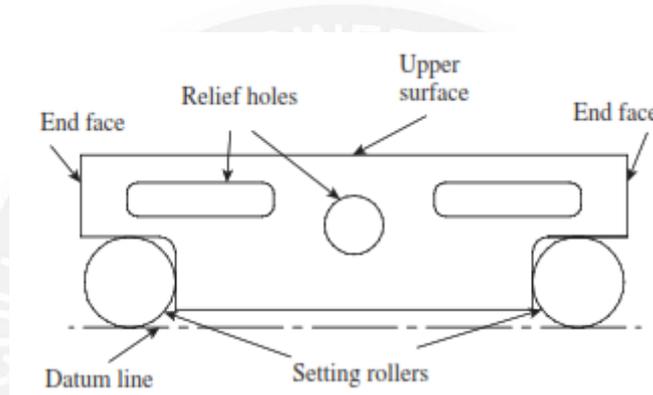


## 2.8 SINE BAR

A sine bar is used to measure angles based on the sine principle. Its upper surface forms the hypotenuse of a triangle formed by a steel bar terminating in a cylinder near each end. When one of the cylinders, called a roller, is resting on a flat surface, the bar can be set at any desired angle by simply raising the second cylinder. The required angle is obtained when the difference in height between the two rollers is equal to the sine of the angle multiplied by the distance between the centres of the rollers.



**Fig. 2.81 Sine bar**

[source: “Engineering Metrology & Measurements”, N.V. Raghavendra., page-123]

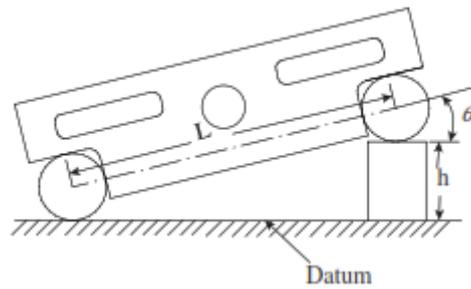
Sine bars are made of corrosion-resistant steel, and are hardened, ground, and stabilized. The size is specified by the distance between the centres of the cylinders, which is 100, 200, or 300 mm. The upper surface has a high degree of flatness of up to 0.001 mm for a 100 mm length and is perfectly parallel to the axis joining the centres of 0.001 mm for a 100 mm length. Relief holes are sometimes provided to reduce the weight of the sine bar. This by itself is not a complete measuring instrument. Accessories such as a surface plate and slip gauges are needed to perform the measurement process.

The sine of angle  $\theta$  formed between the upper surface of a sine bar and the surface plate (datum) is given by

$$\sin(\theta) = h/L$$

where  $h$  is the height difference between the two rollers and  $L$  is the distance between the centres of the rollers.

Therefore,  $h = L \sin (\theta)$



**Fig. 2.82 Sine rule**

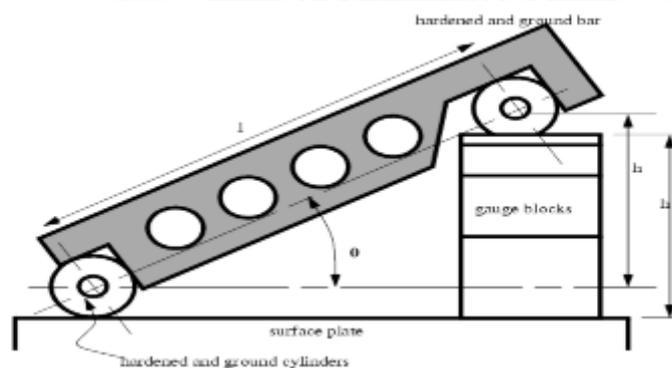
[source: “Engineering Metrology & Measurements”, N.V. Raghavendra., page-123]

### 2.8.1 Working principle of sine bar

The working of sine bar is based on trigonometry principle. To measure the angle of the 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

