

UNIT-II

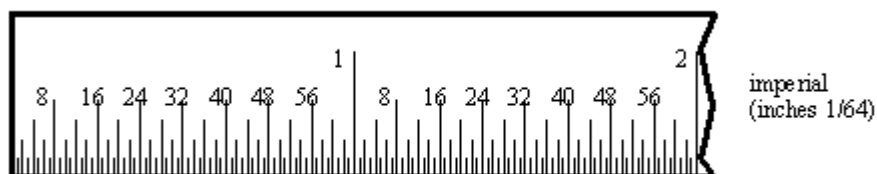
LINEAR AND ANGULAR MEASUREMENTS

MEASUREMENT OF ENGINEERING COMPONENTS:

- ✓ Measurement systems are mainly used in industries for quality control management.
- ✓ Often quality control engineers are applying some the measuring systems such as linear and angular measurements.
- ✓ These measurements are very much useful to compare the actual measurements with already existing standard measurements.
- ✓ The linear measurement includes the measurement of lengths, diameters, heights and thickness.
- ✓ The basic principle of linear measurement is that of comparison with standard dimensions on a suitably engraved instrument or device.
- ✓ The various devices used for measuring the linear measurements are
 - Ø Vernier calipers
 - Ø Micrometers
 - Ø Slip gauge or gauge blocks
 - Ø Comparators
- ✓ Angular measurement is another important element in measuring.
- ✓ This involves the measurement of angles of tapers and similar surfaces. In angular measurements t types of angle measuring devices are used.
- ✓ They are angle gauges corresponding to slip gauges and divided scales corresponding to line standards. The most common instrument is sine bar.
- ✓ The main difference between linear and angular measurement is that no absolute standard is required for angular measurement.

SCALES:

- ✓ The most common tool for crude measurements is the scale (also known as **rules, or rulers**)
- ✓ Although plastic, wood and other materials are used for common scales, precision scales use tempered steel alloys, with graduations scribed onto the surface.
- ✓ These are limited by the human eye. Basically they are used to compare two dimensions.
- ✓ The metric scales use decimal divisions, and the imperial scales use fractional divisions.



- ✓ Some scales only use the fine scale divisions at one end of the scale.
- ✓ It is advised that the end of the scale not be used for measurement. This is because as they become worn with use, the end of the scale will no longer be at a 'zero' position. Instead the internal divisions of the scale should be used.
- ✓ Parallax error can be a factor when making measurements with a scale.

CALIPERS:

- ✓ A tool used to transfer measurements from a part to a scale, or other instrument.
- ✓ Calipers may be difficult to use, and they require that the operator follow a few basic rules, do not force them, they will bend easily, and invalidate measurements made.
- ✓ If measurements are made using calipers for comparison, one operator should make all of the measurements (this keeps the feel factor a minimal error source).
- ✓ These instruments are very useful when dealing with hard to reach locations that normal measuring instruments cannot reach.
- ✓ Obviously the added step in the measurement will significantly decrease the accuracy

(A)Vernier Calipers

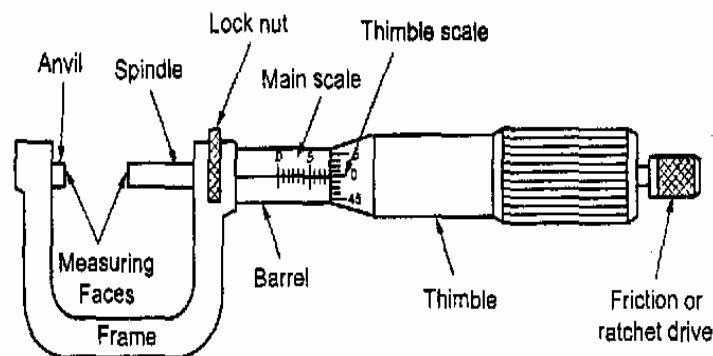
- ✓ Vernier calipers have two scales namely, the main scale and vernier scale. The vernier scale moves along the main scale. Verniers are used to measure both internal and external dimensions.
- ✓ The caliper is placed on the object to be measured and the fine adjustment screw is rotated until the jaws fit tightly against the work piece. The readings from the main and vernier scales are taken.

MICROMETERS

There are two types in it.

- (i) Outside micrometer —To measure external dimensions.
- (ii) Inside micrometer —To measure internal dimensions.

An outside micrometer is shown in Fig.1. It consists of two scales, main scale and thimble scale. While the pitch of barrel screw is 0.5 mm the thimble has graduation of 0.01 mm. The **least count** of this micrometer is 0.01 mm.



COMPARATORS:

- ✓ Comparators are one form of linear measurement device which is quick and more convenient for checking large number of identical dimensions.
- ✓ Comparators normally will not show the actual dimensions of the work piece. They will be shown only the deviation in size. i.e. During the measurement a comparator is able to give the deviation of the dimension from the set dimension.
- ✓ This cannot be used as an absolute measuring device but can only compare two dimensions.
- ✓ Comparators are designed in several types to meet various conditions. Comparators of every type incorporate some kind of magnifying device.
- ✓ The magnifying device magnifies how much dimension deviates, plus or minus, from the standard size.
- ✓ The comparators are classified according to the principles used for obtaining magnification.
- ✓ The common types are:
 - 1) Mechanical comparators.
 - 2) Electrical comparators.
 - 3) Optical comparators.
 - 4) Pneumatic comparators.

1. MECHANICAL COMPARATORS:

- Ø Mechanical comparator employs mechanical means for magnifying small deviations.
- Ø The method of magnifying small movement of the indicator in all mechanical comparators are effected by means of levers, gear trains or a combination of these elements.
- Ø Mechanical comparators are available having magnifications from 300 to 5000 to 1. These are mostly used for inspection of small parts machined to close limits.

1. Dial indicator:

- ✓ A dial indicator or dial gauge is used as a mechanical comparator. The essential parts of the instrument are like a small clock with a plunger projecting at the bottom as shown in fig.
- ✓ Very slight upward movement on the plunger moves it upward and the movement is indicated by the dial pointer.
- ✓ The dial is graduated into 100 divisions. A full revolution of the pointer about this scale corresponds to 1mm travel of the plunger.
- ✓ Thus, a turn of the pointer by one scale division represents a plunger travel of 0.01 mm.

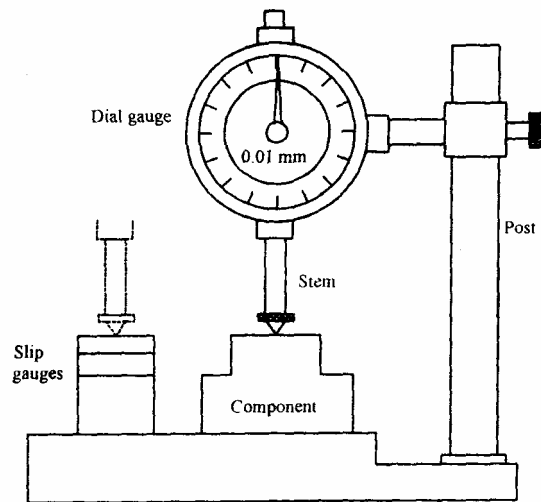
Experimental setup:

- ü The whole setup consists of worktable, dial indicator and vertical post.
- ü The dial indicator is fitted to vertical post by an adjusting screw as shown in fig.
- ü The vertical post is fitted on the worktable, The top surface of the worktable is finely finished.
- ü The dial gauge can be adjusted vertically and locked in position by a screw.

How to use?

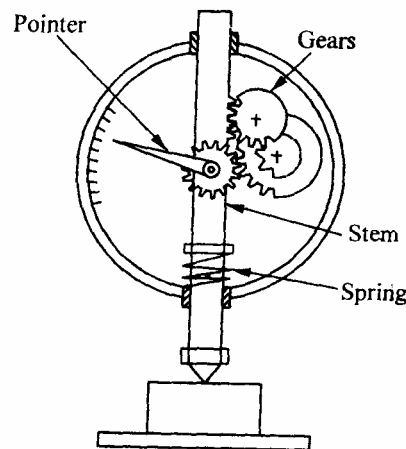
- ✓ Let us assume that the required height of the component is 32.5mm. Initially this height is built up with slip gauges.
- ✓ The slip gauge blocks are placed under the stem of the dial gauge.

- ✓ The pointer in the dial gauge is adjusted to zero. The slip gauges are removed.
- ✓ Now the component to be checked is introduced under the stem of the dial gauge. If there is any deviation in the height of the component, it will be indicated by the pointer.



Mechanism:

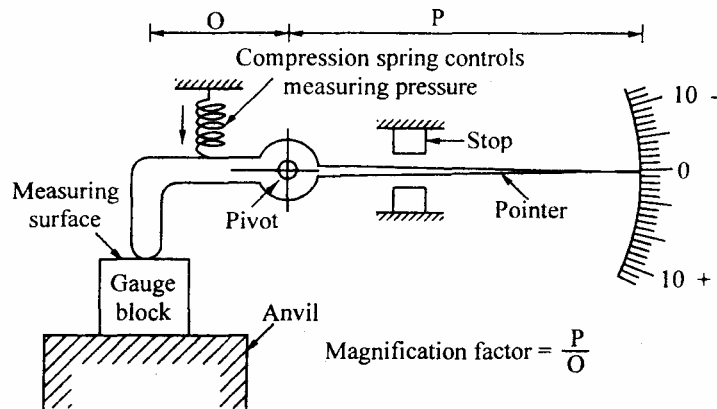
- Ø The mechanism of such an instrument is illustrated in figure.
- Ø The stem has rack teeth. A set of gears engage with the rack.
- Ø The pointer is connected to a small pinion.
- Ø The small pinion is independently hinged, i.e. it is not connected to the stem.
- Ø The vertical movement of the stem is transmitted to the pointer through a set of gears. A spring gives a constant downward pressure to the stem.



2. Read type mechanical comparator:

- Ø In this type of comparator, the linear movement of the plunger is specified by means of read mechanism. The mechanism of this type is illustrated in fig.
- Ø A spring-loaded pointer is pivoted. Initially, the comparator is set with the help of a known dimension eg. set of slip gauges as shown in fig.

