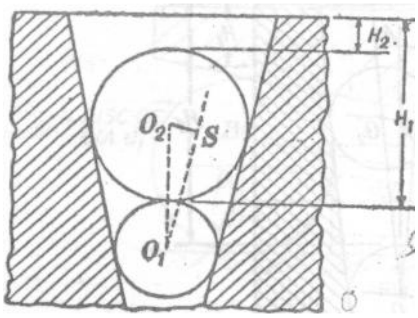
FACULTY OF ENGINEERING
DESIGN AND PRODUCTION ENGINEERING DEPARTMENT

Credit Hour System
Metrology Lab 1 – MDP 240

Report On:

(11)

Miscellaneous



Metrology laboratory

Student Name	Remark
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MISCELLANEOUS MEASUREMENTS

1 Introduction

Some parts are very difficult to be measured by actual tools and measuring instruments. A lot of time is likely to be wasted in thinking about the ways in which some miscellaneous measurements could be made unless some guiding principles are followed. Instead of using tools alone, some parts are best inspected and measured by mathematical calculations. Once the methods given below for some typical problems are visualized they can be applied to any problem being faced in the workshop.

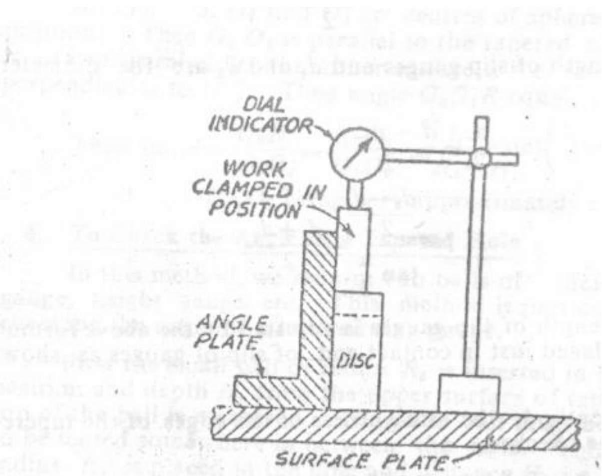


Fig. 1.

2- Checking the Angle of a Piece Tapered on One Side

This can be done by using two discs of different sizes, slip gauges and a dial indicator. The length of slip gauges required for the purpose is calculated as given later and the slip gauge combination of that length prepared. The two discs whose diameters are known and slip gauges are placed on a surface plate as shown in Fig. 1 and the discs are clamped in position against an angle plate by C-clamps. The work is then placed on top of discs and clamped against the angle plate by a C-clamp. If the angle of the piece is all right, then the top edge will be parallel to surface plate and the dial indicator will show no variation when traversed along its surface.

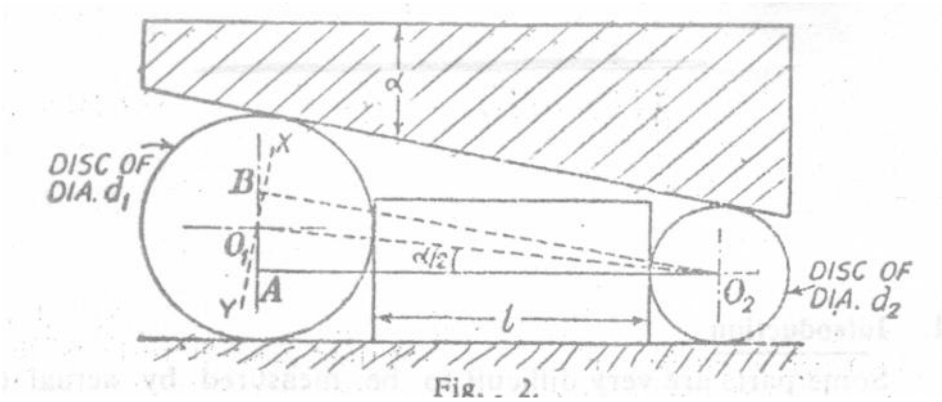


Fig. 2.

In Fig. 2, O_1 and O_2 are the centers of the two discs. Line XY is drawn perpendicular to line joining O_1O_2. O_2A is horizontal line and O_2B is parallel to the tapered surface of the piece i.e. inclined at an angle α to the horizontal line.

The angle $O_1O_2A = \alpha/2$.

Now in rt. $\angle d_2 \Delta O_1O_2A_2$

$$\tan-\frac{\alpha}{2} = \frac{O_2A_2}{AO_2} = \frac{\frac{d_1 - d_2}{2}}{\frac{d_1 + d_2}{2} + 1}$$

Where I is the length of slip gauge and d_2 and d_2 are the diameters of two discs.

