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 metal working. 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.

  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 Proteractor, a graduated circular protractor having a pivoted arm and used for measuring or marking of angles. 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.

Sine Centre: Sine centre is a special type of sine bar, which is used for conical objects having male and female parts.

It cannot measure angles 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.

Thread plug Gauge

A Thread Plug Gauge is used to check acceptance of a "nut" - i.e., an internally threaded part. 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.

Thread ring Gauge

A solid thread ring gauge is used to check the 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 ant not beyond.

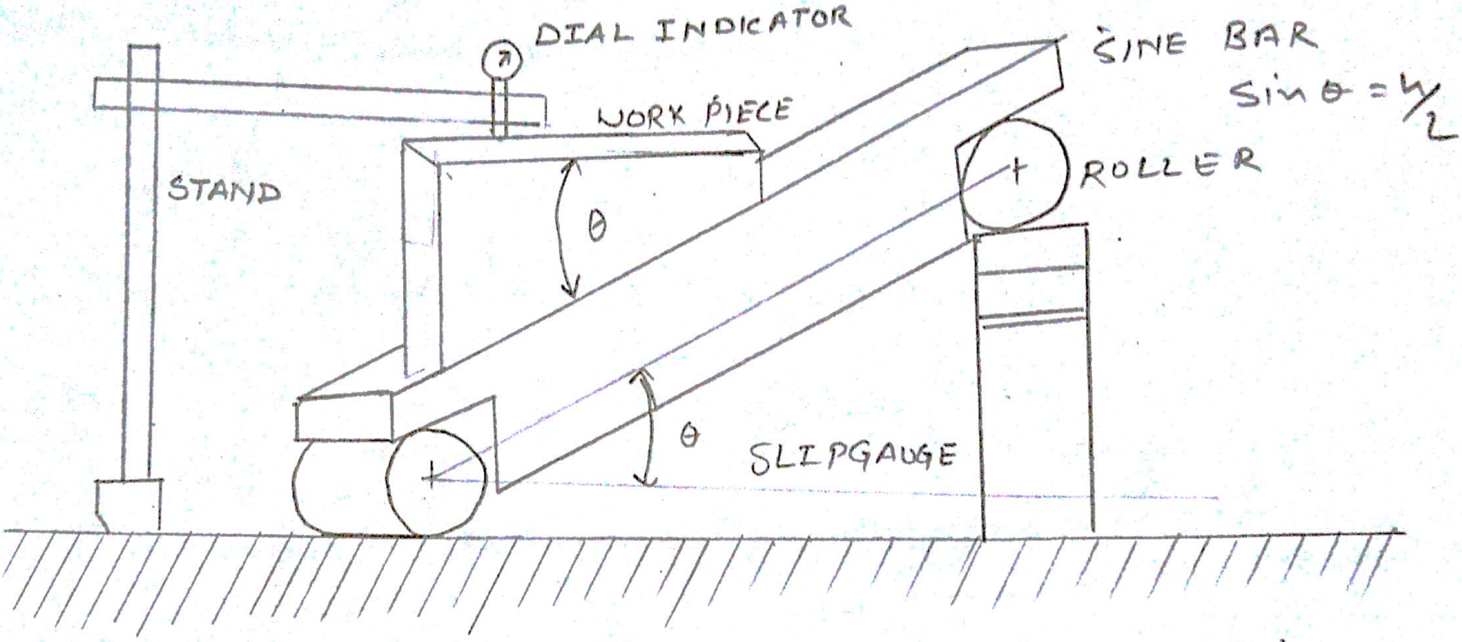


Fig 1: Mesurement of angle by Sine Bar.

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).