- Ø Then the indicator reading is adjusted to zero. When the part to be measured is kept under the pointer, then the comparator displays the deviation of this dimension either in \pm or —side of the set dimension.



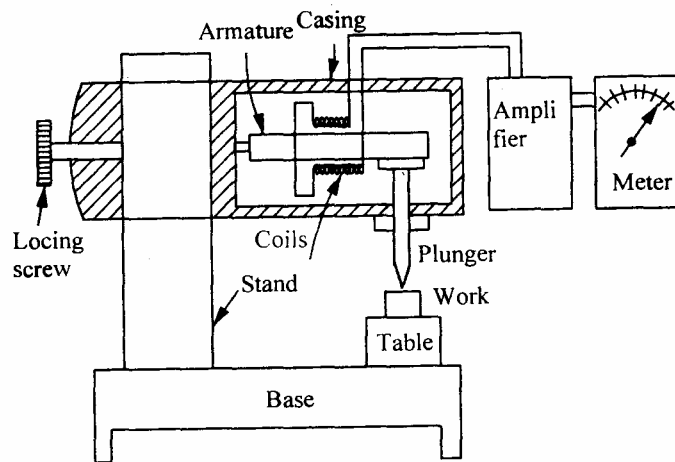
Advantages:

- 1) It is usually robust, compact and easy to handle.
- 2) There is no external supply such as electricity, air required.
- 3) It has very simple mechanism and is cheaper when compared to other types.
- 4) It is suitable for ordinary workshop and also easily portable.

Disadvantages:

- 1) Accuracy of the comparator mainly depends on the accuracy of the rack and pinion arrangement. Any slackness will reduce accuracy.
- 2) (ii) It has more moving parts and hence friction is more and accuracy is less.
- 3) (iii) The range of the instrument is limited since pointer is moving over a fixed scale.

2. ELECTRICAL COMPARATOR:



An electrical comparator consists of the following three major part such as

- 1) Transducer
- 2) Display device as meter
- 3) Amplifier

Transducer:

- ✓ An iron armature is provided in between two coils held by a leaf spring at one end. The other end is supported against a plunger.
- ✓ The two coils act as two arms of an A.C. wheatstone bridge circuit.

Amplifier:

- ✓ The amplifier is nothing but a device which amplifies the given input signal frequency into magnified output

Display device or meter:

- ✓ The amplified input signal is displayed on some terminal stage instruments. Here, the terminal instrument is a meter.

Working principle:

- Ø If the armature is centrally located between the coils. the inductance of both coils will be equal but in opposite direction with the sign change.
- Ø Due to this, the bridge circuit of A.C. wheatstone bridge is balanced. Therefore, the meter will read zero value. But practically, it is not possible. In real cases, the armature may be lifted up or lowered down by the plunger during the measurement.
- Ø This would upset the balance of the wheatstone bridge circuit. Due to this effect, the change in current or potential will be induced correspondingly.
- Ø On that time, the meter will indicate some value as displacement. This indicated value may be either for larger or smaller components.
- Ø As this induced current is too small, it should be suitably amplified before being displayed in the meter.

Checking of accuracy:

- ü To check the accuracy of a given specimen or work, first a standard specimen is placed under the plunger.
- ü After this, the resistance of wheatstone bridge is adjusted so that the scale reading shows zero. Then the specimen is removed.
- ü Now, the work is introduced under the plunger. If height variation of work presents, it will move the plunger up or down.
- ü The corresponding movement of the plunger is first amplified by the amplifier then it is transmitted to the meter to show the variations.
- ü The least count of this electrical comparator is **0.001mm (one microns)**.

3.ELECTRONIC COMPARATOR:

- ✓ In electronic comparator, transducer induction or the principle of application of frequency modulation or radio oscillation is followed.

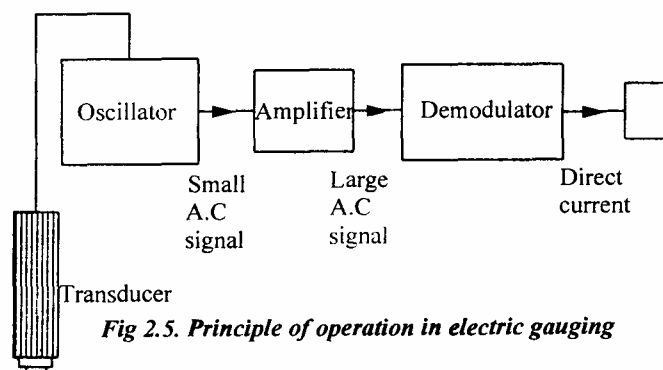


Fig 2.5. Principle of operation in electric gauging

Construction details:

In the electronic comparator, the following components are set as follows:

- i. Transducer
- ii. Oscillator
- iii. Amplifier
- iv. Demodulator
- v. Meter

(i) Transducer: -

It converts the movement of the plunger into an electrical signal. It is connected with oscillator.

(ii) Oscillator: -

The oscillator which receives electrical signal from the transducer and raises the amplitude of frequency wave by adding carrier frequency called as modulation.

(iii) Amplifier: -

An amplifier is connected in between oscillator and demodulator. The signal coming out of the oscillator is amplified into a required level.

(iv) Demodulator: -

Demodulator is nothing but a device which cuts off external carrier wave frequency. i.e. It converts the modulated wave into original wave as electrical signal.

(v) Meter:

This is nothing but a display device from which the output can be obtained as a linear measurement.

Principle of operation:

- ü The work to be measured is placed under the plunger of the electronic comparator. Both work and comparator are made to rest on the surface plate.
- ü The linear movement of the plunger is converted into electrical signal by a suitable transducer. Then it sent to an oscillator to modulate the electrical signal by adding carrier frequency of wave.
- ü After that the amplified signal is sent to demodulator in which the carrier waves are cut off.
- ü Finally, the demodulated signal is passed to the meter to convert the probe tip movement into linear measurement as an output signal.
- ü A separate electrical supply of D.C. is already given to actuate the meter.

Advantages of Electrical and Electronic comparator:

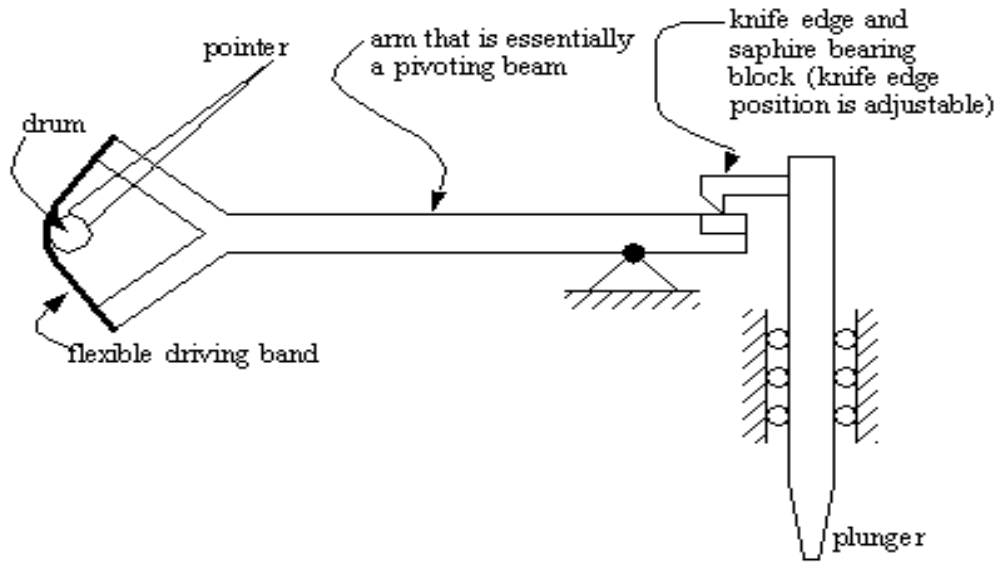
- 1) It has less number of moving parts.
- 2) Magnification obtained is very high.
- 3) Two or more magnifications are provided in the same instrument to use various ranges.
- 4) The pointer is made very light so that it is more sensitive to vibration.
- 5) The instrument is very compact.

Disadvantages of Electrical and Electronic comparator:

- 1) External agency is required to meter for actuation.
- 2) Variation of voltage or frequency may affect the accuracy of output.
- 3) Due to heating coils, the accuracy decreases.
- 4) It is more expensive than mechanical comparator.

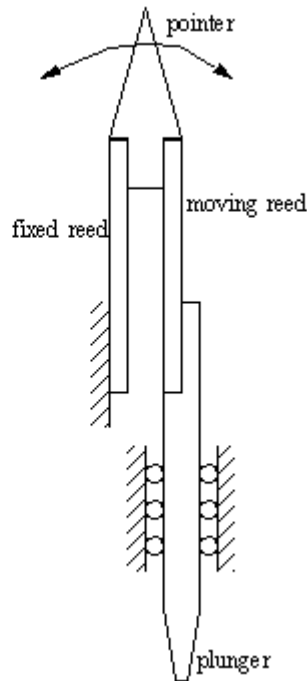
4.SIGMA MECHANICAL COMPARATOR

- The Sigma Mechanical Comparator uses a partially wrapped band wrapped about a driving drum to turn a pointer needle.



5. MECHANICAL AND OPTICAL COMPARATORS

- Ø The Eden-Rolt Reed system uses a pointer attached to the end of two reeds.
- Ø One reed is pushed by a plunger, while the other is fixed.
- Ø As one reed moves relative to the other, the pointer that they are commonly attached to will deflect.



