than the wring type, but their surfaces wear rapidly and they become undersized.

Care of slip gauges: Due to high initial cost and in order to preserve their accuracy, the slip gauges should receive great care during their use. Following factors must be considered regarding the case of slip gauges.

a) It should be used in an atmosphere free from dust.

b) When not in use, they should be kept in their case.

c) Before wringing blocks together, ensure that their faces are perfectly clean.

d) After use, good quality grease should be applied on their faces before they kept in their case.

Wringing:

It takes place when two flat lapped surfaces are placed in contact with a sliding movement. It is the property of measuring faces of a gauge block of adhering by sliding or pressing the gauge against the measuring faces of other gauge blocks of datum surface without the use of any external means. It is due to molecular adhesion between a liquid film and the mating surface of the flat surfaces. The success of precision measurement by slip gauges depends on the phenomenon of wringing. Slip gauges are wrung together by hand through a combined sliding and twisting motion. For separating two wrung slip gauges, combined sliding and twisting motion should be used and no attempt should be made to separate them by direct pull, due to considerable load would have to be applied which may damage the slip gauges. A minute amount of grease or moisture must be present between the surfaces for them to wring satisfactorily.

The technique of wringing together two flat surfaces, such as slip gauges, is quite simple, provided the surfaces are clean and free from burrs. The surfaces should be washed in petrol, benzine and carbon tetra chloride and wiped dry on a clean cloth. It is advisable to hold them across one another at right angles and wring them with rotary motion, it reduces the amount of surface rubbing necessary.

When slip gauges are being used for high precision measurement, or calibration, stringent precautions should be observed concerning cleaning and handling.

Wringing process of slip gauges:

• First keep two slips on one another and slide them to know about any particles present on their surfaces (Fig. 11.2.19(a)).

• Press the faces into contact, perpendicular to each other and give a small twisting motion. (Fig. 11.2.19(b).

• Fig. 11.2.19(c) shows the ‘wrung’ slips, in which gap between two slips is very small in order of 0.00635 jim.

• While removing wrung slips, they can be slide on each other slowly.

• Wringing occurs due to molecular adhesion between a liquid film and mating surfaces.

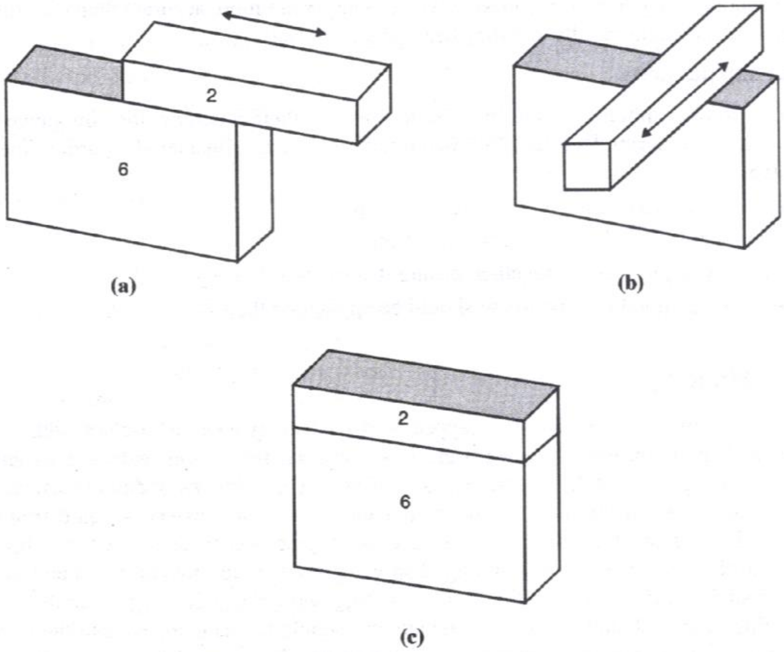


Fig. 11.2.19 : Wringing process of slip gauges

• Thus wringing is defined as the property of measuring faces of a gauge block of adhering, by sliding or pressing against another gauge.

Manufacture of slip gauges:

The following steps should to be followed in order to manufacture good quality slip gauges.

i) Making the approximate size by basic manufacturing operations.

ii) Use of heat treatment process to make the blocks hard, wear and corrosion resistant.

iii) Use of natural or artificial seasoning process to ensure stabilising for the life of blocks. The temperature used for stabilising process is 400, 70°, 130° and 200°C. It is nothing but continuous heating and cooling.

iv) Use of super finishing process to make the block to the appropriate size and shape. A lapping process is carried out at 20°C and controlled humidity of 50%. In American method of manufacturing, the slip gauges are produced to meet the requirement of National Bureau of standards, for size, flatness, parallelism and surface finish. The gauges are made from steel containing 1.45% chromium 0.35% manganese and 1% carbon.

v) Compare the finished gauge with the master gauge.

Angular Measurement:

• For measuring the angle, no absolute standard is required. The measurement is done in degrees, minutes and seconds.

• The measurement of angular and circular divisions is an important part of inspection. It is concerned with the measurement of individual angles, angular changes and deflections on components, gauges and tools. For precision measurement of angles more skill is required.

• Like linear measurement, an angular measurement has their own importance.

• The basic difference between the linear and angular measurement is that no absolute standard is required for angular measurement.

• There are several methods of measuring angles and tapers. The various instruments used are angle gauges, clinometers, bevel protractor, sine bar, sine centers, taper plug and ring gauges.

3 Theory

The sine principle uses the ratio of the length of two sides of a right angle in deriving a given angle. In this arrangement, the angle of sine bar is the sine of the ratio of the difference of heights of the axis of sine bar rollers to the distance of the centers of two axis.

It may be noted that devices operating on sine principle are capable of 'self generation'. The measurement is *usually limited to 45 degree* from loss of accuracy point of view. The accuracy with which the sine principle can be put to use is dependent in practice, on some form of linear measurement.

4 Description of Apparatus

Sine bars used in conjugation with slip gauges constitute a very good device for the precise measurement of angles. 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 established. Two cylinders of equal diameter are attached at the ends.

The axes of these two cylinders are mutually parallel to each other and also 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 5 inches or 10 inches in British system, and 100, 200 & 300 mm in metric system. The various parts are hardened and stabilized before grinding and lapping. All the working surfaces and the cylindrical surfaces of rollers are finished to surface finish of 0.2 - micrometer a value or better. Depending upon the accuracy of the center distance, sine bars are graded as a grade or b grade. Although there are several forms of sine bars

Before using any sine bar for the angular measurement work, for accuracy and precision, it is better to ensure whether the following accuracy requirement as specified by IS 5359-1969 for 100 mm sine bar is met with:

Characteristics	**Permissible tolerance**
• Flatness of upper and lower surfaces	0.001 mm
• Parallelism of upper and lower surface w.r.t datum	
• Surface when resting on it	0.001 mm
• Flatness of side faces	0.005 mm
• Squareness of side faces to upper surface	0.003/25 mm
• Parallelism of side faces to the axes of roller	0.0 1/25 mm
• Flatness of end faces	0.001 mm
• Squareness of end	0.003/25 mm

Sine Bars:

It is used for measurement of an angle of a given job or for setting an angle. They are hardened and precision ground tools for accurate angle setting.

• It can be used in conjunction with slip gauge set and dial gauge for measurement of angles and tapers from horizontal surface.

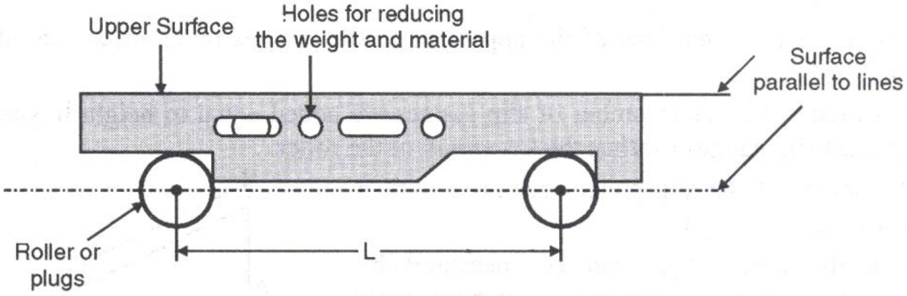


Fig. 11.4.1

• As shown in Fig. 11.4.1, two accurately lapped rollers are located at the extreme position.
• The center to center distance between the rollers or plugs is available for fixed distance i.e. 1 = 100, 200, 250, 300 mm.
• The diameter of the plugs or roller must be of the same size and the center distance between them is accurate.
• The important condition for the sine bar is that the surface of sine bar must be parallel to the center lines of the plug.