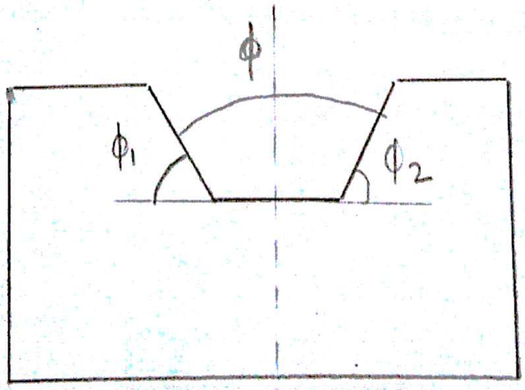


Fig 2: Schematic Diagram of V block

Scanned by CamScanner

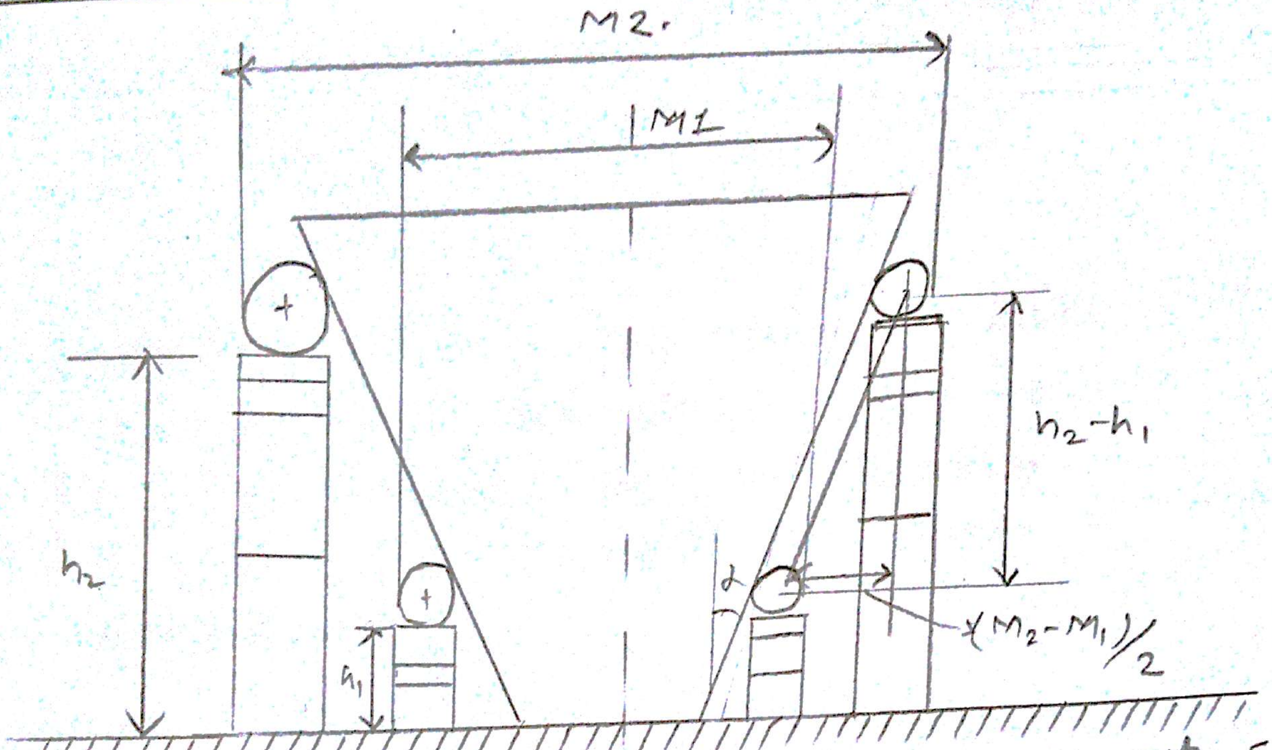


Fig 3 : External Taper measurement set-up.