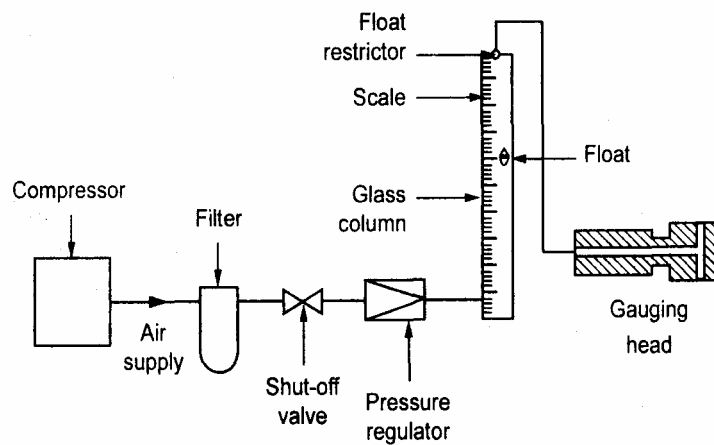
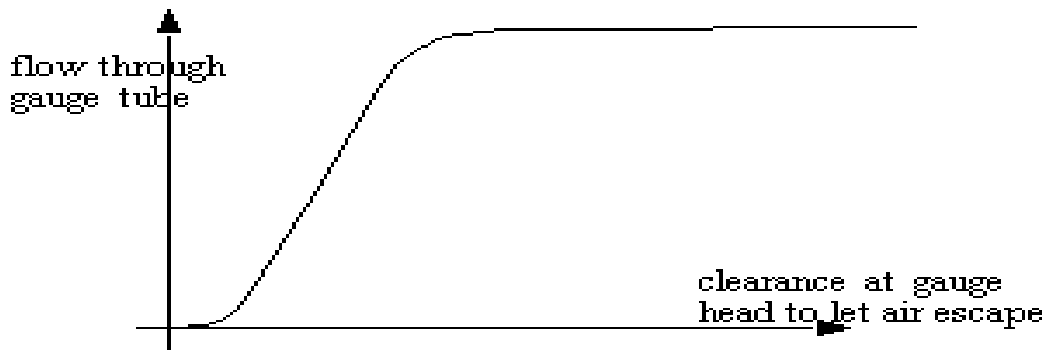
6. PNEUMATIC COMPARATORS:

- ✓ The term pneumatic associates with pressurised air.
- ✓ The pressurized air is used as the working medium in pneumatic comparator.

- ✓ Based on the physical phenomena, the pneumatic comparators are classified into two types.
 - 1) Flow or Velocity type.
 - 2) Back pressure type.

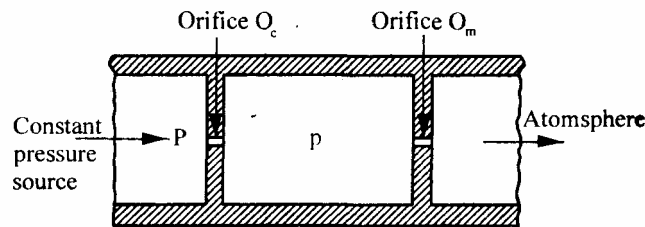
1. Flow type

- ü - the float height is essentially proportional to the air that escapes from the gauge head
- ü - master gauges are used to find calibration points on the scales
- ü - the input pressure is regulated to allow magnification adjustment
- ü - a pressure bleed off valve allows changes to the base level for offset
- ü - The pressure is similar to that shown in the graph below,



2. Back pressure type

- ✓ The Soloflex Back Pressure System uses an orifice with the venturi effect to measure air flow. If the gas is not moving, the pressure on both sides of the orifice will be equal.

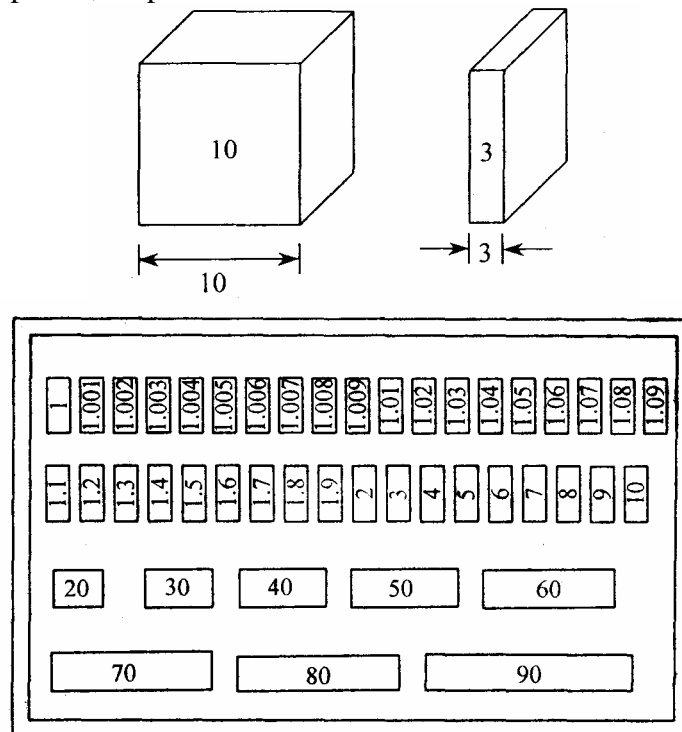


- ✓ If the flow is moving quickly, the air pressure on the downstream side of the orifice will be at a lower pressure.

- ✓ A Differential Back Pressure system uses a split flow channel, one flow goes to the gauge head, the other goes to a zero offset valve.
- ✓ A meter measures the difference in pressures, and thus gives the differences in pressure.

SLIP GAUGES

- ✓ Slip gauges are used as measuring blocks.
- ✓ It is also called as precision gauge blocks.
- ✓ They are made of hardened alloy steel of rectangular cross-section.
- ✓ The surfaces of slip gauges are made to a high degree of accuracy.
- ✓ The distance between the two opposite faces indicates the size of the gauge. But all slip gauges are made to same thickness to perform wringing.
- ✓ **Wringing or Sliding** is nothing but combining the faces of slip gauges one over the other. Due to adhesion property of slip gauges, they will stick together. This is because of very high degree of surface finish of the measuring faces.
- ✓ They are used in comparators and sin bars. They are mainly used as testing and calibrating instruments in metrology.
- ✓ Different sets of slip gauges are manufactured in standard sets of
- ✓ 32 pieces, 45 pieces, 88 pieces etc.



A normal set of slip gauges has 45 pieces as shown in fig.

- ✓ The slip gauges should be stored carefully in a box. For obtaining higher accuracy. They are stored in a temperature-controlled room.
- ✓ **For example**, a slip gauge set of 56 slips is made up as follows:
 - ✚ 9 slips 1.001 to 1.009 in steps of 0.001mm
 - ✚ 9 slips 1.01 to 1.09 in steps of 0.01mm
 - ✚ 9 slips 1.1 to 1.9 in steps of 0.1mm
 - ✚ 25 slips 1 to 25 in steps of 1mm
 - ✚ 3 slips 25 to 75 in steps of 25mm
 - ✚ One slip of 1.0005mm

CLASSIFICATION OF SLIP GAUGES:

Slip gauges are classified into various types according to their use as follows:

- 1) Grade 2
- 2) Grade 1
- 3) Grade 0
- 4) Grade 00
- 5) Calibration grade.

1) Grade 2:

It is a workshop grade slip gauges used for setting tools, cutters and checking dimensions roughly.

2) Grade 1:

The grade I is used for precise work in tool rooms.

3) Grade 0:

It is used as inspection grade of slip gauges mainly by inspection department.

4) Grade 00:

Grade 00 mainly used in high precision works in the form of error detection in instruments.

5) Calibration grade:

The actual size of the slip gauge is calibrated on a chart supplied by the manufactures.

MANUFACTURE OF SLIP GAUGES:

The following additional operations are carried out to obtain the necessary qualities in slip gauges during manufacture.

- i. First the approximate size of slip gauges is done by preliminary operations.
- ii. The blocks are hardened and wear resistant by a special heat treatment process.
- iii. To stabilize the whole life of blocks, seasoning process is done.
- iv. The approximate required dimension is done by a final grinding process.
- v. To get the exact size of slip gauges, lapping operation is done.
- vi. Comparison is made with grand master sets.

Calibration of slip gauges

Comparators are used to calibrate the slip gauges.

SLIP GAUGES ACCESSORIES:

The application slip gauges can be increased by providing accessories to the slip gauges. The various accessories are

- ✓ Measuring jaw
- ✓ Scriber and Centre point.
- ✓ Holder and base.

1. Measuring jaw:

It is available in two designs specially made for internal and external features.

2. Scriber and Centre point:

It is mainly formed for marking purpose.

3. Holder and base:

- ∅ Holder is nothing but a holding device used to hold combination of slip gauges.
- ∅ Base is designed for mounting the holder rigidly on its top surface.

ODD TOPICS

- There are also a number of angular gauge blocks for the measurement of angles. The two common sets are,

16 piece set	degrees	45°, 30°, 15°, 5°, 3°, 1°
	minutes	30', 20', 5', 3', 1'
	second	30", 20", 5", 3", 1"

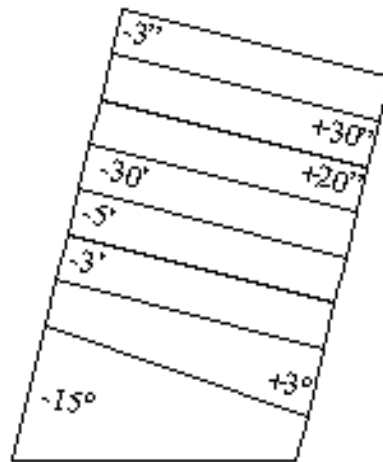
13 piece set	degrees	1°, 3°, 9°, 27°, 41°, 90°
	minutes	1', 3', 9', 27', 0.1', 0.3', 0.5'

tool room accuracy ± 1 second
laboratory accuracy ± 0.25 seconds

- ✓ The selection of angular gauge blocks is similar to the selection of linear gauge blocks, except that subtraction may also be required. (When the blocks are stacked, then angles are simply reversed.)