$$\sin \theta = h/L$$

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



**Fig. 2.83 Measurement of unknown angles**

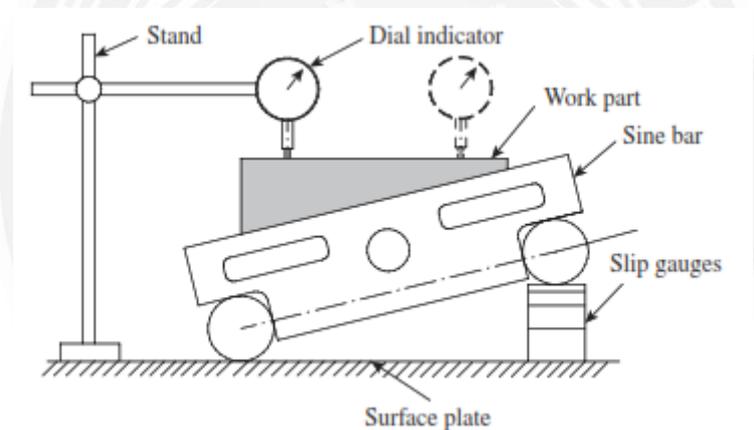
[source:[http://www.gpsrinagar.org/lms/MECHMECH%20AUTO/angular%20measurement\\_mech.pdf](http://www.gpsrinagar.org/lms/MECHMECH%20AUTO/angular%20measurement_mech.pdf)]

## Use of sine bar

Sine bar are used for

- I. Locating any work to a given angle.
- II. To check unknown angle.
- III. Measurement of unknown angles for heavier components
- IV. Measurement of unknown angles of heavier components with more accurate readings.

### 2.8.2 Measuring Unknown Angles with Sine Bar



**Fig. 2.84 Measurement of unknown angles**

[source: “Engineering Metrology & Measurements”, N.V. Raghavendra., page-123]

A sine bar can also be used to measure unknown angles with a high degree of precision. The angle of the work part is first measured using an instrument like a bevel protractor. Then, the work part is clamped to the sine bar and set on top of a surface plate to that angle using slip gauges.

A dial gauge fixed to a stand is brought in contact with the top surface of the work part at one end and set to zero. Now, the dial indicator is moved to the other end of the work part in a straight line. A zero reading on the dial indicator indicates that the work part surface is perfectly horizontal and the set angle is the right one. On the other hand, if the dial indicator shows any deviations, adjustments in the height of slip gauges is

necessary to ensure that the work part surface is horizontal. The difference in height corresponding to the dial gauge reading is incorporated in the slip gauges, and the procedure is repeated until the dial indicators show zero deviation. The actual angle is calculated using the total height of the slip gauges.

Instead of a dial gauge, a high-amplification comparator can be used for better accuracy. Whether setting a sine bar to a known angle or for measuring unknown angles, a few guidelines should be followed to ensure proper usage of the instrument:

1. It is not recommended to use sine bars for angles greater than  $45^\circ$  because any error in the sine bar or height of slip gauges gets accentuated.
2. Sine bars provide the most reliable measurements for angles less than  $15^\circ$ .
3. The longer the sine bar, the better the measurement accuracy.
4. It is preferable to use the sine bar at a temperature recommended by the supplier. The accuracy of measurement is influenced by the ambient temperature.
5. It is recommended to clamp the sine bar and the work part against an angle plate. This prevents misalignment of the workpiece with the sine bar while making measurements.
6. One should always keep in mind that the sine principle can be put to use provided the sine bar is used along with a high-quality surface plate and set of slip gauges.

### **2.8.3 Sine Blocks, Sine Plates, and Sine Tables**

#### **Sine Blocks**

A sine block is a sine bar that is wide enough to stand unsupported



**Fig. 2.85 Sine Blocks**

[source: “Engineering Metrology & Measurements”, N.V. Raghavendra., page-126]

### Sine Plates

If it rests on an integral base, it becomes a sine plate. A sine plate is wider than a sine block.



**Fig. 2.86 Sine Plates**

[source: “Engineering Metrology & Measurements”, N.V. Raghavendra., page-126]

### Sine Tables



**Fig. 2.87 Sine Tables**

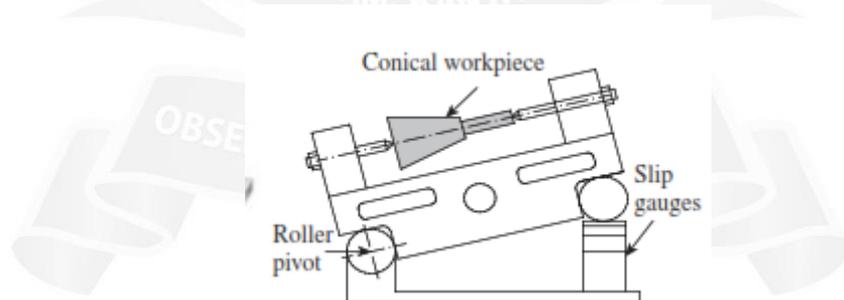
[source: <https://slideplayer.com/slide/5686767/>]

A heavy-duty sine plate is rugged enough to hold work parts for machining or inspection of angles. If a sine plate is an integral part of another device, for example, a machine tool, it is called a sine table.