Or
$$\left(\frac{d_1 + d_2}{2} = 1\right)\tan\frac{\alpha}{2} = \frac{d_1 - d_2}{2}$$

And
$$I = \frac{\frac{d_1 - d_2}{2}}{\tan\frac{\alpha}{2}} - \frac{d_1 + d_2}{2}$$

Thus the length of slip gauges is adjusted by the above formula and two discs placed just in contact end of slip of gauges as shown in Fig. 2.

By this method, the straightness of the edges of the tapered piece can also be checked.

3 - To check the angle of a Tapered Recess whose Angle of Taper is Very Small

In Fig. 3, XY and MN are two tapered faces, inclined at angle A. for this measurement we require one3 sphere of certain diameter depending upon the distance XM, set of slip gauges and a micrometer depth gauge.

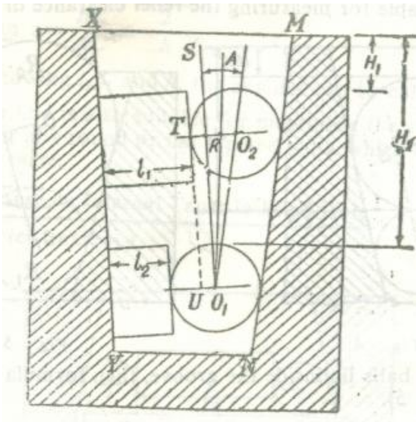


Fig. 3.

A slip gauge of certain length I_2 is chosen and inserted in tapered recess along with sphere as shown in Fig. 3. In this position, the depth H_2 is measured with the micrometer depth gauge. Then a slip gauge of bigger length, I_1 is selected and again inserted with the same sphere in the tapered recess. Again in this position depth H_1 is measured with the depth gauge.

In Fig. 3, O_1 and O_2 are centers of spheres in two different positions. Then O_1O_2 is parallel to the tapered surface MN. O_1S is drawn parallel to the other surface XY of recess O_2R is drawn perpendicular to O_1S. then angle O_2O_1R equal A.

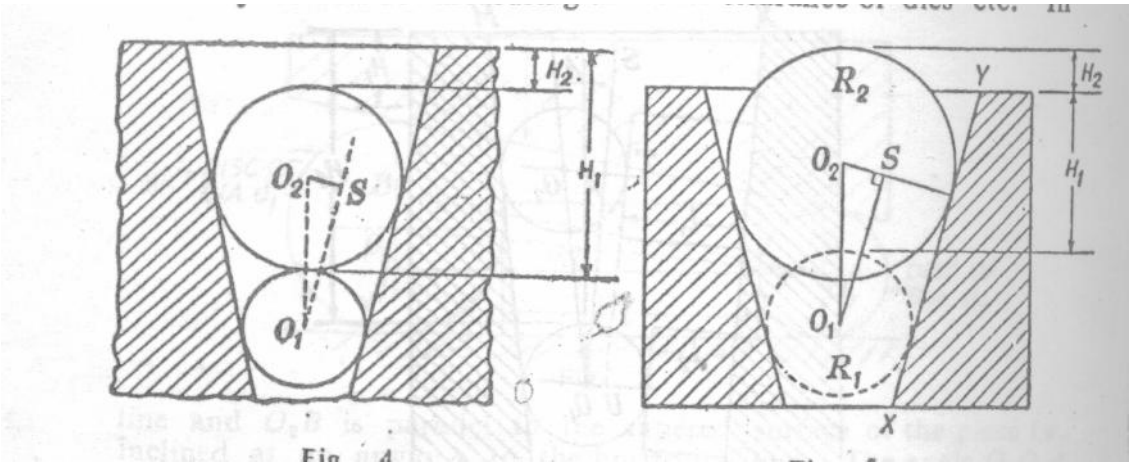
Then $\sin A = \dfrac{O_2R}{O_1O_2} = \dfrac{I_1 - I_2}{O_1O_2} = \dfrac{I_1 - I_2}{H_2 - H_1}$

(O_1O_2 being very approximately equal to $H_2 - H_1$).

4 - To Check the Angle of a Tapered Hole

In this method, we require two balls of different sizes, depth gauge, height gauge etc. This method is particularly suitable for checking the angle of a tapered ring gauge.

First the small ball of radius R_1 is inserted in the hole in lower position and depth H_1 from the upper surface of tapered hole to the top of the ball is measured. The small ball must be of such size, as to be seated somewhere in between the hole. Then bigger ball of radius R_2 is placed in the hole and distance H_2 i.e. between the top of ball and tapered hole is measured with height gauge.