For the angle $12^{\circ}37'13''$, find the angular gauge block stack using the 16 piece set.

$$\begin{array}{r}
12^{\circ}37'13'' \\
-3'' \\
\hline
12^{\circ}37'10'' \\
+30'' \\
\hline
12^{\circ}37'40'' \\
+20'' \\
\hline
12^{\circ}38' \\
-30' \\
\hline
12^{\circ}8' \\
-5' \\
\hline
12^{\circ}3' \\
-3' \\
\hline
12^{\circ} \\
+3^{\circ} \\
\hline
15^{\circ} \\
-15^{\circ} \\
\hline
0
\end{array}$$

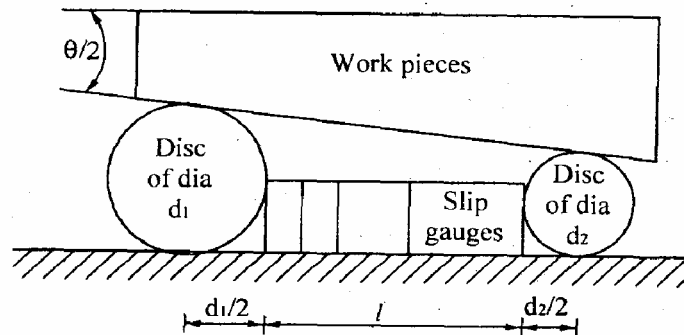


ROLLERS:

- Ø Rollers are precisely manufactured with high accuracy for metrological applications.
- Ø It is used to determine both linear and angular dimensions in conjunction with gauge blocks.
- Ø These are made of good quality steel and are hardened and tapered. The length of the roller is equal to the diameter.
- Ø The use of precision rollers for determining both linear and angular dimensions is explained with the help of following examples.

1. Measurement of angle by using rollers:

- ✓ Angle of the right-tapered piece can be measured by using two rollers of different sizes, slip gauges and a dial indicator.
- ✓ The two rollers whose diameters are known and slip gauges are placed on a surface plate as shown in fig.
- ✓ The rollers may be clamped in position against an angle plate by C-clamps. The work is then placed on top of rollers and clamped against the angle plate C-clamp.
- ✓ If the angle of the piece is all right, then the top edge will be parallel to surface plate. The dial indicator will show no variation when traversed along its surface.



From fig., the triangle $O_1 A O_2$

$$\tan \theta/2 = \frac{O_1 A}{O_2 A} = \frac{\frac{d_2}{2} - \frac{d_1}{2}}{1 + \frac{d_1}{2} + \frac{d_2}{2}} = \frac{d_2 - d_1}{2l + d_1 + d_2}$$

Where, l = Length of slip gauge pile and
 d_1 & d_2 = Diameters of rollers

From the above equation

$$l = \frac{d_2 - d_1}{2 \tan(\theta/2)} - \left(\frac{d_1 + d_2}{2} \right)$$

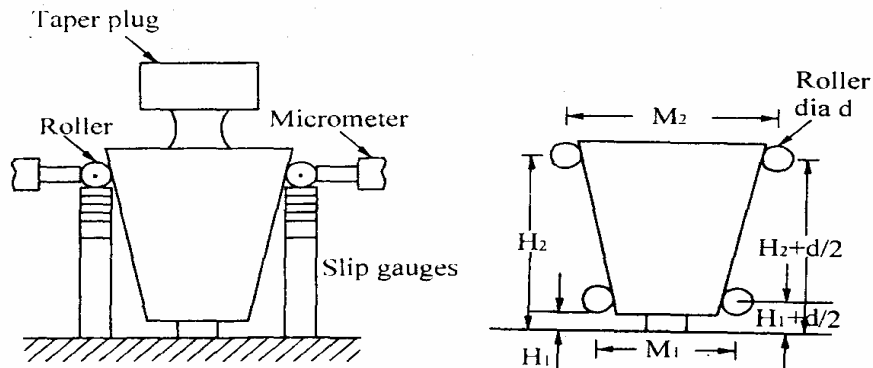
- ✓ Thus, initially the length of the slip gauges is calculated by the above equation and the rollers are placed in contact with the slip gauges.

2. Checking the angle of taper using rollers:

- Ø Method of checking the angle of a taper plug gauge using rollers.
- Ø Micrometer and slip gauges are illustrated by fig.
- Ø Taper plug is placed on a surface plate. First two rollers of equal diameters are placed touching on the opposite sides of the lower surface of the plug on the slip gauge combinations of equal heights (H) The distance (M) between the ends of the roller is measured with a micrometer.
- Ø Then the rollers are placed on slip gauge combinations of height touching on the opposite sides of the top portion of the plug.
- Ø The distance between the ends of the rollers in this new position is again measured by means of micrometer.
- Ø The half of the taper angle of the plug is then calculated as follows:
- Ø If d = diameter of rollers, then

$$\tan \theta/2 = \frac{\left[\left(\frac{M_2 - d}{2} \right) - \left(\frac{M_1 - d}{2} \right) \right]}{\left(H_2 + \frac{d}{2} \right) - \left(H_1 + \frac{d}{2} \right)}$$

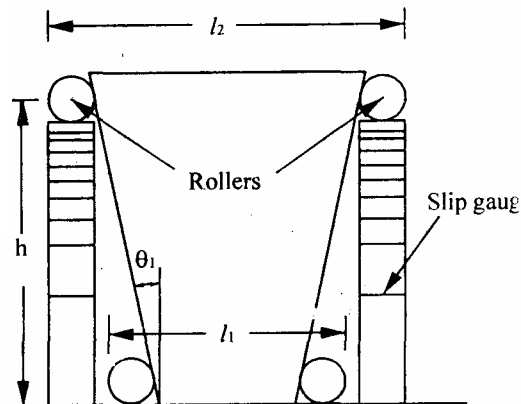
$$\therefore \tan \theta/2 = \frac{M_2 - M_1}{2(H_2 - H_1)}$$



3. Measuring of included tingle o/an internal dovetail:

- ✓ Dovetail slides are widely used in machine tools as a guide ways.
- ✓ The sloping side of the dovetail slide act as guide and prevent the lifting of the female mating part during sliding operation.
- ✓ This angle can be measured by using two rollers of equal size, slip gauges and a micrometer.
- ✓ The two rollers of equal diameters are placed. One each at the two corners and distance i is measured across the rollers with a micrometer.
- ✓ Then the rollers equal size slip gauge blocks and the distance is measured. It should be noted that the rollers do not extend above the top surface of dovetail.
- ✓ Let the height of slip gauges be h, then

$$\tan \theta = \frac{l_2 - l_1}{h}$$

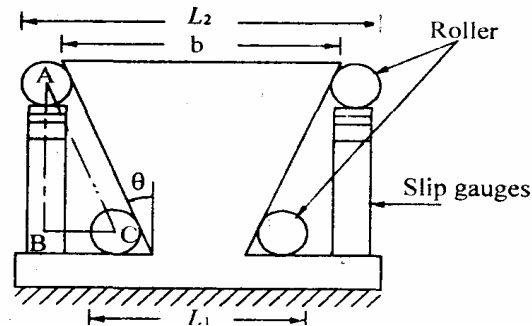


4. Measuring external dovetail slide:

- ✓ Figures shows an external dovetail slide with angle of dovetail θ .
- ✓ To check the width of opening b as shown in fig., two rollers of equal diameter d are placed one each in the two corners.

- ✓ Then the length L is obtained by trial and error with the help of slip gauges or end bars if L is greater than 250mm.
- ✓ Then the width ' b ' can be calculated by the relation

$$b = l + d + d \cot \theta / 2$$



LIMIT GAUGES:

- ✓ A limit gauge is not a measuring gauge. Just they are used as inspecting gauges.
- ✓ The limit gauges are used in inspection by methods of attributes.
- ✓ This gives the information about the products which may be either within the prescribed limit or not.
- ✓ By using limit gauges report, the control charts of P and C charts are drawn to control invariance of the products.
- ✓ This procedure is mostly performed by the quality control department of each and every industry.
- ✓ Limit gauge are mainly used for checking for cylindrical holes of identical components with a large numbers in mass production.

Purpose of using limit gauges:

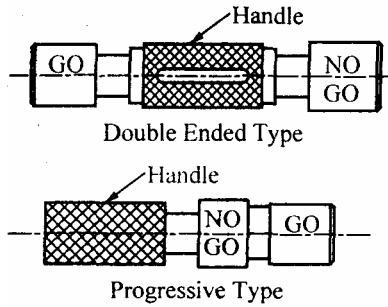
- Ø Components are manufactured as per the specified tolerance limits, upper limit and lower limit. The dimension of each component should be within this upper and lower limit.
- Ø If the dimensions are outside these limits, the components will be rejected.
- Ø If we use any measuring instruments to check these dimensions, the process will consume more time. Still we are not interested in knowing the amount of error in dimensions.
- Ø It is just enough whether the size of the component is within the prescribed limits or not. For this purpose, we can make use of gauges known as limit gauges.

The common types are as follows:

- 1) Plug gauges.
- 2) Ring gauges.
- 3) Snap gauges.

PLUG GAUGES:

- Ø The ends are hardened and accurately finished by grinding. One end is the GO end and the other end is NOGO end.
- Ø Usually, the GO end will be equal to the lower limit size of the hole and the NOGO end will be equal to the upper limit size of the hole.



- ∅ If the size of the hole is within the limits, the GO end should go inside the hole and NOGO end should not go.
- ∅ If the GO end does not go, the hole is under size and also if NOGO end goes, the hole is **over size**. Hence, the components are rejected in both the cases.

Now, we are having two chances to make plug gauges.

1. Double ended plug gauges:

In this type, the GO end and NOGO end are arranged on both the ends of the plug. This type has the advantage of easy handling.

2. Progressive type of plug gauges:

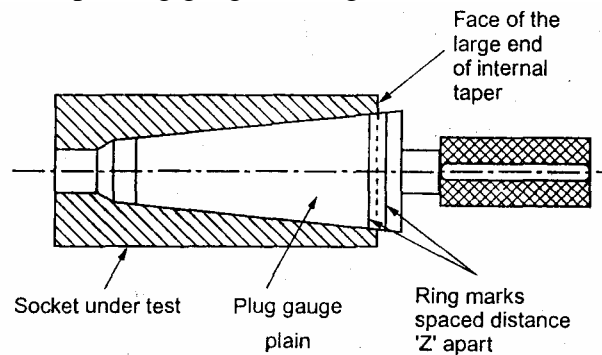
In this type both the GO end and NOGO end are arranged in the same side of the plug. We can use the plug gauge ends progressively one after the other while checking the hole. It saves time. Generally, the GO end is made larger than the NOGO end in plug gauges.