In all these three devices, the work part rests on them. They are often used like a fixture to keep the work part at a particular orientation, so that the required angle is machined. The instruments have attachments to raise and lock the block to the required angle, and to also fasten work parts. The sine table is the most rugged device, which may be swung to any angle from  $0^\circ$  to  $90^\circ$  by pivoting about the hinged end.

There are many instances where compound angles need to be machined or inspected. While simple angles lie on one plane, compound angles of a surface lie on more than one plane. In a surface formed by the intersections of planes, the angles on the surface planes are called face angles. A compound sine plate can conveniently measure or set itself to this face angle. In a typical compound sine plate, there are two sine plates: a base plate creates one plane, while the top plate creates the second plane. Compound sine plates are usually used for finishing operations, for example, a finish grinding operation.

### Sine Centre



**Fig. 2.88 Sine Plates**

[source: “Engineering Metrology & Measurements”, N.V. Raghavendra., page-126]

A sine centre provides a convenient means of measuring angles of conical workpieces that are held between centres, as shown in Fig. 5.13. One of the rollers is pivoted about its axis, thereby allowing the sine bar to be set to an angle by lifting the other roller.

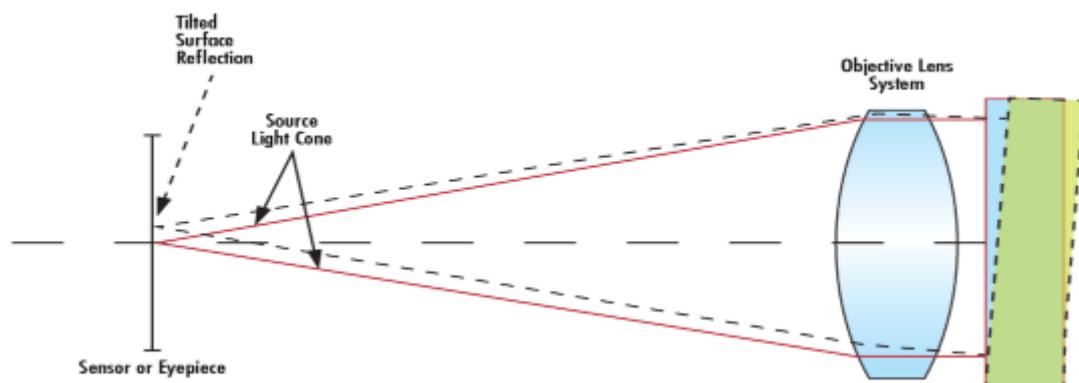
The base of the sine centre has a high degree of flatness, and slip gauges are wrung and placed on it to set the sine bar at the required angle. Conical workpieces that need to be inspected are placed between the centres. The sine centre is used for measuring angles up to  $60^\circ$ .

A dial gauge clamped to a stand is set against the conical workpiece. The sine bar is set to an angle such that the dial gauge registers no deviation when moved from one end of the workpiece to the other. The angle is determined by applying the sine rule.

#### 2.8.4 Auto- collimator

- An autocollimator is an optical instrument for non-contact measurement of angles.
- It's 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



**Fig. 2.89 Principle of Auto-collimator**

[source:[http://www.gpsrinagar.org/lms/MECHMECH%20AUTO/angular%20measurement\\_mech.pdf](http://www.gpsrinagar.org/lms/MECHMECH%20AUTO/angular%20measurement_mech.pdf)]

- If a light source is placed in the focus of a collimating lens, it is projected as a parallel beam of light.