Principle of Working:
• The job is placed over the surface plate.
• The sine bar is placed over the job with plug or roller of one end of the bar touching the surface plate.
• One end of the sine bar is rested on the surface plate and the other end is rested on the slip gauges.

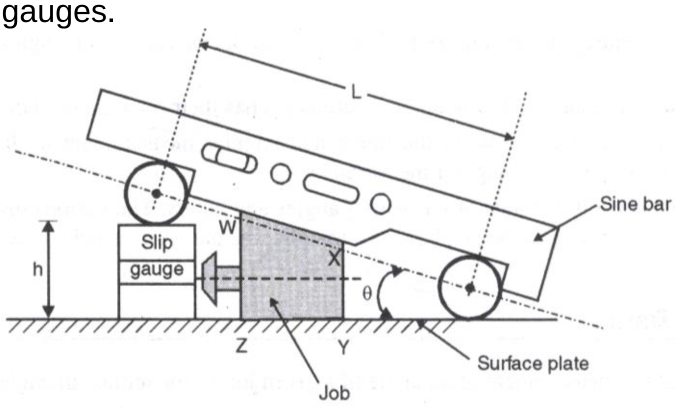


Fig. 11.4.2 : Sine bar

• The angle of the job is then first measured by some non-precision instrument, such as bevel protector.
• That angle gives the idea of the approximate slip gauges required, at the other end of sine bar.
• And finally the exact number of slip gauges is added equal to height h, such that, the top most slip gauges touches the lower end of the roller.
• The height of the slip gauges required is then measured.
• Then the taper angle can be measured by making sine bar as a hypotenous of right angle triangle and slide gauge as the opposite side of the triangle as shown in Fig. 11.4.3.
h = height in mm

L = center distance in mm

$$\sin\theta = \frac{\text{Opposite side}}{\text{Hypotenuse}} = \frac{h}{L}$$

$$\boxed{\therefore \text{ Taper angle } \theta = \sin^{-1}\left(\frac{h}{L}\right)}$$

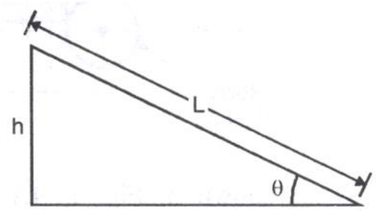


Fig. 11.4.3(a)

When the size of the job is large having taper then we use slip gauges for both the side to find the taper angle of the job.

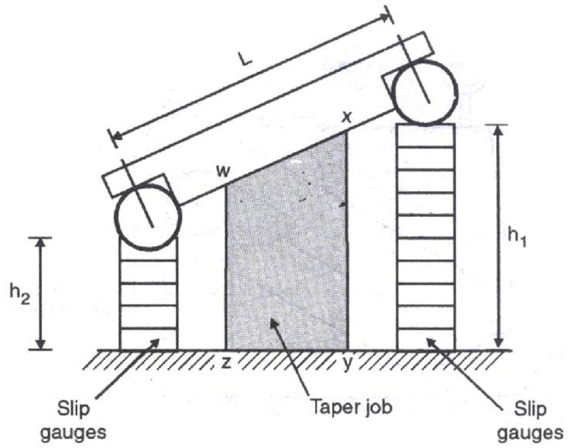
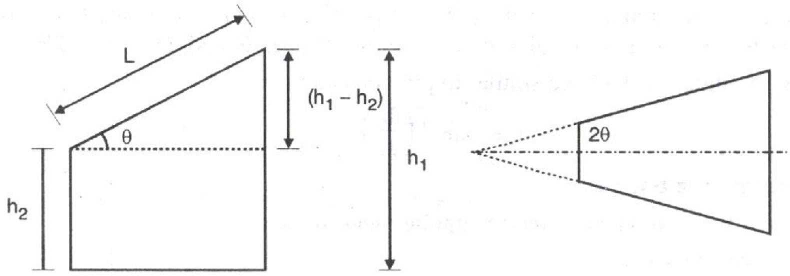


Fig. 11.4.3(b)



(c) **(d)**

Fig. 11.4.3

$$\therefore \text{The taper angle } \theta = \frac{\text{Opposide side}}{\text{Hypotenuse}}$$

$$\therefore \sin\theta = \frac{(h_1 - h_2)}{L}$$

$$\therefore \theta = \sin^{-1}\frac{(h_1 - h_2)}{L}$$

$$\boxed{\therefore \text{Total taper angle} = 2\,\theta = 2\sin^{-1}\frac{(h_1 - h_2)}{L}}$$

- For a small component, the component or workpiece can be placed over a sine bar as shown in Fig. 11.4.4.
- The job is held on the sine bar with some suitable accessories.
- The dial indicator are provided at the top position and the reading is taken at A position.
- The dial indicator is then moved to the right hand side and the reading is taken at position B.

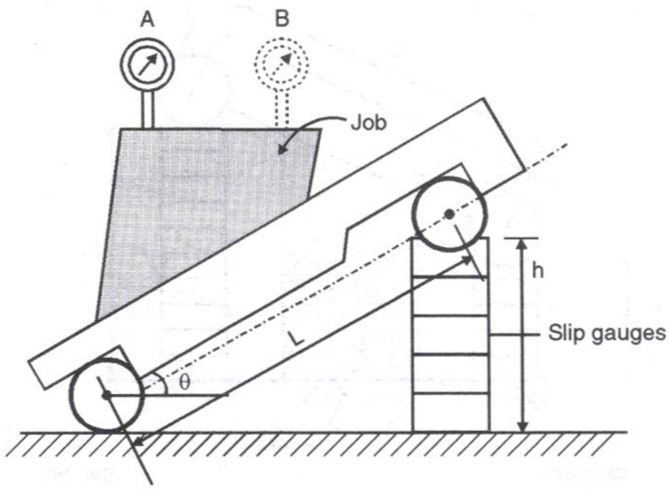


Fig. 11.4.4

• If there is a difference between reading at position A and B, then the height of the slip gauges is adjusted until the dial indicator shows the same reading at A and B.
• Then the angle is calculated similar to previous method as,

$$\theta = \sin^{-1}\left(\frac{h}{L}\right)$$

Advantages of sine bar:
(1) It is used for accurate and precise angular measurement.
(2) It is available easily.
(3) It is cheap.
Disadvantages:
(1) The application is limited for a fixed center distance between two plugs or rollers.
(2) It is difficult to handle and position the slip gauges.
(3) If the angle exceeds 45°, sine bars are impracticable and inaccurate.
(4) Large angular error may results due to slight error in sine bar.

Sine Centers:
• It is the extension of sine bars where two ends are provided on which centers can be clamped, as shown in Fig. 11.5.1.
• These are useful for testing of conical work centered at each end, upto 600.
• The centers ensure correct alignment of the workpiece.
• The procedure of setting is the same as for sine bar.
• The dial indicator is moved on to the job till the reading is same at the extreme position.

- The necessary arrangement is made in the slip gauge height and the angle is calculated as $\theta = \sin^{-1}\left(\frac{h}{L}\right)$.