In Fig. 4, O_1 and O_2 represent the centers of two balls. Draw O_1S parallel to the line XY of tapered hole in section and O_2S perpendicular to O_1S.

Then $O_2O_1S = A/2$

Where A is the angle of tapered hole.

$$\sin\frac{A}{2} = \frac{O_2S}{O_1O_2} = \frac{R_2 - R1}{H_1 + H_2 + R_1 - R_2}$$

Thus the angle of taper A can be found out. This method is also very suitable for measuring the relief clearance of dies etc. in case both the balls lie inside the groove, then formula is modified as shown (Fig. 5).

$$\sin\frac{A}{2} = \frac{R_2 - R_1}{H_1 + R_1 - (H_2 + R_2)}$$

5 - To Determine the Included Angle of an Internal Dovetail.

In dovetail the sloping sides act as guide and prevent the lifting of the female mating part during mating operation. The angle which the loping face makes with an imaginary vertical centre plane is important in case of dovetail. For measuring this angle we require two pins of equal size, slip gauges and micrometers.

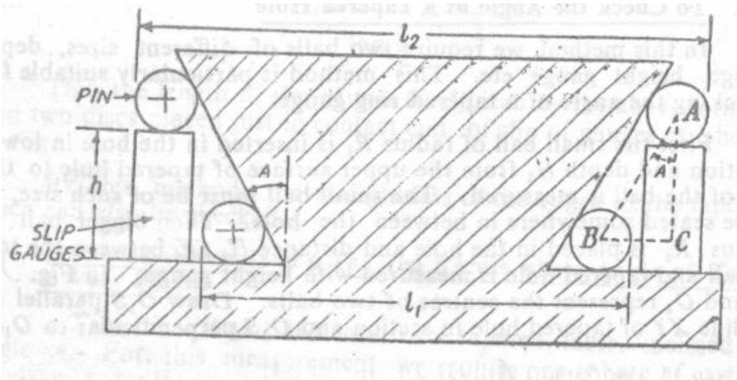


Fig. 6.

First the two pins are placed touching both the sides of dovetail as show in Fig. 6 and distance I_1 is measured across these pins with a micrometer. Then the pins are raised on two sets of equal slip gauge blocks. Here care should be taken that the pins do not extend above the top surface of dovetail. Again distance I_2 across the pins is measured. Let the height of the slip gauges be I_1.

Then tan a = $$\frac{BC}{AC} = \frac{\frac{I_2 - I_1}{2}}{h}.$$

Thus knowing $I_2 I_1$ and h, the angle A can be calculated.

This method is also suitable for measuring the angle of a taper plug gauge or any round or flat tapered work which can be placed on a surface plate.

6 - To Measure and Internal Taper in Blind Hole

Let tapered angle = A.

For this method we require two steel balls of equal size and slip gauges. First two balls of equal diameter are placed in each bottom corner of the taper as shown in Fig. 7, and the space between the balls is filled with a correct combination of slip gauges. The length of slip gauges which just fits in the space between the balls must be noted very carefully and let it be l_1.

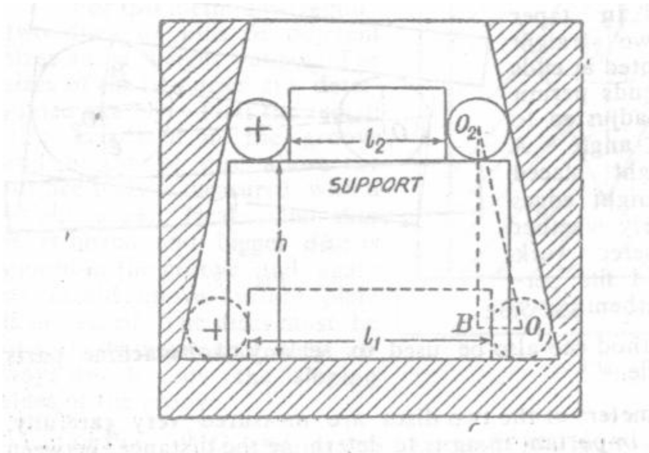


Fig. 7.

Next prepare a combination of slip gauges of convenient height 'h' and place it in the hole as support. Again place the two balls in upper position, each touching the tapered hole and the space between them again being filled up by suitable combination of slip gauges. Let the length of slip gauges in this case be l_2.

Then angle O_1O_2B equals half the taper angle, where O_1 and O_2 are the centers of the balls and O_1O_2B is a right angled tri-angle.

$$\tan\frac{A}{2} = \frac{O_1B}{O_2B}$$

$$= \frac{\frac{I_1 - I_2}{2}}{h}$$

or
$$A = 2\tan^{-1}\left(\frac{I_1 - I_2}{2h}\right)$$

Thus the internal tapered angle can be calculated.

