Metrology Laboratory
Department of Mechanical Engineering

Experiment No. 2

MEASUREMENT OF ANGLES

Aim:

- To measure the included angle of the V-block using Sine bar.
- To measure external taper angle of a tapered plug gauge using precision rollers.
- To measure internal taper angle of a tapered ring gauge using precision balls.

Instruments:

- Sine bar
- Dial indicator
- A set of slip gauges
- Micrometer
- Depth gauge
- Two rollers of same diameter
- Two spherical balls of same diameter

Theory:

A sine bar is a tool used to measure angles in metalworking. It consists of a hardened, precision ground body with two precision ground cylinders fixed at the ends. The distance between the centers of the cylinders is precisely controlled, and the top of the bar is parallel to a line through the centers of the two rollers as shown in Fig. 1.

Fig. 1 Sine Bar

The dimension between the two rollers is chosen to be a whole number (for ease of later calculations) and forms the hypotenuse of a triangle when in use. Generally, the centre distance between two cylindrical rollers is 10 inch or 100 mm sine bar (however, in the U.S., 5 inch sine bars are the most commonly used).

When a sine bar is placed on a level surface the top edge will be parallel to that surface. If one roller is raised by a known distance, usually using gauge blocks, then the top edge of the bar will be tilted by the same amount forming an angle that may be calculated by the application of the sine rule.

A Bevel Protractor, a graduated circular protractor having a pivoted arm and used for measuring or marking off angles, is shown in Fig. 2. Sometimes vernier scales are attached to give more accurate readings. It has wide application in architectural and mechanical drawing although with the availability of modern drawing software or CAD.

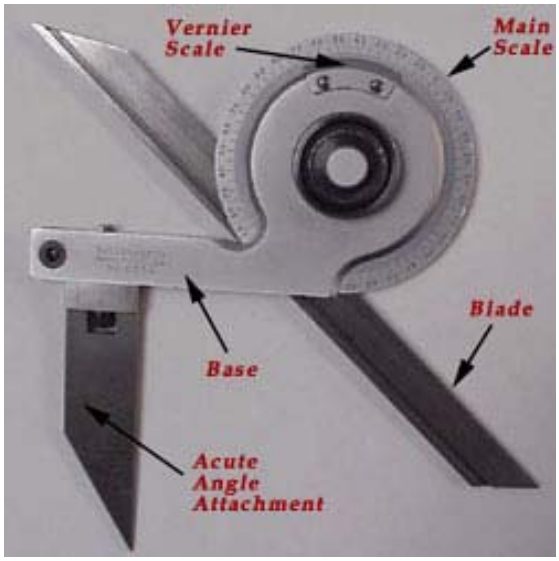

Fig. 2 The Universal Bevel Protractor

Angles are measured using a sine bar with the help of gauge blocks and a dial gauge or a spirit level. The aim of a measurement is to make the surface on which the dial gauge or spirit level is placed horizontal. For example, to measure the angle of a wedge, the sine bar is placed on a horizontal surface plate. The wedge is clamped over the sine bar with inclined surface on the top. At this position, the top surface of the wedge is inclined with respect to surface plate. Using slip gauges, the top surface of wedge is made horizontal. The sine of the angle of inclination of the wedge is the ratio of the height of the slip gauges used and the distance between the centers of the cylinders.

Sine Centre is a special type of sine bar, which is used for conical objects having male and female parts, as shown in Fig. 3. It cannot measure the angle more than 45 degrees. Sine table (or sine plate) is used to measure angles of large workpieces. Compound sine table is used to measure compound angles of large workpieces. In this case, two sine tables are mounted one over the other at right angles. The tables can be twisted to get the required alignment.

Fig. 3 Sine Center

A Thread Plug Gauge is used to check acceptance of a “nut” – i.e. an internally threaded part (Fig. 4). For small threaded parts, the gauge will be double ended, with one end carrying the GO gauge and the other end, the NO-GO. For large parts, the two may be separate pieces. A thread plug gauge is designed to check the correctness of the pitch diameter (to the given pitch / TPI).

For acceptance of the part, the GO gauge should pass through the entire length of the nut, without too much of wringing force. The NO-GO gauge can at the best enter into the nut, checked at both ends, over not more than 2 turns and NOT beyond as shown in figure below.

Fig. 4 Thread Plug Gauge and Ring Gauge

A solid thread ring gauge is used to check acceptance of a “screw” – i.e. externally threaded part. The GO and NO-GO rings are normally separate pieces. A thread ring gauge is designed to check the correctness of the pitch diameter (to the given pitch / TPI).

For acceptance of the part, the GO ring gauge should pass through the entire length of the screw, without too much of wringing force. The NO-GO ring gauge can at the best enter into the screw over not more than 2 rotations and NOT beyond.