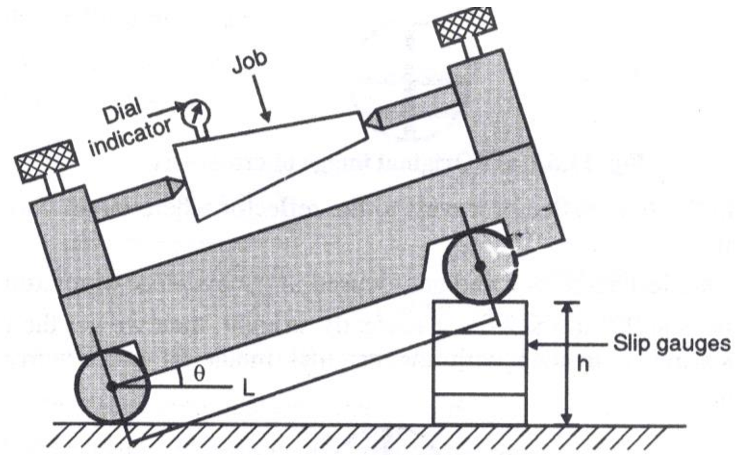
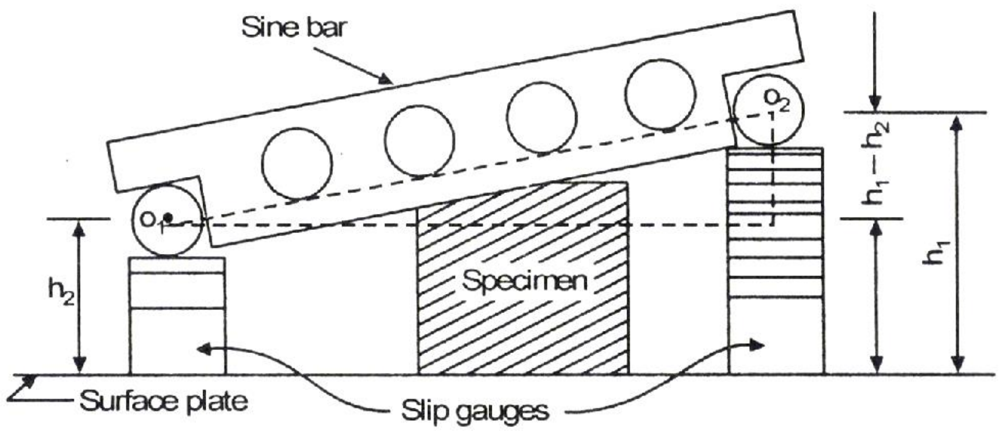


Fig. 11.5.1 : Sine centre

6 Observation
Least Count of Slip gauges =
Length os Sine bar =

Dimension of specimen	**Trial**	**Slip gauge reading on one side (H_1)**	**Slip gauge reading on other side(H_2)**	**Angle sin((H_1-H_2)/L**	**Remarks**
Angle of face 1 with base face	1 2 3				
Angle of face 1 with base face	1 2 3				

Result:
Angle between face1 & face2 =



…..Viva Questions…..

1. Suggest the instrument to measure small angles.
2. What are the different types of sine bars?
3. What is the formula to find angle by using sine bar?
4. Why do we not use sine bar to measure angle of larger size (more than 45°) ?
5. What are the other methods for angle measurement?
6. Why holes are provided in the body of sine bar?

7. Calculate the cone angle of the plug gauge, when slip gauge ($h1 = 50.665$, $h2$ 38.645) length of sine bar 125 mm.
8. Sine bars are specified by
9. Up to what value of angle to be measured, sine bar is preferred.

EXPERIMENT NO-3

Objecitve Study and understanding of limit, fits and tolerances.

Theory

NOMINAL SIZE : The nominal size of the dimension or part is the size by which it is refered to as a matter of convenience.

BASIC SIZE : It is got to be described for the sake of convenience and is the size of a part in relation to which the limits of variation are determined. Often basic size and nominal size of a part of dimension are used with the same sense. When used for fits between shaft and holes, same basic size is specified for both shaft and hole

ZERO LINE This is the line which represents the basic size so that the deviation from the basic size is zero

ACTUAL SIZE : This is the measured size.

LIMITS : These are two extreme permissible sizes for any dimension (high & low).

TOLERENCES Toleranced on a dimension is the difference between the high and low limits of size. It is got to be allowed in order to cover reasonable imperfection in workmanship and the inevitabl in accuracy of manufacturing process, and various with different grades of work. It can be unilateral and bilateral

AllOWANCES : An international difference between the whole dimension and shaft dimension for any type of fit is called the allowance. Maximum allowance is obtained by subtracting the minimum shaft size from the largest whole size and the minimum allowance is the difference in the largest shaft and the smallest hole size.
Thus allowance is positive for clearance fit and negative for interference fit.

FITS : When two parts are to be assembled, the relation resulting from the difference between there sizes before assembling is called the fit. Depending upon the actual limit of hole or shaft, the fit may be clearance fit, or tolerance fit, or interference fit. In connection with figure 1.2 following may be noted.
Tolerance is considered on one side only. Actually it is representive of total tolerance. It is done for sake of clarity and simplification. In schematic representation of tolerances, no regard is given to show shaft and holes fully, but only there magnitude and relative position w.r.t basic size are highlighted.

(a) CLEARANCE FIT : In this type of fit, largest permitted shaft diameter is smaller than the diameter of the smallest hole, so that the shaft can rotate or slide though with different degrees of freedom according to the purpose of the mating member.

(b) INTERFERENCE FIT : In this type of fit the minimum permitted diameter of the shaft is larger than the maximum allowable diameter of the hole. In this case shaft and hole members are intended to be attached permanently and used as a solid component but according to the application of this combination, this type of fit can be varied. Thus, if in use one of the two members is subjected to were. it should be possible to derive of force the two members apart for replacement purposes. Examples of this type of fit are bearing bushes which are in an interference fit in their housing eg. A small end in the connecting rod of an engine.

(c) TRANSITION FIT : In a fit of this type the diameter of the largest allowable hole is greater than that of the smallest shaft, but the smallest hole is smaller than the largest shaft, so that small positive or negative clearance between the shaft and hole members are employable.

Location fits eg. Spigot in mating holes, coupling rings and recesses are the example of transition fit.
DEVIATION : It is defined as algebraic difference between a size (Actual, maximum etc.) [the corresponding basic size.

UPPER DEVIATION It is algebraic difference between the maximum limit of size either hole or shaft) and the corresponding basic size. It is designated by letters ES for hole I es for shaft. It is a positive quantity when the maximum limit of size is greater than the ic size and a negative quantity when the maximum limit of size is less than the basic size

LOWER DEVIATION : It is the algebraic difference between the maximum limit of size I the corresponding basic size. It is a positive quantity when the minimum limit of size is ater than the basic size and a negative quantity when the minimum limit of size is less than basic size. It is designated by El for hole and ei for shaft.

FUNDAMENTAL DEVIATION : It is that one of the two deviations which is conventionally sen to define the position of the tolerance zone in relation to the zero line (refer fig 1.6). This .y be upper or lower deviation which is closer to the zero line (refer figure 1.4-1.5). It fixes position of zero line.

MINIMUM CLEARANCE : In a clearance fit, it refers to the difference between the nimum size of hole and maximum size of shaft.

MAXIMUM CLEARANCE : In the case of clearance or transition fit, it refers to the ference between the maximum size of hole and minimum size of shaft.

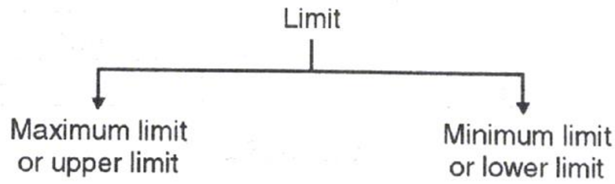
MINIMUM INTERFERENCE : It is a difference between the maximum size of hole and minimum size of shaft in and interference fit prior to assembly.

MAXIMUM INTERFERENCE : In interference of transition fit it is the difference between minimum size of hole and the maximum size of the shaft prior to assembly

ALLOWANCE The difference in the maximum shaft size and minimum hole is known allowance. in a clearance fit this is the minimum clearance and positive allowance. In an erference fit, it is the maximum interference and is negative allowance. Positive and negative owances are shown
Basic shaft is a shaft whose upper deviation is zero, e.g. Shaft ‘h’. Basic hole is one whose lower deviation is zero, e.g. Hole ‘H’.

10.5.1 Limits :

- The term limit refers to the two extreme permissible values between which the actual value of a component is present. Limit of size can be classified as maximum limit and minimum limit of size.



- Maximum limit of size is the greater value out of the two limits or we can say it is the maximum permissible size of a job.
- Minimum limit of size is the smaller value out of the two limits or we can say it is the minimum permissible size of a job.