7 - To Set Two Straight Edges at a Desired Angle to Close Limits

This method requires two discs of different diameters and a vernier caliper. This method is very suitable for setting the two straight edges of a taper gauge to check tapered components. In taper gauge, the two straight edges are pivoted at ends and slots at ends permit them to be adjusted to the desired angle. A source of light placed below the straight edges indicates clearly whether or not the tapered work being inspected fits perfectly against them.

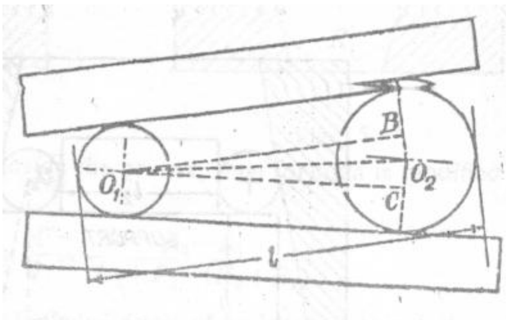


Fig. 8.

This method can also be used to set any two machine parts at desired angle.

The diameters of the two discs are measured very carefully. Then the next important thing is to determine the distance between the two balls such that the two straight edges be adjusted at angle A and diameters of two discs be d_1 and d_2. O_1 and O_2 are centers of two discs. Lines O_1B and O_1C are parallel to two straight edges.

Then : $$B\hat{O}_2O_2O = C\hat{O}_1O_2 = \frac{A}{2}$$

And $$\sin\frac{A}{2} = \frac{BO_2}{O_1O_2} = \frac{\frac{d_1 - d_2}{2}}{O_1O_2}$$

$$\therefore \quad O_1O_2 = \frac{\frac{d_1 - d_2}{2}}{\sin\frac{A}{2}}$$

and distance across the discs,

$$I = O_1O_2 + \frac{d_1 + d_2}{2}$$

$$= \frac{\frac{d_1 - d_2}{d}}{\sin\frac{A}{2}} + \frac{d_1 + d_2}{2}.$$

Thus the two discs are adjusted exactly to above distance by tapping one disc slightly with a mallet and the distance checked by a vernier caliper.

8 - To Measure the Angle of a V-groove

For this method we require two discs or pins of different sizes and a height gauge. The sizes of the two discs are determined exactly. First the small disc is placed in the groove and height of disc above the surface plate is measured with a height gauge. Next small disc is removed and bigger disc is placed in the groove and again its height above surface plate is measured. The discs must be of such diameter that they always touch only the sloping sides of the groove.

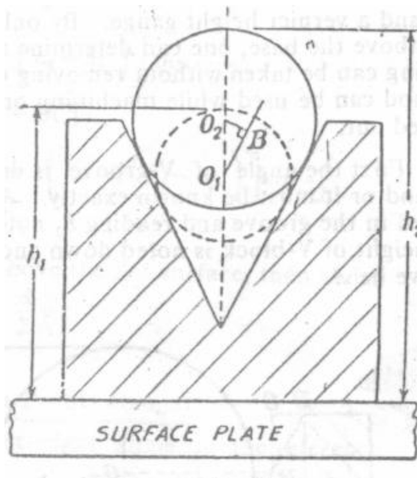


Fig. 9.

In Fig. 9, O_1 are the centers of the two balls. O_1B is drawn parallel to one of the inclined surfaces and $O_2B \perp O_1B$. Then O_2O_1B equals half the angle of V-groove.

Now $$O_1B = \frac{d_2 - d_1}{2}$$

Where d_1 and d_2 are the diameters of the two discs,

And $$O_1O_2 = \left(h_2 - \frac{d_2}{2}\right) - \left(h_1 - \frac{d_1}{2}\right)$$

$$= h_2 - h_1\left(\frac{d_2 - d_1}{2}\right)$$

Let angle of V-groove = A,

Then $$\sin\frac{A}{2} = \frac{O_2B}{O_1O_2}$$

$$= \frac{\frac{d_2 - d_1}{2}}{h_2 - h_1\left(\frac{d_2 - d_1}{2}\right)}$$

This method is very suitable for measuring the angle of machine-tool slides, angle of profile gauges and the angle of shallow grooves and threads.

In case of threads etc., $h_2 - h_1$ can be found out by using a dial indicator.