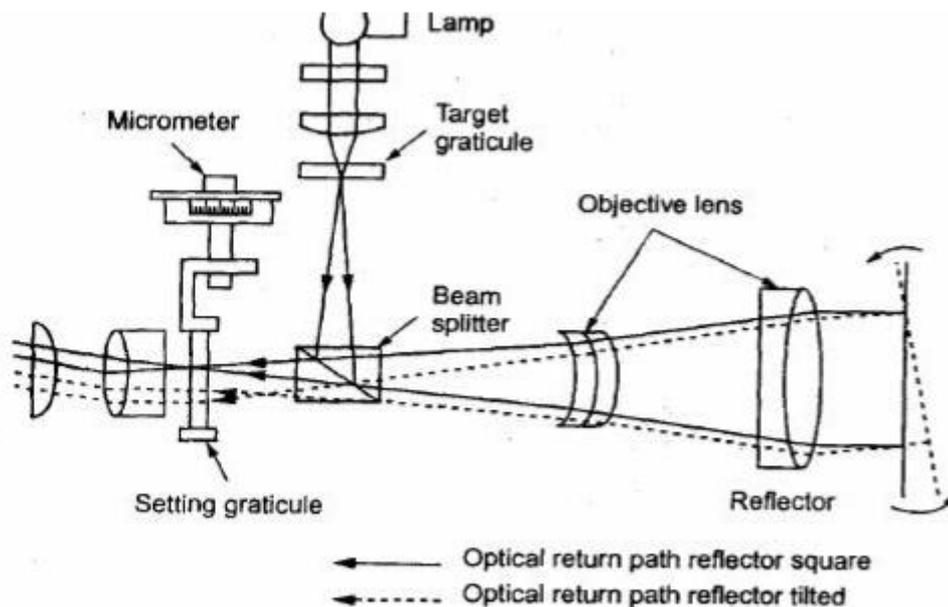
- If this beam is made to strike a plane reflector, kept normal to the optical axis, it is reflected back along its own path and is brought to the same focus.
- If the reflector is tilted through a small angle ' $\theta$ '. Then the parallel beam is deflected twice the angle and is brought to focus in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

### Working of auto-collimator

There are three main parts in auto-collimator.

1. Micrometer microscope.
2. Lighting unit and
3. Collimating lens.

- Fig. Shows a line diagram of a modern auto-collimator. A target graticule is positioned perpendicular to the optical axis.
- When the target graticule is illuminated by a lamp, rays of light diverging from the intersection point reaches the objective lens via beam splitter.
- From objective, the light rays are projected as a parallel ray to the reflector.



**Fig. 2.90 Line Diagram Auto-collimator**

[source:[http://www.gpsrinagar.org/lms/MECHMECH%20AUTO/angular%20measurement\\_mech.pdf](http://www.gpsrinagar.org/lms/MECHMECH%20AUTO/angular%20measurement_mech.pdf)]

- 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 ( $\theta$ ), 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  $2\theta \cdot f$ .
- 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**

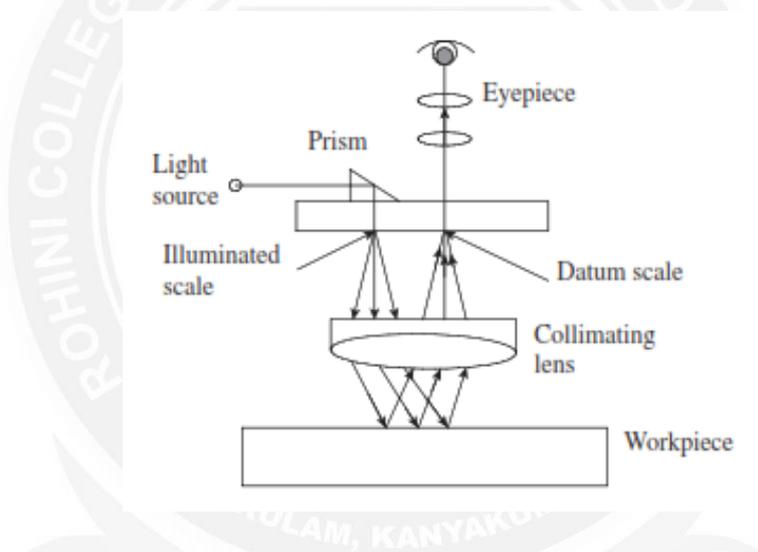
Auto-collimators are used for

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

### **2.8.5 Angle Dekkor**

An Angle Dekkor is a small variation of the autocollimator. This instrument is essentially used as a comparator and measures the change in angular position of the

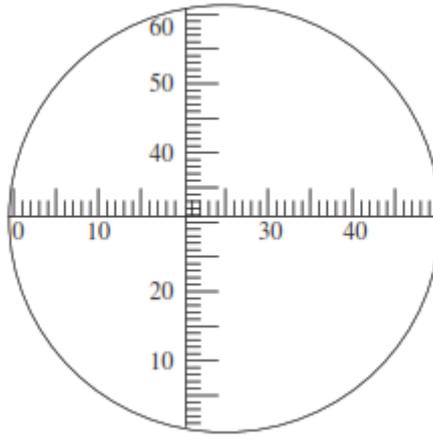
reflector in two planes. It has an illuminated scale, which receives light directed through a prism. The light beam carrying the image of the illuminated scale passes through the collimating lens, and falls onto the reflecting surface of the workpiece. After getting reflected from the workpiece, it is refocused by the lens in field view of the eyepiece. While doing so, the image of the illuminated scale would have undergone a rotation of  $90^\circ$  with respect to the optical axis. Now, the light beam will pass through the datum scale fixed across the path of the light beam. When viewed through the eyepiece, the reading on the illuminated scale measures angular deviations from one axis at  $90^\circ$  to the optical axis, and the reading on the fixed datum scale measures the deviation about an axis mutually perpendicular to this.