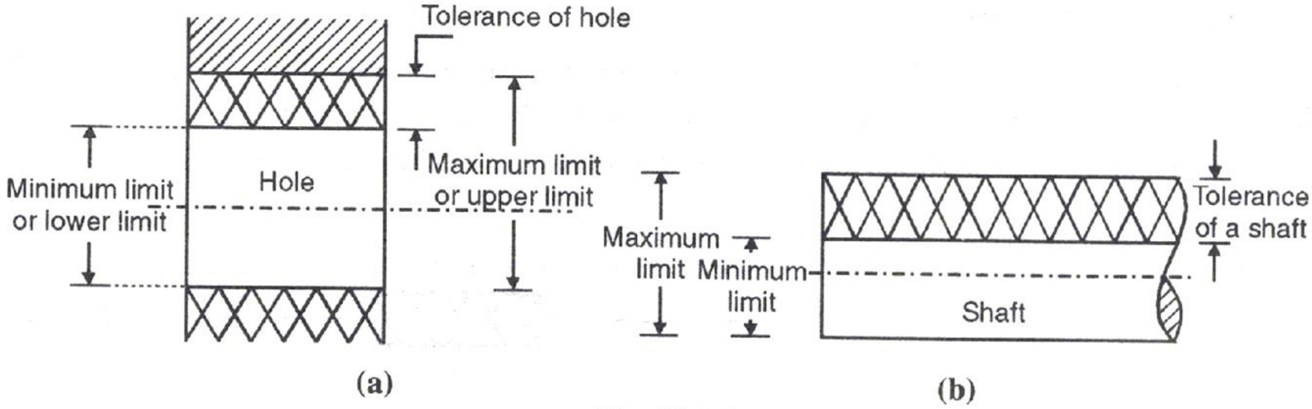


Fig. 10.5.1

Tolerance:

Tolerance is defined as the difference between maximum limit and minimum limit of a hole or a shaft.

Importance of tolerance:

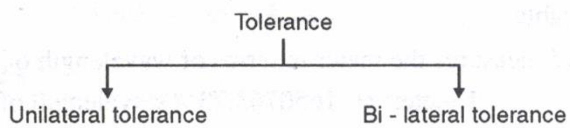
Tolerances are specified due to following purposes:

(i) It is very difficult for an operator to manufacture a component of actual size.

(ii) The production machines themselves have some inherent inaccuracies in them and have limitations to produce a perfect part.

Fig. 10.5.1

(iii) Variations in the properties of the material being machined introduces errors. Tolerance is classified as unilateral tolerance and bi-lateral tolerance.



(a) Unilateral tolerance:

• When the tolerance distribution is only on one side of the basic size, it is referred to as unilateral tolerance.

• In this case, one value of the limit of tolerance is zero while the other value indicates the allowable deviation or variation.

e.g.

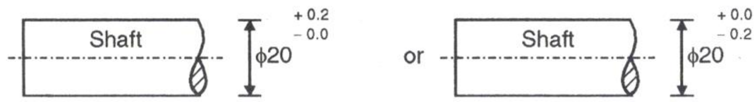


Fig. 10.5.2

Fig. 10.5.3

(b) Bilateral tolerance:

When one limit of size is on one side of zero line and other limit of size is on the other side of zero line then the tolerance specified is called as bilateral tolerance.

In this case, the variations are specified on both sides of the zero line.

e.g.

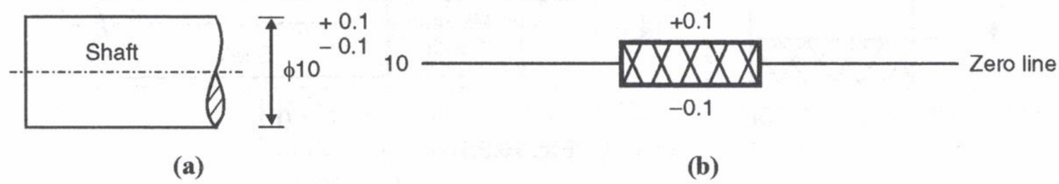


Fig. 10.5.4

Fits:

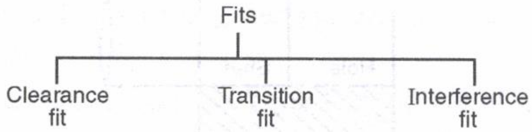
It is defined as the degree of tightness or looseness between two mating parts.

• When two parts are to be assembled together, the relation resulting from the difference between their sizes before assembly is termed as fit.

• It is the term used to specify the range of tightness that will occur with the application of tolerance and allowance in mating parts.

• The selection of fits is made from the tables.

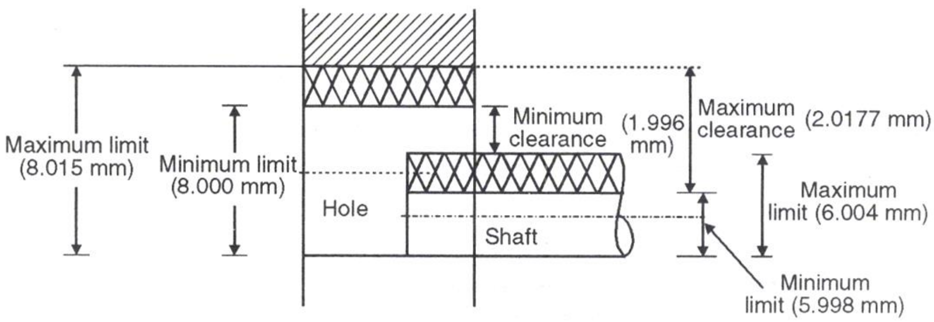
• Depending upon the actual limit of the hole or shaft, the fit may be decided as a clearance fit, transition fit or interference fit.



(a) Clearance fit:

• It is the difference between the sizes of the hole and the shaft before assembly.

• The tolerance zone of the hole is entirely above the tolerance zone of shaft. We can say that the largest permissible shaft diameter is smaller than the smallest size of a hole so that shaft can rotate or slide easily.



e.g. Maximum clearance = Maximum limit of a hole-minimum limit of a shaft= 8.015 -5.998 = 2.017 mm

Minimum clearance = Minimum limit of a hole-Maximum limit of a shaft= 8.00-6.004 = 1.996 mm

(b) Interference fit:

• When the minimum limit of a shaft is greater than the maximum limit of a hole, then it is referred to as interference fit.
• The difference between the size of the hole and the shaft is negative. In this type of fit, shaft is always larger than hole.
Fig.
• In clearance fit, maximum material remains on the component.

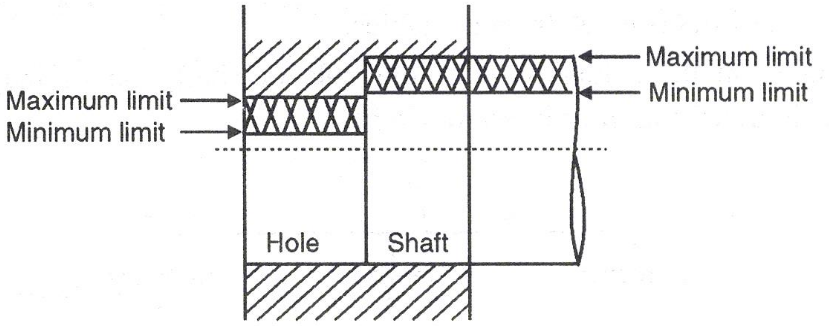


Fig. 10.5.6 : Interference fit

• Minimum interference can be calculated as the difference between maximum limit of hole and the minimum limit of shaft, where as maximum interference can be calculated as the difference between the minimum limit of a hole and the maximum limit of a shaft.
• The value of maximum and minimum interference is always negative.

(c) Transition fit:

• When the diameter of largest allowable hole is greater than the smallest size of shaft, but the smallest hole is smaller than the largest shaft, then the mating of hole and shaft is referred to as a transition fit.

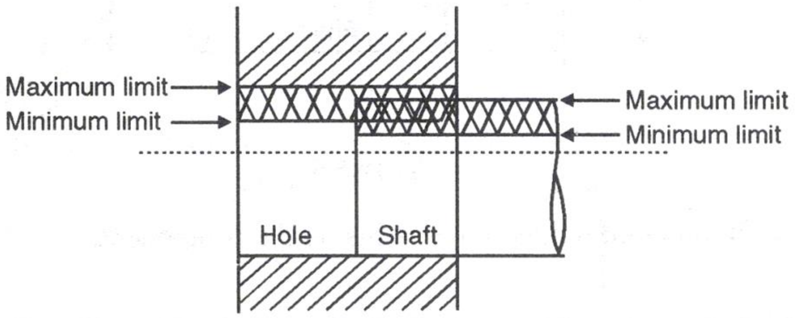


Fig. 10.5.7 : Transition fit

• Transition fit may provide either a clearance fit or an interference fit and the tolerance zones of hole and shaft overlap in this type of fit.
• In this, the shaft with the minimum limit will fit into a hole with maximum limit with an amount of clearance, indicating clearance fit.
• Also, the shaft with maximum limit will fit into a hole with the minimum limit with an amount of interference, indicating interference fit.