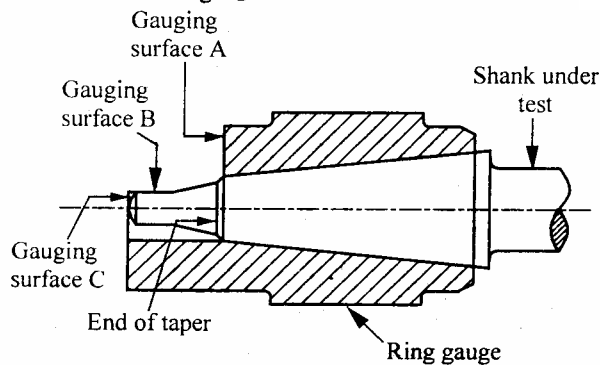
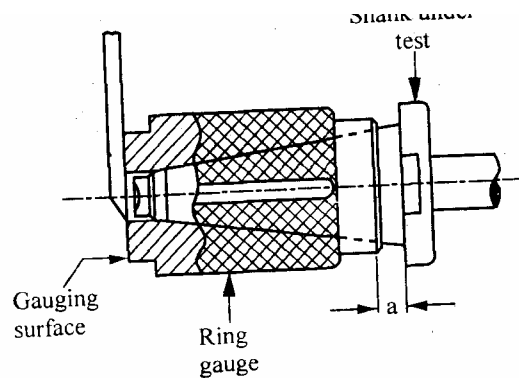
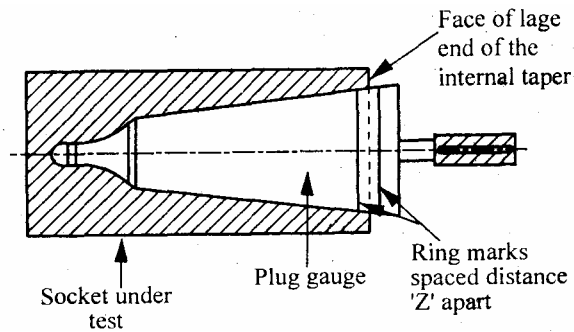
TAPER PLUG GAUGE:

- ✓ Taper plug gauges are used to check tapered holes. It has two check lines. One is a GO line and another is a NOGO line.
- ✓ During the checking of work, NOGO line remains outside the hole and GO line remains inside the hole.

They are various types taper plug gauges are available as shown in fig. Such as

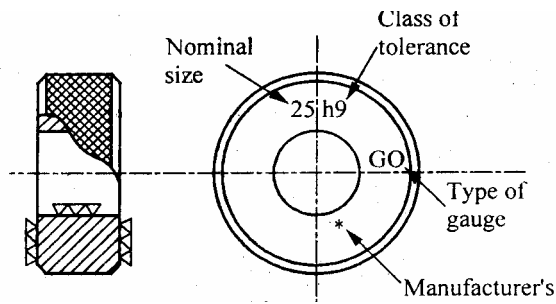
- 1) Taper plug gauge —plain
- 2) Taper plug gauge —tanged.
- 3) Taper ring gauge plain
- 4) Taper ring gauge —tanged.





RING GAUGES:

- ✓ Ring gauges are mainly used for checking the diameter of shafts having a central hole. The hole is accurately finished by grinding and lapping after taking hardening process.
- ✓ The periphery of the ring is knurled to give more grips while handling the gauges. We have to make two ring gauges separately to check the shaft such as GO ring gauge and NOGO ring gauge.
- ✓ But the hole of GO ring gauge is made to the upper limit size of the shaft and NOGO for the lower limit.
- ✓ While checking the shaft, the GO ring gauge will pass through the shaft and NOGO will not pass.
- ✓ To identify the NOGO ring gauges easily, a red mark or a small groove cut on its periphery.

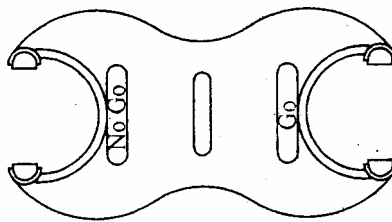


SNAP GAUGE:

✓ Snap gauges are used for checking external dimensions. They are also called as gap gauges. The different types of snap gauges are:

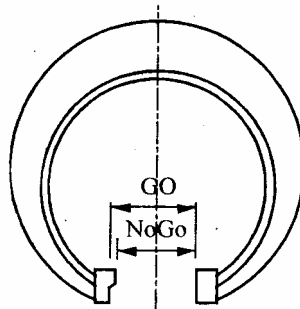
1. DOUBLE ENDED SNAP GAUGE:

- ∅ This gauge is having two ends in the form of anvils.
- ∅ Here also, the GO anvil is made to lower limit and NOGO anvil is made to upper limit of the shaft.
- ∅ It is also known as solid snap gauges



2. PROGRESSIVE SNAP GAUGE:

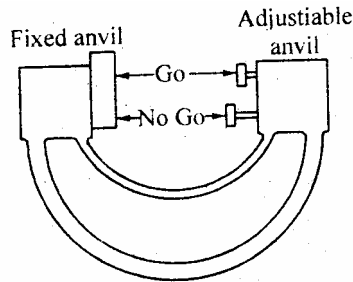
- ✓ This type of snap gauge is also called caliper gauge.
- ✓ It is mainly used for checking large diameters up to 100mm. Both GO and NOGO anvils at the same end. The GO anvil should be at the front and NOGO anvil at the rear.
- ✓ So, the diameter of the shaft is checked progressively by these two ends.
- ✓ This type of gauge is made of horse shoe shaped frame with I section to reduce the weight of the snap gauges



3. ADJUSTABLE SNAP GAUGE:

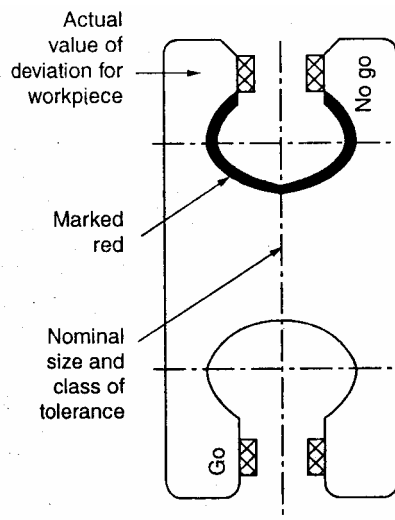
- ✓ Adjustable snap gauges are used for checking large size shafts made with horseshoe shaped frame of I section.

- ✓ It has one fixed anvil and two small adjustable anvils. The distance between the two anvils is adjusted by adjusting the adjustable anvils by means of setscrews.
- ✓ This adjustment can be made with the help of slip gauges for specified limits of size.



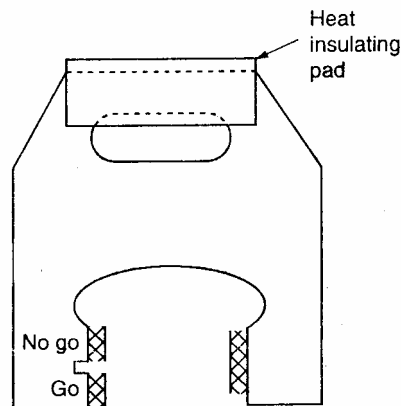
4. PLATE TYPE DOUBLE ENDED SNAP GAUGE:

This type is used for sizes from 2mm to 100mm as shown in fig



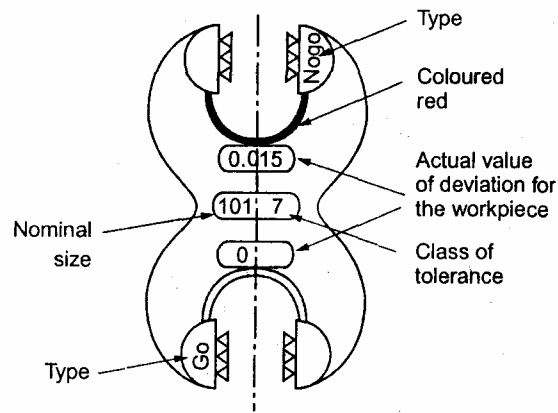
5. PLATE TYPE SINGLE ENDED PROGRESSIVE SNAP GAUGE:

This type is used for sizes from 100mm to 250mm as shown in fig.



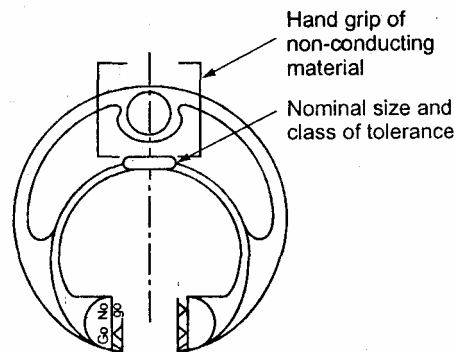
6. COMBINED LIMIT GAUGES:

- ✓ A spherical projection is provided with GO and NOGO dimension marked in a single gauge.
- ✓ While using GO gauge the handle is parallel to axes of the hole and normal to axes for NOGO gauge.



7. POSITION GAUGE:

- ✓ It is designed for checking the position of features in relation to another surface.
- ✓ Other types of gauges are also available such as contour gauges, receiver gauges, profile gauges etc.



TAYLOR'S PRINCIPLE:

- ✓ It states that GO gauge should check all related dimensions. Simultaneously whereas NOGO gauge should check only one dimension at a time.

Maximum metal condition:

It refers to the condition of hole or shaft when maximum material is left on i.e. high limit of shaft and low limit of hole.

Minimum metal condition:

It refers to the condition of hole or shaft when minimum material is left on such as low limit of shaft and high limit of hole.