**Fig. 2.91 Angle Dekkor**

[source: “Engineering Metrology & Measurements”, N.V. Raghavendra., page-123]

The view through the eyepiece, which gives the point of intersection of the two scales, is shown in below Fig. The scales usually measure up to an accuracy of  $1'$ .



**Fig. 2.92 Intersection of two scales**

[source: “Engineering Metrology & Measurements”, N.V. Raghavendra., page 123]

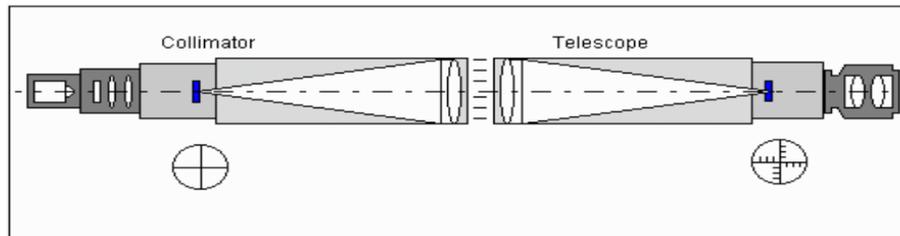
This reading actually indicates changes in angular position of the reflector in two planes. In other words, the initial reading of the angle dekkor corresponds to the reading on the two scales before shifting the position of the reflector. After the reflector undergoes an angular tilt, the second reading is noted down by recording the point of intersection on both scales. The difference in readings on the two scales indicates the tilt of the reflector in two planes at  $90^\circ$  to each other.

The optical system in an angle dekkor is enclosed in a tube, which is mounted on an adjustable bracket. It has a wide range of applications, as angular variations can be directly read through the eyepiece of the instrument. Some of the typical applications are as follows:

1. Measurement of sloping angle of V-blocks
2. Calibration of taper gauges
3. Measurement of angles of conical parts
4. Measurement of angles of work part surfaces, which are simultaneously inclined in two planes
5. Determination of a precise angular setting for machining operations, for example, milling a slot at some precise angle to a previously machined datum surface.

## 2.8.6 Angle alignment of telescope

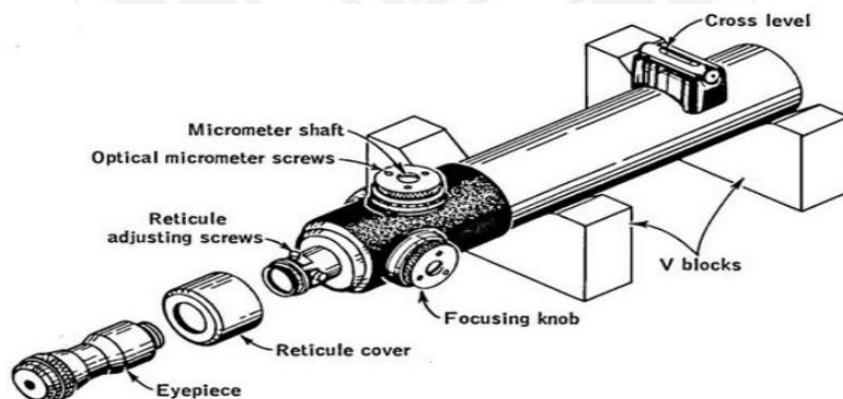
Alignment telescope is used for aligning of bores, surfaces and checks squareness, straightness, flatness, parallelism, vertically and level. One of the important types of alignment telescope is Taylor-Hobson alignment telescope.



**Fig. 2.93 Angle alignment of telescope**

[source:<https://pdfcoffee.com/me-6504-metrology-amp-measurement-all-unit-notes-pdf-free.html>]

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.



**Fig. 2.94 Parts of Angle alignment of telescope**

[source:<https://pdfcoffee.com/me-6504-metrology-amp-measurement-all-unit-notes-pdf-free.html>]