6 Types of System:

1 Hole Basis System:

• In this system, the hole is kept constant and the shaft diameter is varied to get the various types of fits.
• The basic size of the hole is taken as lower limit of size of the hole. Then the higher limit of size of the hole is selected along with the two limits of size for shaft to get the desired fit.
• In the basic hole system, the holes get the letter H and the shafts get different letters to decide the position of tolerance zone to obtain a desired fit.
• The actual size of hole that is within the tolerance limits is always more than the basic size.
• It is preferable to use the hole basis system because it is economical.

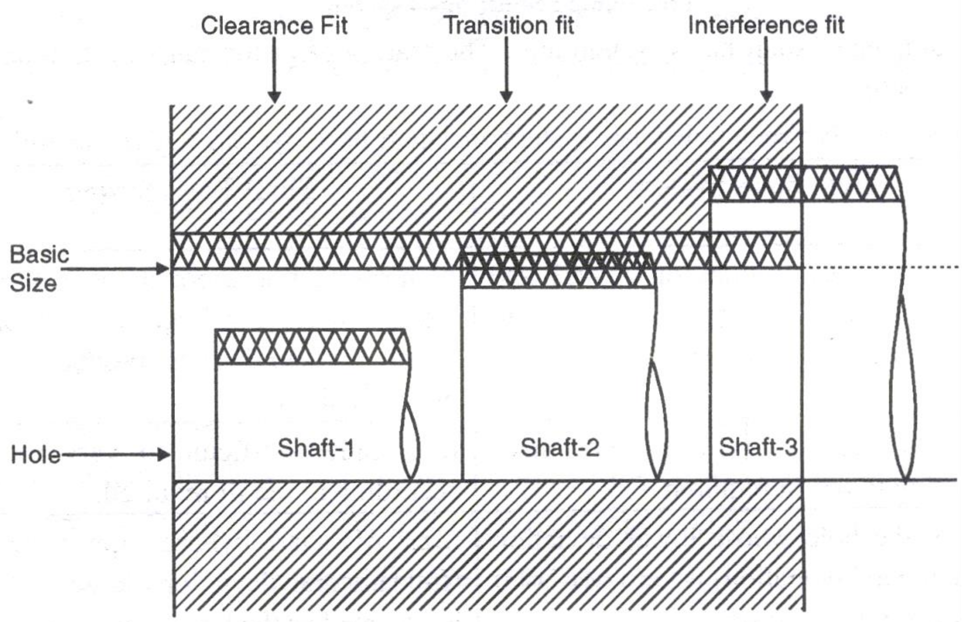


Fig. 10.6.1 : Hole basis system

2 Shaft Basis System:
• The shaft is kept constant and the size of hole is varied to get the various fits. The basic size of the shaft is taken as one of the limits of size for the shaft (maximum limit).
• The other shaft limit of size and the two limits of size for the hole are then selected to get the desired fit.
• The actual size of a shaft that is within the tolerance limits is always less than the basic size. It is easier and more convenient to manufacture shafts of varying sizes than holes of varying sizes. The shaft basis system is indicated by h'.

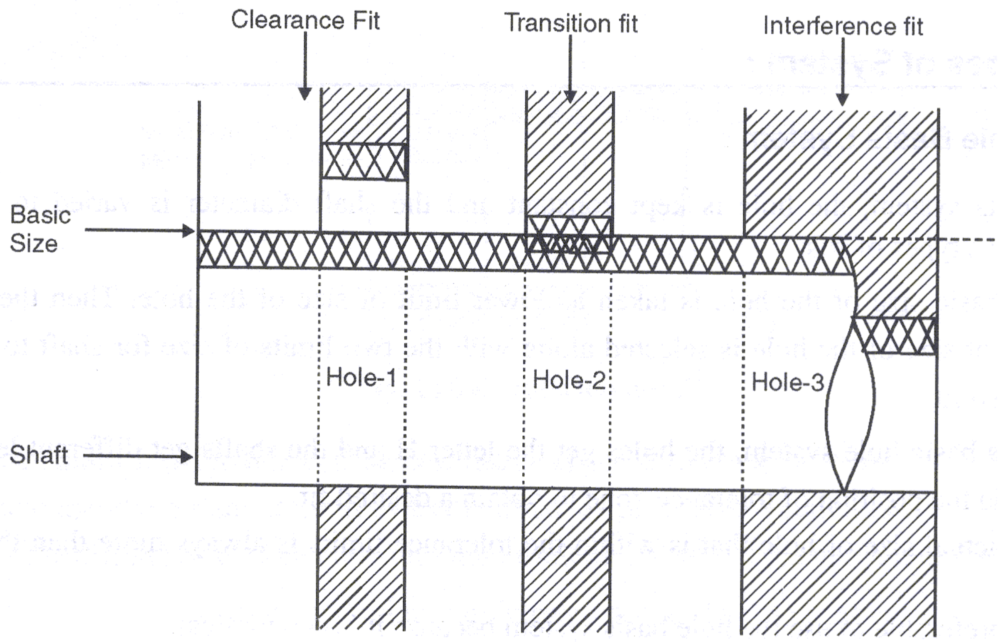


Fig. 10.6.2 : Shaft basis system

Shaft basis system

• The examples of shaft basis system are: The mating of piston pin with both the piston and connecting rod.

• The difference between hole basis system and shaft basis system is given as follows:

Sr. No.	Hole Basis System	Shaft Basis System
1	It requires less amount of capital and storage space for tools needed to produce shafts of different sizes.	It needs large amount of capital and storage space for large number of tools which are required to produce holes of different sizes.
2	It is much easy to vary the shaft sizes according to the fit required.	It is rather difficult to vary the holes according to the fit required.
3	Size of the hole whose lower deviation (fundamental deviation) is zero, (H-hole) is assumed on basic size.	Size of shaft whose upper deviation (fundamental deviation) is zero (h-shaft) is assumed as the basic size.
4	Limits of the hole are kept constant and those of the shaft are varied to obtain the desired type to fit.	Limits on the shaft are kept constant and those on the hole are varied to get the necessary fit.
5	System is preferred in mass production because it is easy, convenient and less costly to make a hole of correct size.	System is not suitable in mass production because it is not convenient and it is costly to make a shaft of correct size.
6	Gauging of shafts can be easily and conveniently done with adjustable gauging.	Being internal measurement, gauging of holes cannot be easily and conveniently done.

EXPERIMENT NO- 4

Study and Angular Measurement using Bevel Protractor

1.Objective- Study and angular measurement using Bevel protractor

2.Instrument- Vernier Bevel Protractor,Specimen for Angle measurement.

3.Theory

The vernier Bevel Protractor instrument used an additional scale, called the vernire circular Which can slide along the main circular scale. This arrangement enables a friction of scale division to be determined with a fixed accuracy depending upon the nature of the scale.

The difference between one scale division and vernier division is called the vernier constant or least-count of the vernier Bevel protractor. This represents the smallest angle that can be measured accurately by using the vernier Bevel Protractor.

1V.C.S.D. = 23/24 M.C.S,D.
1 M.C.S.D - 1V.C.S.D = (1 - 23/24) M.C.S.D.
= 0.041667 M.C.S.D.
= 2.5'

4.Description of Instrument

It is probably the simplest instrument for measuring the angle between two faces of component. It consists of a base plate attached to the main body and an adjustable blade,
which is attached to a cirular plate contaning vernier scale. The adjustable blade is capable of rotating freely about the center of main scale engraved on the body of the instrument & can be locked in any position, an acute angle attachment is provided at the top for the purpose of measuring acute angle, the base of the base plate is made flat so that it could be laid Flat upon the work and any type of angle measured. It is capable of measuring from 0 - 360 The vernier scale has 24 divisions coinciding with 23 main scale divisions. Thus the count of the instrument is 5'. This instrument is most commonly used in workshop for angular measurement till more precision is required.

Types of Bevel Protractor

The bevel protractors are of two types
1. Mechanical Bevel protractor
2. Optical Bevel protractor.