APPLICATIONS OF LIMIT GAUGES:

1. Thread gauges
2. Form gauges
3. Screw pitch gauges
4. Radius and fillet gauges
5. Feeler gauges
6. Plate gauge and Wire gauge

1. THREAD GAUGES

- ✓ Threads are checked with the help of thread gauges.
- ✓ For checking internal threads, (nuts, bushes) plug thread gauges are used. Similarly, ring thread gauges are used for checking external threads (bolts, screws).

1. Thread gauge



Standard screw gauge

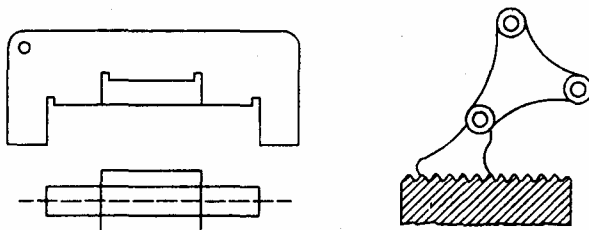


Go

No go

2. FORM GAUGES:

- ✓ Form gauges may be used to check the contour of a profile of a work piece.
- ✓ Form gauges are nothing but template gauges made of sheet steel.
- ✓ A profile gauges may contain two outlines which indicates the limits of a profile.

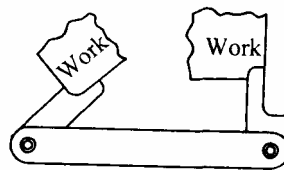


3. SCREW PITCH GAUGES:

- ✓ Screw pitch gauges are used to check the pitch of the thread immediately. It is very much in everyday tool used to pick out a required screw.
- ✓ The number of flat blades with different pitches is pivoted in a holder. The pitch value is marked on each blade.

4. RADIUS AND FILLET GAUGES:

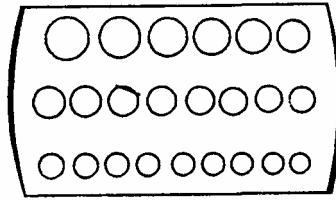
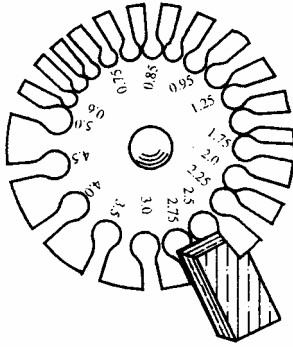
- ✓ The radius of curvature can be measured by using these gauges. The radius may be either outer or inner radius.
- ✓ According to the type of radius to be measured, the end of the blade is made to either concave or convex profile.



5. FEELER GAUGES:

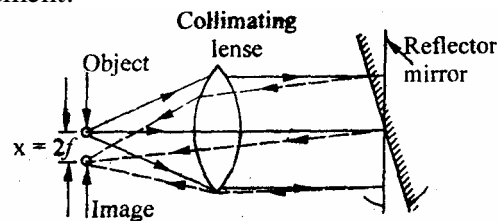
- ✓ Feeler gauges are used for checking the clearance between mating surfaces.
- ✓ They are mainly used in adjusting the valve clearance in automobiles.
- ✓ They are made from 0.03 to 1.0 mm thick of 100 mm long. The blades are pivoted in a holder.

6. PLATE GAUGE AND WIRE GAUGE:



AUTO- COLLIMATOR:

- ✓ Auto-collimator is an optical instrument used for the measurement of small angular differences, changes or deflection, plane surface inspection etc.
- ✓ For small angular measurements, autocollimator provides a very sensitive and accurate approach.
- ✓ An auto-collimator is essentially an infinity telescope and a collimator combined into one instrument.



Basic principle:

- Ø If a light source is placed in the focus of a collimating lens, it is projected as a parallel beam of light.
- Ø If this beam is made to strike a plane reflector, kept normal to the optical axis, it is reflected back along its own path and is brought to the same focus.
- Ø If the reflector is tilted through a small angle ' θ '. Then the parallel beam is deflected twice the angle and is brought to focus in the same plane as the light source.
- Ø The distance of focus from the object is given by

$$x = 2\theta \cdot f$$

Where, f = Focal length of the lens

θ = Tilted angle of reflecting mirror.

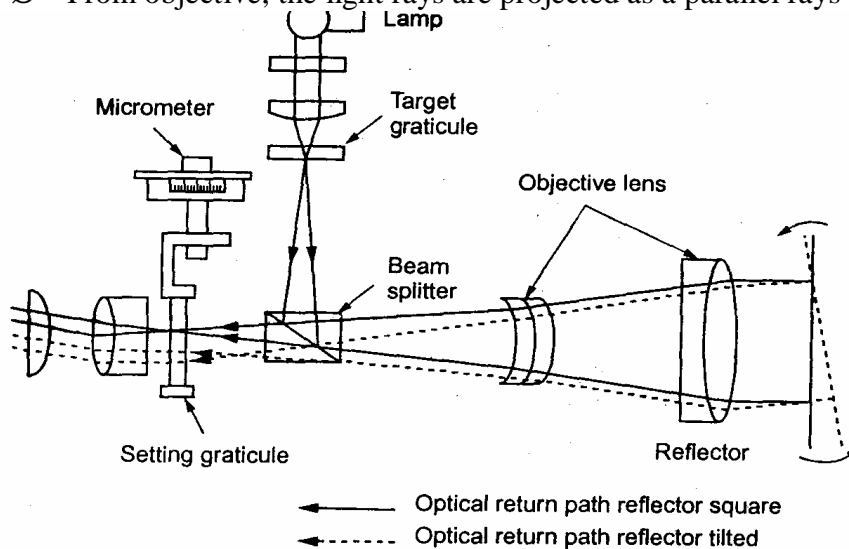
Note:

- ✓ The position of the final image does not depend upon the distance of reflector from the lens. i.e. distance x is independent of the position of reflection from the lens.
- ✓ But if the reflector is moved too much back then reflected rays would completely miss the lens and no image will be formed.
- ✓ Thus for full range of reading of instrument to be used, the maximum remoteness of the reflector is limited.
- ✓ For high sensitivity, i.e. for large range of reading of x for a small angular deviation θ , a long focal length is required.

WORKING OF AUTO-COLLIMATOR:

There are three main parts in auto-collimator.

1. Micrometer microscope.
 2. Lighting unit and
 3. Collimating lens.
- Ø Fig. Shows a line diagram of a modern auto-collimator. A target graticule is positioned perpendicular to the optical axis.
- Ø When the target graticule is illuminated by a lamp, rays of light diverging from the intersection point reach the objective lens via beam splitter.
- Ø From objective, the light rays are projected as a parallel rays to the reflector.



- ✓ A flat reflector placed in front of the objective and exactly normal to the optical axis reflects the parallel rays of light back along their original paths.
- ✓ They are then brought to the target graticule and exactly coincide with its intersection.
- ✓ A portion of the returned light passes through the beam splitter and is visible through the eyepiece.
- ✓ If the reflector is tilted through a small angle (θ), the reflected beam will be changed its path at twice the angle.
- ✓ It can also be brought to target graticule but linearly displaced from the actual target by the amount $2\theta \times f$.
- ✓ Linear displacement of the graticule image in the plane tilted angle of eyepiece is directly proportional to the reflector. This can be measured by optical micrometer.
- ✓ The photoelectric auto-collimator is particularly suitable for calibrating polygons, for checking angular indexing and for checking small linear displacements.

. APPLICATIONS OF AUTO-COLLIMATOR

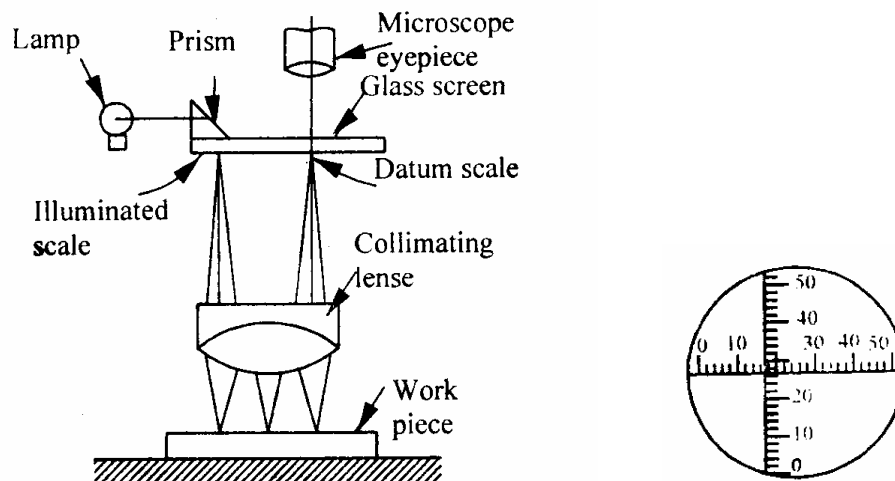
Auto-collimators are used for

- ✓ Measuring the difference in height of length standards.
- ✓ Checking the flatness and straightness of surfaces.
- ✓ Checking squareness of two surfaces.
- ✓ Precise angular indexing in conjunction with polygons.
- ✓ Checking alignment or parallelism.
- ✓ Comparative measurement using master angles.

- ✓ Measurement of small linear dimensions.
- ✓ For machine tool adjustment testing.

ANGLE DEKKOR

- ✓ This is also a type of auto-collimator.
- ✓ There is an illuminated scale in the focal plane of the collimating lens.
- ✓ This illuminated scale is projected as a parallel beam by the collimating lens which after striking a reflector below the instrument is refocused by the lens in the field of view of the eyepiece.
- ✓ In the field of view of microscope, there is another datum scale fixed across the center of screen.
- ✓ The reflected image of the illuminated scale is received at right angle to the fixed scale as shown in fig.
- ✓ Thus the changes in angular position of the reflector in two planes are indicated by changes in the point of intersection of the two scales.
- ✓ One division on the scale is calibrated to read 1 minute.



- ✓ The whole optical system is enclosed in a tube which is mounted on an adjustable bracket.
- ✓ The adjustable bracket is attached to a flat lapped reflective base as shown in fig.