Procedure:

- Mesurement of angle by Sine Bar (Ref: Fig.5)

1. Place the wedge block on the sine bar and clamped at the centre.
2. Use appropiate slip gauges to make the top wedge surface horizontal to surface plate.
3. Select the suitable slip gauge combination so that the surface of gauge block remains perfectly horizontal i.e. When dial indicator shows no deflection as it is moved over its surface from one end to another.

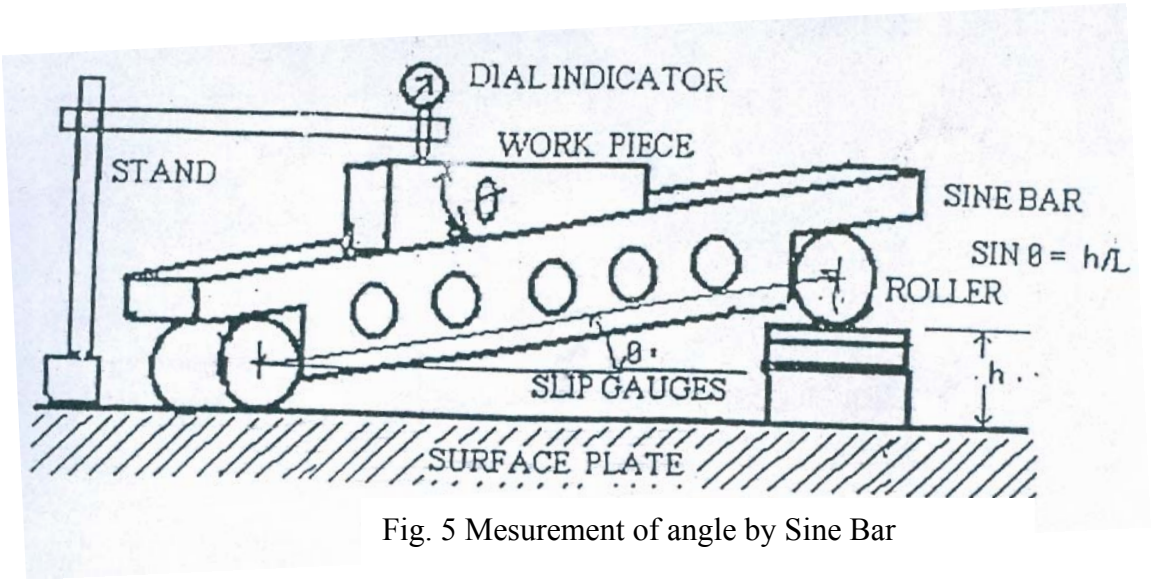

Fig. 5 Mesurement of angle by Sine Bar

Then, the wedge angle may be expressed as: $\theta = \sin^{-1}(h/L)$

Where, h = Slip gauge combination height;
L= Center distance between two rollers of sine bar (5 inches)

Similarly, two different inclination angles can be measured to measure the included angle the V block. The included angle of the V block, $\theta = 180° - (\theta_1 + \theta_2)$, as shown in Fig. 6.

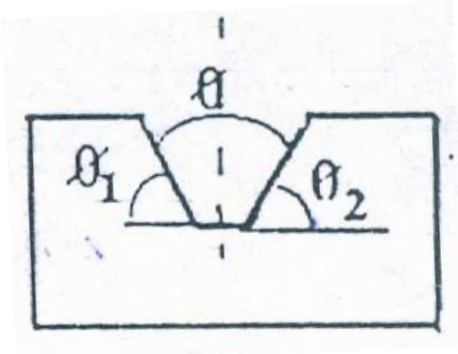

Fig. 6 Schematic diagram of V block

- External taper measurement: (Ref: Fig. 7)

1. Place the smaller end of the tapered plug gauge on the surface plate.
2. Place equal height of slip gauge combinations (h_1) on either side of gauge and measure M1 using a micrometer.
3. Increase height of slip gauge combinations ($h_2 > h_1$) on either side of gauge and measure M2 using micrometer.