The Mechanical Bevel protractors are further classified into 4 types A, B, C, D. In type A & B the vernier is graduated to read to 5 minute of arcs whereas in case of type C, the scale is graduated to read in degree and the bevel protractor in without vernier or fine adjustment device. The difference between type A & B is that type A is provided with fine adjustment device or acute angle attachment whereas type B is not. The scales of all the types are graduated either as a full scale mark 0-90-0-90 with one vernier or as semi circle marked 0-90-0 with two vernier 180 apart. Type D is graduated in degree and is not provided with either vernier or fine adjustment device or acute angle attachment.

Uses of Bevel protractor

It is used for testing flatness, squareness, parallelism, straightness & angular intervals.

5. Observation:
Least Count of vernier Bevel protractor=

6. Observation Table

Angle b/w faces	Trial	Main scale reading	Vernier scale reading	Size=M.S.R+V.S.R x LC	Remarks
Angle of face 1 with face 2	1 2 3				
Angle of face 2 with face 3	1 2 3				

Result
Angle between face 1 & face 2 =
Angle between face 2 & face 3 =

……..Viva Questions……….

1. Name various instruments used for measuring angle.
2. Name different types of protractors.
3. Which instrument do you prefer for measuring 85° angle?
4. What is the system of representation of angle?
5. What is Clinometer?
6. What is the least count of Bevel protracor?
7. Define an angle, right angle and one radian.
8. Which one is more accurate (vernier/optical) Bevel Protractor?
9. A Bevel protractor is a measuring instrument/gauge/comparator.

EXPERIMENT NO-

Study of Dial Indicator and its constructional Details

1 Objective-To Study the constructional features and functions of the components

2 Instrument- Dial Indicator, Screw Driver.

3 Theory

Dial Indicators are instruments used for making and checking linear measurements. The instrument should be capable of giving trouble free and dependable measurements. The design and construction should be studied. When dial indicator is used as essential part in the mechanism of any set-up for comparison measurement purpose, it is referred to as dial gauge. These are generally used as comparators.

4 Description of Instrument

Dial indicators are smaller indicating devices containing a graduated dial scale and these depend upon gear and pinion or lever magnification system.

The dial indicators take the form of a circular or semi circular scale upon which a pointer gives a direct indication of the movements of a contact arm or spindle. Small changes of dimension of the component in contact with the spindle are made to assume large proportions by employing some mechanical amplification and the reading to be obtained on scale.

There is a plunger which is a perfect sliding fit in its own bearings. Two gears and two pinions are meshed with this plunger. The rotation of the plunger about its own axis is prevented by a pin attached to it. The pointer is fixed to the spindle. If the pointer makes more than one revolution, a revolution counter is also incorporated. A light hair spring is incorporated to avoid backlash.

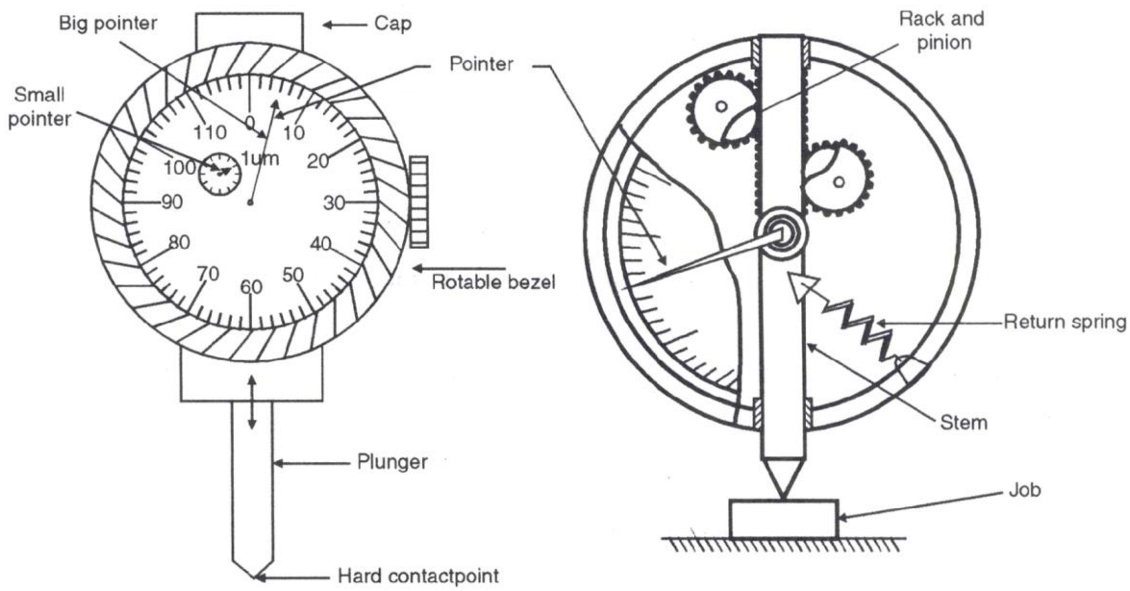
5 Procedure

1. Place the dial indicator on a clean cloth.
2. Remove the back plate of dial indicator by removing the screw by screw Driver.
3. Carefully study all the components.
4. Draw the sketch of the dial indicator.

6 Description and Function of Components with Sketch:

1. Plunger:
2. Large Pointer:
3. Small Pointer:
4. Bezel:
5. Bezel clamp knob:
6. Main Case:
7. Bottom Plate:
8. Plunger Guide pin:
9. Centre plate with centre pinion:
10. Backlash spindle and wheel assembly:
11. Top plate:
12. Plunger stop screw:
13. Rack pinion and wheel assembly:
14. Tension spring:

• It operates on the principle, that a very slight upward pressure on the spindle at the contact point is multiplied through a system of gears and levers. It is indicated on the face of the dial by a dial finger.
• Dial indicators basically consists of a body with a round graduated dial and a contact point connected with a spiral or gear train so that hand on the dial face indicates the amount of movement of the contact point.
• They are designed for use on a wide range of standard measuring devices such as dial box gauges, portable dial, hand gauges, dial depth gauges, diameter gauges and dial indicator snap gauge.



(a) Dial indicator (b) Mechanism of dial indicator

Fig. 15.5.1

• They are available in dial graduations of 0.01 mm and some sensitive types of gauges have graduations of 0.002 mm.
• One revolution of dial finger corresponds to a spindle movement of 1 mm.
• The movement mechanism of the instrument is housed in a metal case for it’s protection. The large dial scale is graduated into 100 divisions.
• The indicator is set to zero by the use of slip gauges representing the basic size of part.

Requirements of good dial indicator:
i) It should give trouble free and dependable readings over a long period.
ii) The pressure required on measuring head to obtain zero reading must remain constant over the whole range.
iii) The pointer should indicate the direction of movement of the measuring plunger.
iv) The accuracy of the readings should be within close limits of the various sizes and ranges.
v) The movement of the measuring plunger should be in either direction without affecting the accuracy.
vi) The pointer movement should be damped, so that it will not oscillate when the readings are being taken.

……………Viva Questions…………

1. What is a Dial Indicator?
2. What is the function of Dial Indicator?
3. What are the requirements of a good dial indicator.
4. What is gear backlash, how to overcome from this.
5. What is least count and span of dial indicator.
6. Name any four different types of dial gauges.
7. Explain the working principle of a dial indicator.
8. What are the important characteristics of dial indicator.
9. A Dial indicator is a measuring instrument/gauge/comparator.