USES OF ANGLE DEKKOR:

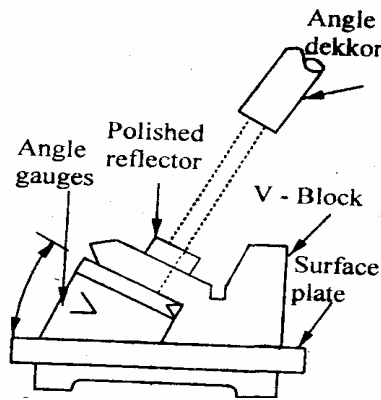
(i) Measuring angle of a component:

- ✓ Angle dekkor is capable of measuring small variations in angular setting i.e. determining angular tilt.
- ✓ Angle dekkor is used in combination with angle gauge. First the angle gauge combination is set up to the nearest known angle of the component.
- ✓ Now the angle dekkor is set to zero reading on the illuminated scale. The angle gauge build up is then removed and replaced by the component under test.
- ✓ Usually a straight edge being used to ensure that there is no change in lateral positions. The new position of the reflected scale with respect to the fixed scale gives the angular tilt of the component from the set angle.

(ii) Checking the slope angle of a V-block:

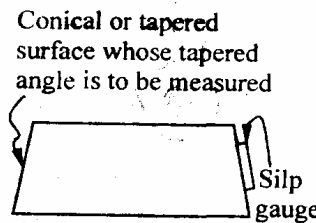
- ✓ Fig. shows the set up for checking the sloping angle of V block.
- ✓ Initially, a polished reflector or slip gauge is attached in close contact with the work surface. By using angle gauge zero reading is obtained in the angle dekkor.

- ✓ Then the angle may be calculated by comparing the reading obtained from the angle dekkor and angle gauge.



(iii) To measure the angle of cone or Taper gauge:

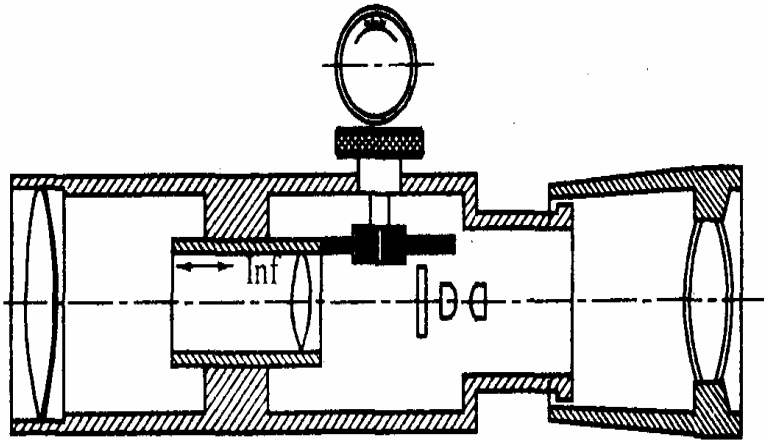
- ✓ Fig. shows the set up for this purpose. Initially, the angle dekkor is set for the nominal angle of cone by using angle gauge or sine bar.
- ✓ The cone is then placed in position with its base resting on the surface plate.



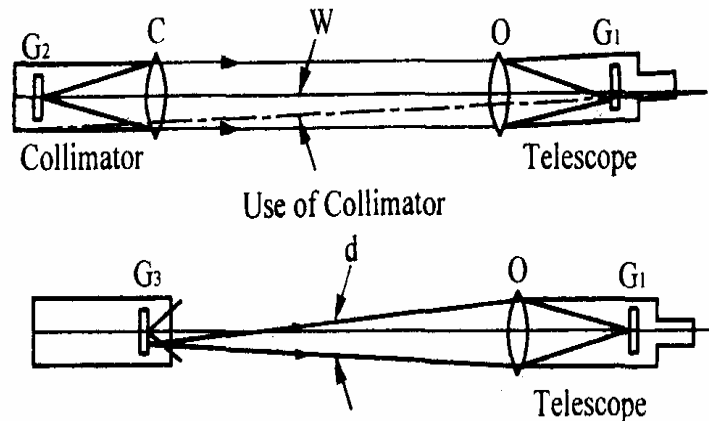
- ✓ A slip gauge or reflector is attached on the cone since no reflection can be obtained from the curved surface.
- ✓ Any deviation from the set angle will be noted by the angle dekkor in the eyepiece and indicated by the shifting of the image of illuminated scale.

ALIGNMENT TELESCOPE

- ✓ Alignment telescope is used for aligning of bores, surfaces and check squareness, straightness, flatness, parallelism, vertically and level.
- ✓ One of the important type of alignment telescope is **Taylor-Hobson alignment telescope**.
- ✓ This instrument can be used to measure angular alignment as well as lateral displacement and for this purpose the sighting target is mounted in a collimating unit.
- ✓ The telescope has an internal-focusing optical system, similar in principle to that of the surveyor's level built into a robust unit having a precisely ground external diameter.
- ✓ The focusing knob can be clearly seen in the optical system is shown in fig.
- ✓ The collimating unit consists of another steel tube, ground to the same diameter as the telescope and containing an illuminating system, a graticule G a collimating lens and another graticule G.
- ✓ The graticule G is graduated with central cross lines, surrounded with scales and concentric circles and lies exactly at the principal focus of the collimating lenses.
- ✓ The graticule G contains a central pattern of converging V and several graduated scales lying in two directions at right angles.



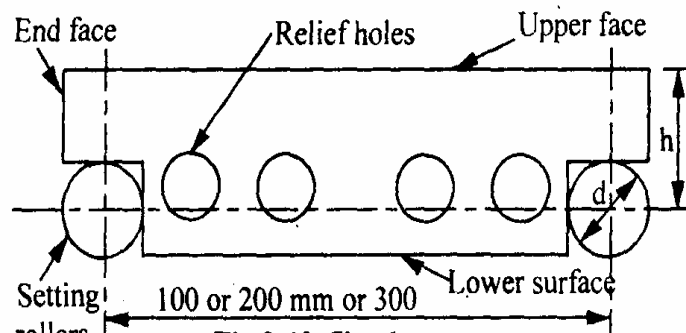
- ✓ The use of telescope with the collimator is given in fig.
- ✓ If the telescope is aligned with the collimator and sighted on it with its focus adjusted to infinity target graticule G will appear in the field of view, since rays from this target will emerge parallel beams from the collimating lens.
- ✓ Purely lateral displacements of telescope and target will therefore not register, but any angular misalignment will show as a displacement of the image of the target.
- ✓ If the telescope is now refocused until the target G appears in the field, only lateral displacements of the collimator will be indicated, the parallel beams from the target G being out of focus.



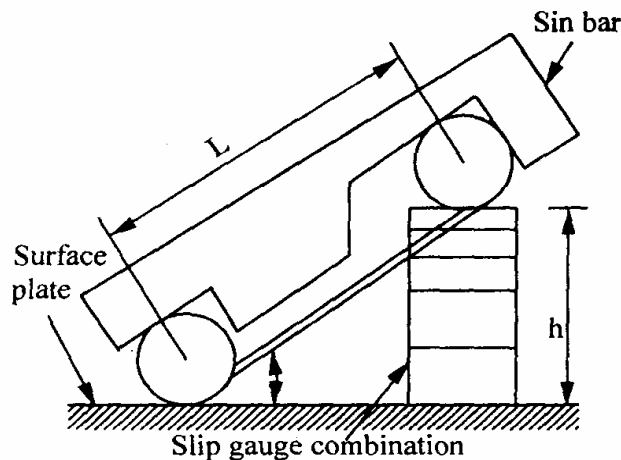
- ✓ Lateral displacements of the collimator unit will therefore be measured in the telescope by means of the scales on graticule G
- ✓ The ground bores of the telescope and collimator make the instrument particularly suitable for the alignment of two or more bores, such as bearings of a large engines.
- ✓ The two units can be located centrally in each bore, using ground bushes where necessary. and both lateral and angular alignment can be measured.
- ✓ Accurate optical alignment of the telescope with its ground diameter is ensured by careful centering of the lenses and accuracy of the draw table of the focusing lens.
- ✓ The use of the optical micrometer and the accuracy obtainable by rotation of the telescope are only available for the measurement of lateral displacement of the target.
- ✓ The instrument is not equipped for a similar accuracy or angular measurement without any reason; a micrometer eyepiece would provide the means of doing this.

SINE BAR

- ✓ Sine bars are always used along with slip gauges as a device for the measurement of angles very precisely.
- ✓ They are used to
 - 1) Measure angles very accurately.
 - 2) Locate the work piece to a given angle with very high precision.
- ✓ Generally, sine bars are made from high carbon, high chromium, and corrosion resistant steel. These materials are highly hardened, ground and polished.
- ✓ In sine bars, two cylinders of equal diameter are attached at the ends with their axes mutually parallel to each other.
- ✓ They are also at equal distance from the upper surface of the sine bar mostly the distance between the axes of two cylinders is 100mm, 200mm or 300mm.
- ✓ The working surfaces of the rollers are finished to 0.2µm R value.
- ✓ The cylindrical holes are provided to reduce the weight of the sine bar.