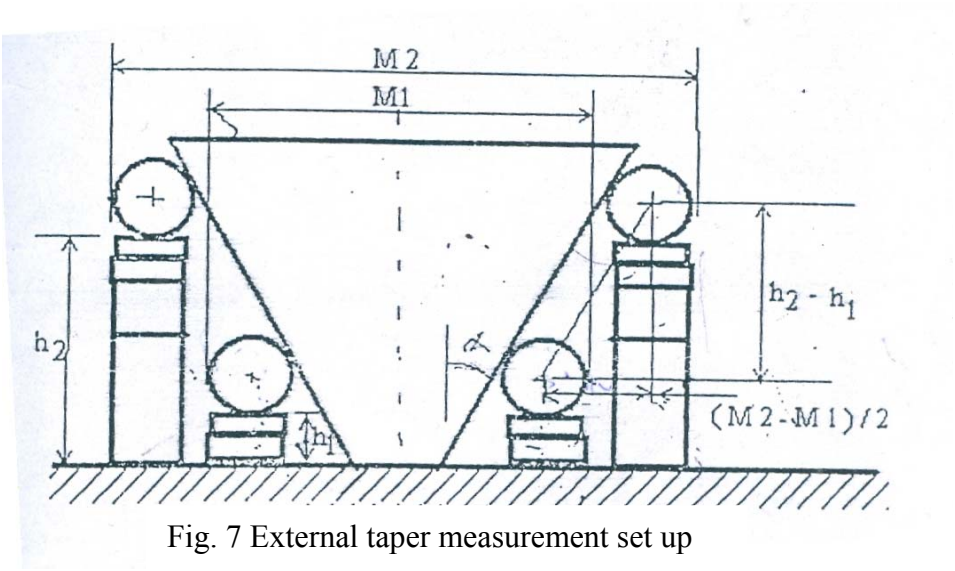

Fig. 7 External taper measurement set up

Then, $\tan \alpha = (M2-M1) /2 (h_2- h_1)$,

where M1 = Distance between two rollers at lower position
M2 = Distance between two rollers at upper position
h_1 = Slip gauge combination height at lower position
h_2 = Slip gauge combination height at upper position
α = Half taper angle

- Internal taper measurement: (Ref: Fig. 8)

1. Place one end of the tapered ring gauge on the surface plate.
2. Place suitable slip gauge combinations (M1) in between two balls such that both balls arc in contact with internal side of the ring gauge.
3. Place the reverse end of the tapered ring gauge on the surface plate and repeat the above procedure for reading M2.
4. Measure the height (H) of ring gauge with a Vernier height gauge.
5. Measure the diameter of balls (d) with a micrometer.

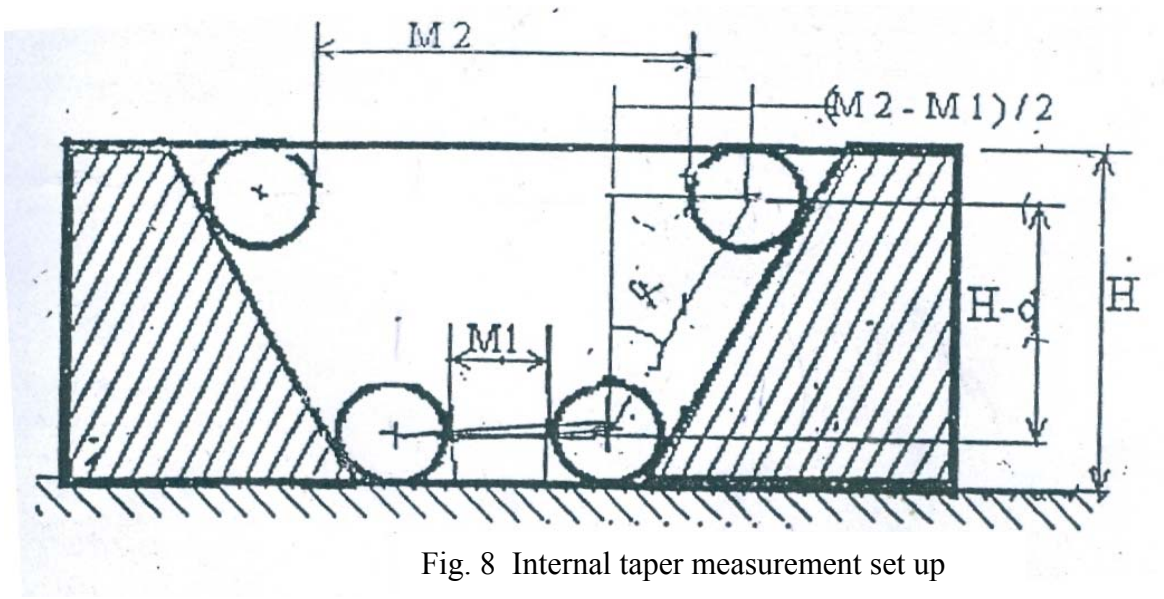

Fig. 8 Internal taper measurement set up

Then, tan α = (M 2-M1) /2 (H- d)

M1 = Distance between two balls at upright position
M2 = Distance between two balls at upside down position
H = Height of the tapered part
d=Diameter of the ball
α = Half taper angle

Questions:

1. Differentiate between sine bar, sine table and sine center.
2. Is it recommended to use a sine bar to measure angles more than 45° ? If not, why?