EXPERIMENT NO-

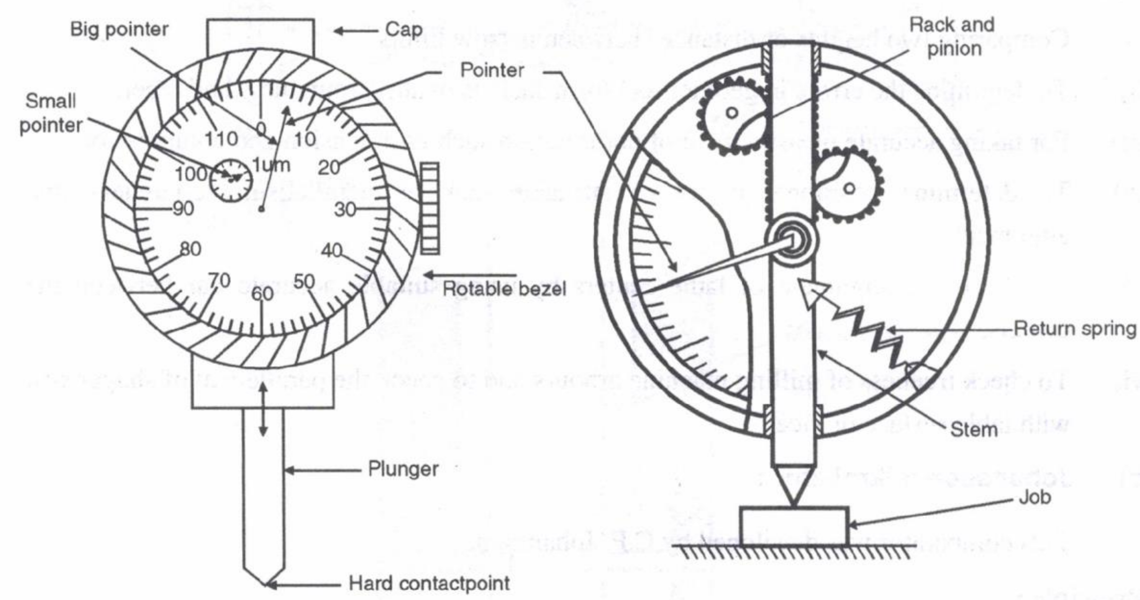
Use of Dial Indicator to check circularity of Rod

Objective -To Check the Circularity of a given Rod using Dial Indicator

Apparatus / Device-Surface table, V- Block, Dial Indicator, Vernier Caliper.

Theory-In the assembly of the circular parts, only the dimensional tolerances on diameter will not sufficient requirements, but it is the geometrical accuracy that needs closer attention. Roundness and circularity are interchangeable word.
Roundness is defined as a condition of a surface of evolution where all the points of the surface intersected by any plane perpendicular to a common axis in case of cylinder and cone are equi-distant from the axis. Since the axis and centre do not exist physically, measurements have to be made with reference to surfaces of the figures of revolution only. For measuring roundness, it is only the circularity of the contour which is determined.

• It operates on the principle, that a very slight upward pressure on the spindle at the contact point is multiplied through a system of gears and levers. It is indicated on the face of the dial by a dial finger.
• Dial indicators basically consists of a body with a round graduated dial and a contact point connected with a spiral or gear train so that hand on the dial face indicates the amount of movement of the contact point.
• They are designed for use on a wide range of standard measuring devices such as dial box gauges, portable dial, hand gauges, dial depth gauges, diameter gauges and dial indicator snap gauge.



(a) Dial indicator (b) Mechanism of dial indicator

Fig. 15.5.1

• They are available in dial graduations of 0.01 mm and some sensitive type of gauges have graduations of 0.002 mm.
• One revolution of dial finger corresponds to a spindle movement of 1 mm.

• The movement mechanism of the instrument is housed in a metal case for it's protection. The large dial scale is graduated into 100 divisions.
• The indicator is set to zero by the use of slip gauges representing the basic size of part.

Characteristics of Good Comparators:

(1) It should be compact.
(2) It should be easy to handle.
(3) It should give quick response or quick result.
(4) It should be reliable, while in use.
(5) There should be no effects of environment on the comparator.
(6) Its weight must be less.
(7) It must be cheaper.
(8) It must be easily available in the market.
(9) It should be sensitive as per the requirement.
(10) The design should be robust.
(11) It should be linear in scale so that it is easy to read and get uniform response.
(12) It should have less maintenance.
(13) It should have hard contact point, with long life.
(14) It should be free from backlash and wear.

Requirements of good dial indicator:

i) It should give trouble free and dependable readings over a long period.
ii) The pressure required on measuring head to obtain zero reading must remain constant over the whole range.
iii) The pointer should indicate the direction of movement of the measuring plunger.
iv) The accuracy of the readings should be within close limits of the various sizes and ranges.
v) The movement of the measuring plunger should be in either direction without affecting the accuracy.
vi) The pointer movement should be damped, so that it will not oscillate when the readings are being taken.

Procedure

1. Clean the Surface of the Surface table with cleaning cloth; apply a thin layer of oil on the table.
2. Place the V- block on the surface table.
3. Divide the circle of the circular rod into 12 equal parts, each angle equal to 30°. Mark the lines on the rod, corresponding to the divided angle.
4. Place the given work piece on the V-block.
5. Fix the dial indicator with the stand and make ensure the tip of the spindle of dial indicator touches the rod gently.
6. Adjust the needle to dial indicator to zero.
7. Rotate the rod on the V- block, such that the spindle tip of dial indicator touches the next marked point.
8. Observe for the pointer deflection, if the pointer deflects ***clockwise the deflection*** is considered as **+ve,** if the pointer deflects ***anticlockwise***, then the deflection is considered as**-ve**.
Note down the reading of the pointer in units. Mark the points on a sheet of paper and join all the 12 points.
9. Repeat the procedure for another set of points
10.Draw all the points on the sheet of paper, selecting suitable scale & draw the circles for maximum inward departure &maximum outward departure

Observation
Length of the Rod **L** = ___________________**mm**

Diameter of the Rod **D**=___________________**mm**

Observation Table: ***For Circle A***

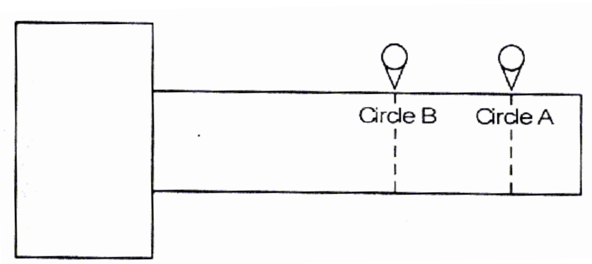
Point	**Dial indicator Reading in MM**	**Point**	**Dial indicator Reading in MM**
1		**7**	
2		**8**	
3		**9**	
4		**10**	
5		**11**	
6		**12**	

For Circle B

Point	**Dial indicator Reading in MM**	**Point**	**Dial indicator Reading in MM**
1		**7**	
2		**8**	
3		**9**	
4		**10**	
5		**11**	
6		**12**	

Result & Conclusion

The circularity of rod varies from maximum inward departure diameter______________ mm to maximum outward departure diameter______________ mm



Applications:
i) Comparing two heights or distances between narrow limits.
ii) To determine the errors in geometrical form such as ovality, roundness and taper.
iii) For taking accurate measurement of deformation such as in tension and compression.
iv) To determine positional errors of surfaces such as parallelism, squareness and alignment.
v) To check the alignment of lathe centers by using suitable accurate bar between the centers.
vi) To check trueness of milling machine arbours and to check the parallelism of shaper arm with table surface or vice.

………..Viva Questions……………

1. What is Circularity?
2, Explain V- block.
3. Explain ovality.
4. What is Lobbing?
5. How to measure run out.
6. What is the Least Count of Dial indicator?
7. What is Backlash error?
8. Does the angle of V. Block have any effect in circularity measurement?
9. What are other methods to check the circularity?
10. Is there any difference in the reading of dial indicator while using surface plate instead of V block?

EXPERIMENT NO. -

Study of feeler Gauges

Objective- (1) Study of Limit gauges

Objective- (2) Adjustment of spark plug gap using feeler gauges. (Say 1.7mm)

Study of Limit gauges

When parts are produced in large scale, they must be inspected quickly to check *conformation* to the design dimensions before delivering the parts to the customer. A gauge can be defined as an inspection tool that is *without a scale* & is used to check the dimensions of the manufactured parts quickly, since its without scale, it does not indicate the actual value of the inspected dimensions on the specimen.
Gauges are used to determine whether the inspected dimension lies within the specified limits or not.
Though their seems to be some functional similarities between a gauge & comparator

Taylor's principle of gauge design:

According to Taylor, GO-gauge corresponds to maximum material condition while NO GO-gauge corresponds to minimum material condition

The difference between the sizes of these two gauge is equal to the tolerance on the work piece

For shafts GO ring gauge corresponds to upper limit for shafts
NO Go ring gauge corresponds to lower limit for shafts

It can be contemplated (think) that the ***shaft is within the specified limits if it can't enter NO GO ring*** <u>but can pass through GO ring gauge.</u>

For Holes GO ring gauge corresponds to lower limit of hole
NO Go ring gauge corresponds to upper limit of hole

Thus it can be contemplated (think) that the hole is manufactured within the specified (prescribed) limits if it NO GO ring cannot enter the hole <u>**but *GO ring gauge can pass through the hole.***</u>

Classification of gauges

According to their type-	Std. gauge, limit gauge
According to their use-	Master gauge, Inspection gauge, Workshop gauge
According to the form of tested surface-	plug gauge, Ring gauge, Snap gauge,
According to their design-	Single limit & double limit gauge

Limit plug gauge: - Limit gauge comprises with GO & NO- GO gauges. As there are two permissible limits of a dimension.