Working principle of sine bar:



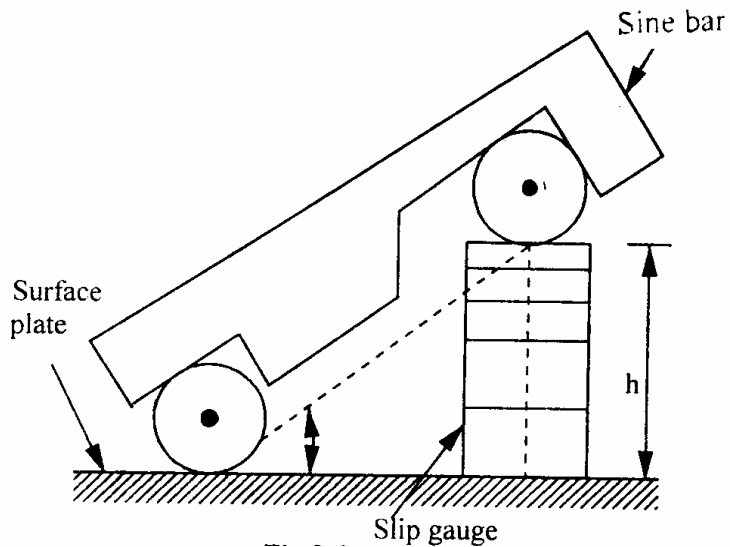
- ∅ The working of sine bar is based on **trigonometry principle**.
- ∅ To measure the angle of a given specimen, one roller of the sine bar is placed on the surface plate and another one roller is placed over the surface of slip gauges.
- ∅ Now, 'h' be the height of the slip gauges and 'L' be the distance between roller centers, then the angle is calculated as

$$\sin\theta = \frac{h}{L}$$

$$\therefore \theta = \sin^{-1}(h/L)$$

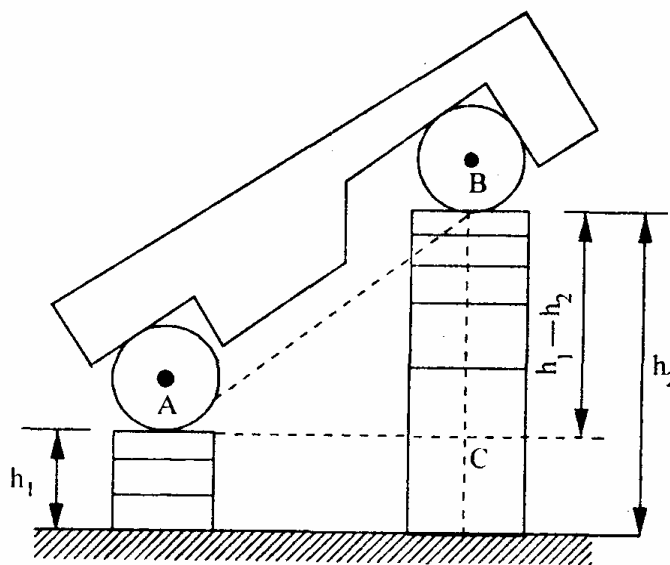
USE OF SINE BAR:

(1,) Locating any' work to a given angle:

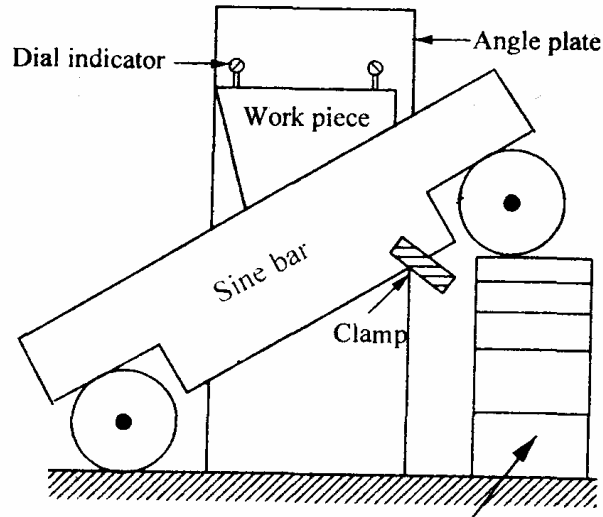


- i. To set at a given angle θ , first 'h' of slip gauge is calculated by the formula $\text{Sin}\theta = h/L$
- ii. After calculating the height 'h', the required height 'h' is made by using suitable slip gauge combinations.
- iii. After this, one of the rollers is placed on the top of the sine bar and the other one is placed on the top of the slip gauge combination.

For getting more accurate results, both the rollers can be placed slip gauges as shown in fig. 2.65.



(ii) To check unknown angles:



- 1) Before checking the unknown angle of the specimen, first the angle (θ) of given specimen is found approximately by bevel protractor.
- 2) Then the sine bar is set at angle of θ and clamped on the angle plate.
- 3) Now, the work is placed on the sine bar and the dial indicator set at one end of the work is moved across the work piece and deviation is noted.
- 4) Slip gauges are adjusted so that the dial indicator reads zero throughout the work surface.

Limitations of sine bars:

- 1) Sine bars are fairly reliable for angles than 15° .
- 2) It is physically difficult to hold in position.
- 3) Slight errors in sine bar cause larger angular errors.
- 4) A difference of deformation occurs at the point of roller contact with the surface plate and to the gauge blocks.
- 5) The size of parts to be inspected by sine bar is limited.

Sources of error in sine bars:

The different sources of errors are listed below:

- 1) Error in distance between roller centers.
- 2) Error in slip gauge combination.
- 3) Error in checking of parallelism.
- 4) Error in equality of size of rollers and cylindricity.
- 5) Error in parallelism of roller axes with each other.
- 6) Error in flatness of the upper surface of sine bar.

BEVEL PROTRACTORS

Bevel protractors are nothing but angular measuring instruments.

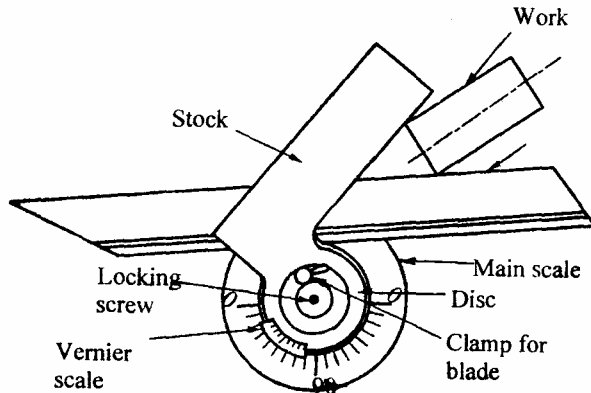
Types of bevel protractors:

The different types of bevel protractors used are:

- 1) Vernier bevel protractor
- 2) Universal protractor
- 3) Optical protractor

1. VERNIER BEVEL PROTRACTOR:

Working principle:



- ✓ A vernier bevel protractor is attached with acute angle attachment.
- ✓ The body is designed its back is flat and no projections beyond its back. The base plate is attached to the main body and an adjustable blade is attached to the circular plate containing vernierscale.
- ✓ The main scale is graduated in degrees from 0° to 90° in both the directions. The adjustable can be made to rotate freely about the center of the main scale and it can be locked at any position.
- ✓ For measuring acute angle, a special attachment is provided. The base plate is made fiat for measuring angles and can be moved throughout its length. The ends of the blade are beveled at angles of 45° and 60°.
- ✓ The main scale is graduated as one main scale division is 1° and vernier is graduated into 12 divisions on each side of zero. Therefore the least count is calculated as

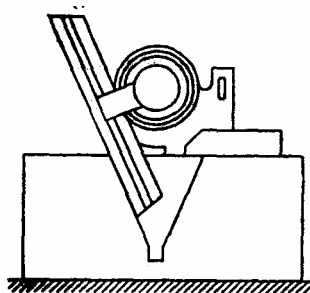
$$\begin{aligned} \text{Least count} &= \frac{\text{One main scale division}}{\text{No. of divisions on vernier scale}} \\ &= \frac{1^\circ}{12} \text{ (degrees)} \\ &= \frac{1}{12} \times 60 = 5 \text{ min utes} \end{aligned}$$

Thus, the bevel protractor can be used to measure to an accuracy of 5 minutes.

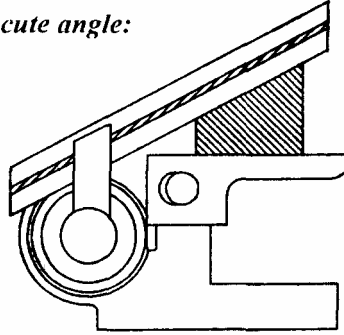
Applications of bevel protractor

The bevel protractor can be used in the following applications.

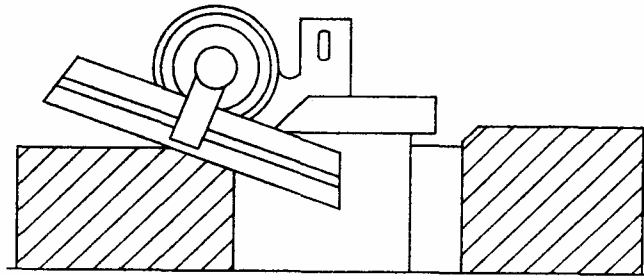
1. For checking a 'V' block:



2. For measuring acute angle:



3. For checking in inside beveled face of a ground surface.



PART-A

1. What is comparator?
2. Give the uses of comparators.
3. How are comparators classified?
4. Name important mechanical comparators.
5. State the advantages and disadvantages of mechanical comparators.
6. What are the various linear measuring devices?
7. What are the various angular measuring devices?
8. How levels are calibrated?
9. State the advantages of vernier caliper and micrometer?
10. How slip gauges are manufactured?
11. What is the other name for slip gauges?
12. Define-Rollers and its types?
13. Define-Limit gauges and its types?
14. State the applications of limit gauges?
15. Define-Feeler gauges?
16. Define-Auto collimator?
17. Define-Angle Dekkor?
18. Define-Alignment telescope ?
19. Define-Sine Bar?
20. Define-Bevel protractor ?

PART-B

1. Describe a 'dial indicator' with a neat sketch.
2. Explain about Comparators and its types in detail with neat sketch?
3. Explain about Mechanical Comparators and its types in detail with neat sketch?
4. Explain about Pneumatic Comparators in detail with neat sketch?
5. Explain about Optical Comparators and its types in detail with neat sketch?
6. Explain about Electrical Comparators and its types in detail with neat sketch?
7. Explain about Slip gauges and its classification in detail with neat sketch?
8. Explain about Rollers and its types in detail with neat sketch?
9. Explain about Limit gauges and its types in detail with neat sketch?
10. Explain about Auto collimator in detail with neat sketch?
11. Explain about Angle Dekkor in detail with neat sketch?
12. Explain about Alignment telescope in detail with neat sketch?
13. Explain about Sine Bar in detail with neat sketch and its applications?
14. Explain about Bevel protractor in detail with neat sketch and its applications?