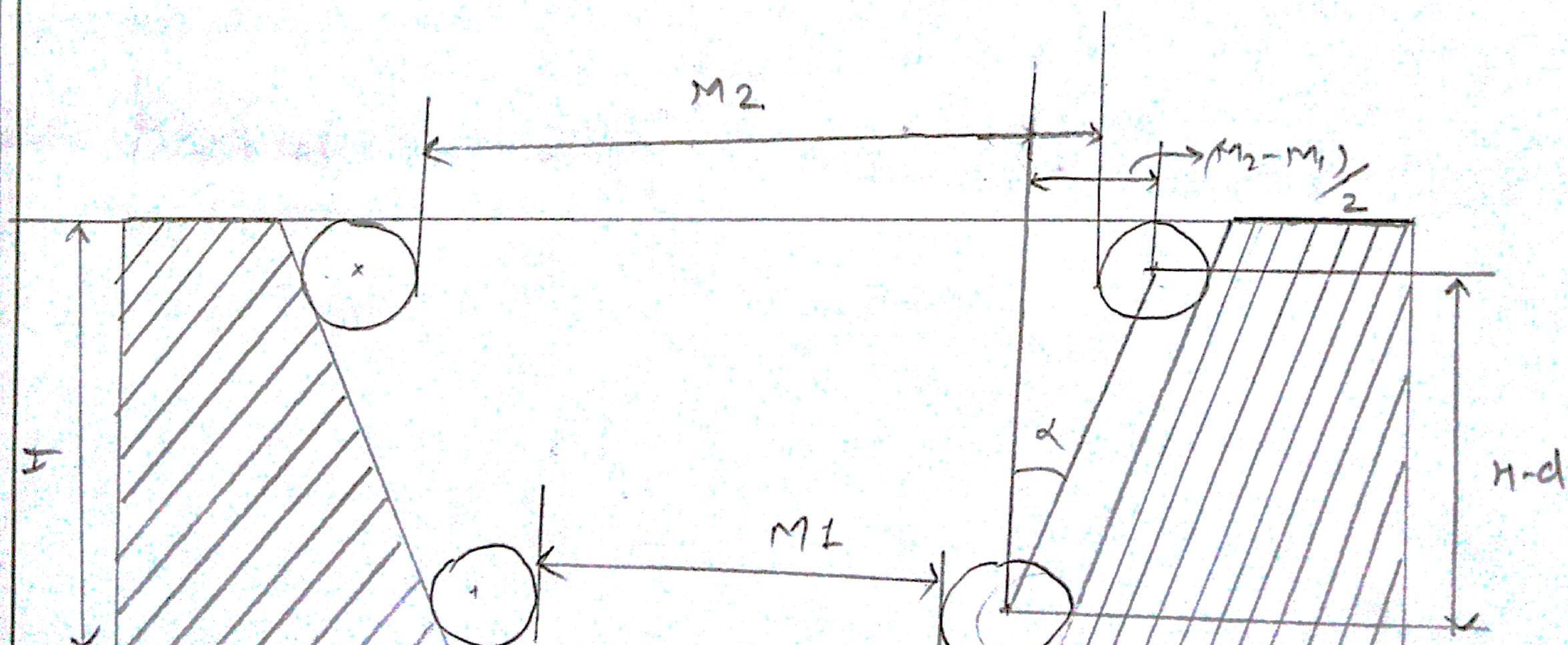


fig 4 : Internal taper measurement set-up.

For figure 3

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

where M1 = Distance between two rollers at lower position

M2 = Distance between two rollers at upper position.

h1 = Slip gauge combination height at lower position

h2 = Slip gauge combination height ~~ha~~ at upper position

α = Half taper angle.

For figure-4

Then $\tan\alpha = (M2 - M1) / 2(H - d)$.

M1 = Distance between two balls at upright position

M2 = Distance between two balls at upside down position.

H = Height of tapered part

d = Diameter of the ball

α = Half taper angle.

Questions :-

① Differentiate between sine bar, sine table and sine center.

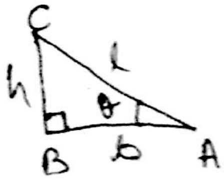
Ans→ Angles are measured using a sine bar with the help of gauge blocks and a dial gauge or a spirit level. The aim of a measurement is to make the surface on which the dial gauge or spirit level is placed horizontal.

Sine centre is a special type of sine bar which is used for conical objects having male and female parts. It can not measure the angle more than 45 degrees.

Sine table (or sine plate) is used to measure angles of large work pieces. When two sine tables are mounted one over the other at right angles, it is called compound sine table and is used to measure the compound angles of large workpieces.

② Is it recommended to use a sine bar to measure angles more than 45°? If not, why?

Ans:- No, it is not recommended to use a sine bar to measure angles more than 45°. For right angled triangle ABC in the figure, $\sin\theta = \frac{h}{l}$ — ①



Differentiating eqⁿ ① and after arranging the terms we get :-

$$d\theta = \tan\theta \left[\frac{dh}{h} - \frac{dl}{l}\right]$$

∵ l is constant so, $dl = 0$

$\Rightarrow d\theta = \tan\theta \frac{dh}{h}$, Now $\frac{dh}{h}$ is error in height measured.

We know that for $\theta < 45°$, $\tan\theta < 1$ and for $\theta > 45°$, $\tan\theta > 1$

So, when $\theta > 45°$, the ~~error~~ value increases significantly for $d\theta$.

So, if $\theta > 45°$, we do not use sine bar.

Calculations: For measurement of angle using Sine bar

The wedge angle may be expressed as

For $h_1 = 63.72$ mm
$l = 5$ inch

$\theta_1 = \sin^{-1}\frac{h_1}{l} = 30.12°$

For $h_2 = 63.75$ mm
$l = 5$ inch

$\theta_2 = \sin^{-1}\frac{h_2}{l} = 30.13°$

$\therefore \theta_1 + \theta_2 = 60.25°$

So included angle of V block $= 180° - (\theta_1 + \theta_2)$
$= 119.75°$

External taper measurement:-

We know that $\tan\alpha = \frac{M_2 - M_1}{2(h_2 - h_1)}$

$M_2 = 40$ mm
$M_1 = 40.71$ mm
$h_2 - h_1 = 10$ mm

So $\tan\alpha = 0.0355$
$\alpha = 2.033°$

Internal taper measurement:-

We know that $\tan\alpha = \frac{M_2 - M_1}{2(H - d)}$

$M_1 = 38.24$ mm $\quad H = 23.43$
$M_2 = 39.17$ mm $\quad d = 6.34$ mm

$\tan\alpha = 0.0272$ mm $\quad \alpha = 1.56°$