To check a dimension both Go & NO GO gauges are used. The GO gauge should pass through or over the specimen & NO GO gauge should fail to pass through or over the specimen under the action of its own weight.
This indicates that dimensions being checked are within the specified tolerance.
If both the gauges fail to pass, it means that the hole is under sized or shaft is over sized, If both the gauges pass, it means that the hole is over sized or shaft is under sized

Snap Gauge: - Snap gauges are suitable for gauging both cylindrical as well as non cylindrical work. Double- ended snap gauges are used for checking sizes in the range of 3mm to 100mm.

Radius Gauge: - Generally, at the intersection of two flat surfaces, a radius is provided to avoid stress concentration & also to avoid sharp edges, rounding is done. To measure such radius a radius gauge can be used. It consist of a set of blades, there is internal & external radius on each blade which is also stamped with the corresponding radius value.

Pitch Screw Gauge: - It is used to determine pitch of screw threads by matching the teeth on the blades with threads on the specimen.

Objective- (2) Adjustment of spark plug gap using feeler gauges. (Say 1.7mm)

2 Apparatus- Feeler gauge set, spark plug.

3 Theory

Feeler gauges are used to measure the gap between two parallel flat faces e.g. in gauging of the clearance between the piston and cylinder, gap of pointer of spark plug etc.

Their working depends entirely on the sense of feel the feeler blade should neither before between the surface nor should it slide freely, rather the correct blade will give a characteristic gauge fit type of feel. If necessary, two blades may be joined together for making a dimension.

4 Descriptions of Apparatus

A feeler gauge consists of a narrow strip of sheet steel made to a given thickness. The complete set consists of a number of gauging blades of different thickness assembled together.

Feeler gauge generally comprise of a series of gauging blade of different grades and thickness, from .03 to 1 mm assembled in protective sheath. The blades are made of heat treated bright polished tool steel having a tensile strength of about 170 kgf/mm2 for thickness up to .5 mm and 70kgf/mm2 for thickness .5 mm and above.

Generally the blades are available in over all length of 100 mm. These are 12 mm wide at heel and are tapered for the outer part of their length so that the width at the tip is approximately 6mm. These are hinged in the sheath on a screw and nut of such a design that the blades are removable.
The nut is in the form of bush, passing through both sides of the sheet and form a hinge upon which the blades may be rotated. The sheath is so designed as to fully protect the blades when not in use.

Each blade is legibly and permanently marked with the nominal thickness and grade. These are available in two grades depending upon the accuracy. The various blades should be assembled in such a way that each thin blade is given the maximum protection by being inter-leaved between two thicker blades. The maximum variation in the thickness of blades should not exceed .04 mm for blades up to and including .3 mm thick.

5 Observation

Feeler gauge set has the strips of the size =

So, we can measure the gap sizing from --------------------To------------- With ----------------intervals of gap

6. Observation Table

Combined dim. Of strips	Status (Goes/ not goes)	Gap of pointer	Remarks
1 2 3 4 5			Readjust the plug pointer
1 2 3 4 5			Readjust the plug pointer
1 2 3 4 5			O.K

Result & conclusion

The spark plug gap is adjusted for _______________mm.

………Viva Questions…………

1. Name the instrument for checking clearance between two matching parts.
2. Strips of feeler gauge are made of SS/MS/HSS.
3. What is the purpose of holder in feeler gauge?
4. Feeler gauge reading depends upon the sense of feel. Explain.
5. What is the least count and range of feeler gauge?
6. Why front of feeler gauge strips are made round.

7. What is the strip width of feeler gauge?
8. A feeler gauge is a measuring instrument/gauge/comparator.

(DEPARTMENT OF MECHANICAL ENGINEERING)

EXPERIMENT NO-

Weight Measurement by Strain Gauge

Objective-To Find the Unknown weight by using Strain Gauge Kit

Apparatus-Strain Gauge Kit, Vernier Caliper, unknown weight

Theory

When a bar is subjected to simple tensile loading, there occurs an increase in length of bar in the direction of the load. Strain refers to the relative change in dimensions of the bar under load and it is prescribed as the ratio of the change in length to the unstressed length of the bar. An increase in length of the bar in the direction of applied load is also accompanied by a decrease in the lateral dimensions perpendicular to the load. The operation of an electrical resistance strain gauge is based on the fact that when a conductor is subjected to mechanical deformation, its length and diameter are altered and a change in its resistance occurs. The resistance change is measured and correlated to strain.

Description of Apparatus

The Strain Gauge Kit is based on the principle that when an external load is applied on a mechanical element, the element gets deformed for the applied load; the cantilever beam has been used as the Element. The deformation can be measured by using strain gauge bonded on that element. The strain gauge is a very fine wire; 0.025 mm in diameter is arranged in the form of a grid shape consisting of a series of long loops on to the Element.

When the load is applied on the element, the strain gauge also undergoes deformation along with the element. The deformed length of the Strain gauge alters the resistance in that, in turn the current in the circuit changes. The change can be read in two ways, one way is by micro strain and the other way is by resistance. The strain gauge is in connection with Wheatstone bridge.

5 Procedures

1. Measure the width, thickness and length of the cantilever beam by using Vernier Caliper.
2. Connect the wire from the strain gauge kit to the main supply.
3. Switch on the instrument.
4. Give some time to stabilize the instrument for stabilization.
5. Select the digital output, for micro strain by the switch provided.
6. Set the output reading to zero by rotating the knob.
7. Slowly place the unknown weight at the center of the circular disc provided at the free end of the cantilever beam.
8. Note down the micro strain reading for the corresponding load.

6 Observations:

Length of the beam L =______________________mm.
Width of the beam, W =______________________mm.
Thickness of the beam, t = ___________________mm.
Young's modulus of the beam, E = _____________gm/mm^2

7 Calculations and Observation Table

Bending moment equation

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

Where, M = Bending moment = WL

I = Moment of Inertia = $b.t^3/12$

σ = Stress in N/mm^2

y = Half of the thickness of beam = $t/2$

E = Young 's modulus of the beam = Gpa

But, $\sigma = \frac{M.y}{I}$ and $\sigma = e.E$

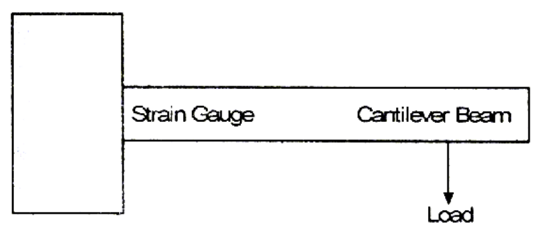
Therefore, $\frac{M.y}{I} = e.E.$

$$M = \frac{E.e.I}{y}$$

and also, $M = W.L$

$$W.L = \frac{E.e.I}{y}$$

$$W = \frac{E.e.I}{y.L} \text{ Gms}$$



Experimental determination of weight

S.No.	Trial No. 1 Micro Strain	Trial No. 2 Micro Strain	Mean Micro Strain	Calculated Wt. of the component W gms	Remarks
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Experimental determination of Strain

S. No.	Trial No. 1		Calculated Micro Strain e= w.y.l/ E.I	Trial No. 2		Calculated Micro Strain e= w.y.l/ E.I
	Wt. (gms)	Indicated Micro Strain		Wt. (gms)	Indicated Micro Strain	
1	**100**			**600**		
2	**200**			**700**		
3	**300**			**800**		
4	**400**			**900**		
5	**500**			**1000**		

Result & Conclusion:

S. No.	Component Name	Wt. of component in (gms)	Wt. of component in (gms)	Actual Strain	Calculated Strain
A			**200**		
B			**400**		
C			**600**		
D			**800**		
E			**1000**		

……….Viva Questions………….

1. What do you know about Strain Gauges?
2. What are the different types of Strain Gauges?
3. What are the different materials used for Strain Gauge.
4. What do you mean by gauge factor?
5. How strain gauges are manufactured.
6. Differentiate Bonded and Unbonded strain gauges.
7. Explain half bridge circuit and full bridge circuit for strain measurement.
8. What do you mean by temperature compensation of gauge?