9 - To Determine the Width of a V-groove

It is actually very difficult to measure the width of a V-groove directly with standard tools. This method requires the use of a steel ball and a vernier height gauge. By only one reading i.e., height of ball above the base, one can determine the width of groove. Since reading can be taken without removing or changing the set-up, this method can be used while machining or grinding operation is being carried out.

First the angle of V-groove is determined by the two balls method or it must be known exactly. A ball of diameter d is then placed in the groove and reading h_1 noted down (Fig. 10). Next the height of V-block is noted down and let it be h_2. Let angle of groove be A.

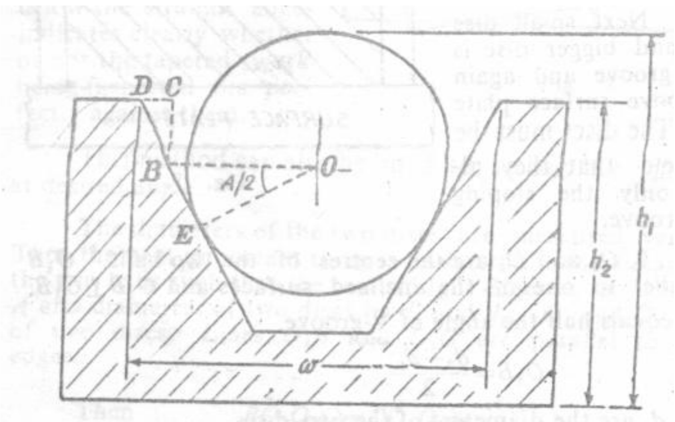


Fig. 10.

Let width of groove is w.

O is the centre of the ball. Draw OE ⊥ to one of the sloping sides and OB a horizontal line.

Then $B\hat{O}E = \frac{A}{2}$–, i.e., half the angle of groove.

$$\cos\frac{A}{2} = \frac{OE}{OB}$$

or $$OB = \frac{oE}{\cos\frac{A}{2}} = \frac{d/2}{\cos\frac{A}{2}}$$

In rt. $\angle$ d Δ BCD,

$$D\hat{B}C = \frac{A}{2}$$

and $$BC = \frac{d}{2} - (h_1 - h_2)$$

$$\therefore \quad DC = \frac{d}{2} - (h_1 - h_2)$$

$$= \left[\frac{d}{2} - (h_1 - h_2)\right] \quad \tan\frac{A}{2}$$

$\therefore$ Width of slot = 2 [OB + DC]

$$= \frac{d}{\cos\frac{A}{2}} + [d - 2(h_1 - h_2)]\tan\frac{A}{2}$$

In case centre of the ball lies above the flat surface, then width of slot = $\frac{d}{\cos\frac{A}{2}}[2(h_1 - h_2) - d]\tan\frac{A}{2}$.

10 - To Check Interior Angle of a Profile Gauge

This method requires the use of two discs of different sizes and a Vernier height gauge. First a small disc of diameter d_1 is placed in the slot and the height of disc above some reference surface is determined (Fig. 11). Let it be h_1. Then the bigger disc is placed in the slot after removing the smaller one and again height h_2 with reference to same plane is noted down. The difference of height $(h_2 – h_1)$ could also be noted down by means of dial-indicator.

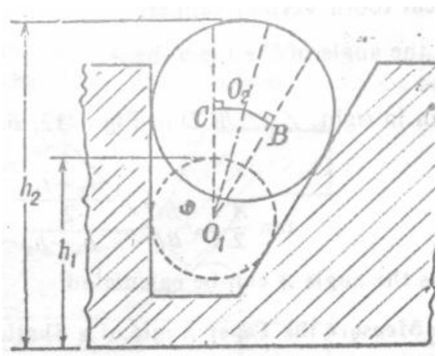


Fig. 11.

Let O_1 and O_2 be the centers of two discs. Through O_1 draw a line O_1C parallel to the vertical surface and O_1B parallel to the sloping surface. Through O_2 draw $O_2C \perp O_1C$ and $O_2B \perp O_1B$.

Let angle of taper be A.

$$\therefore \qquad C\hat{O}_1O_2 = \frac{A}{2} = O_2\hat{O}_1B$$

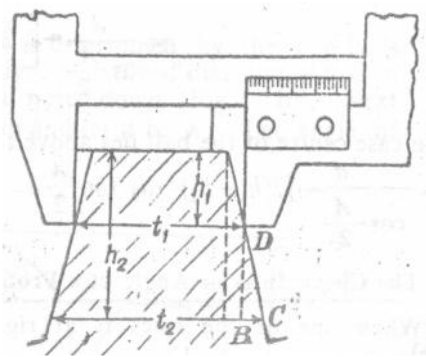
$$\tan\frac{A}{2} = \frac{O_2C}{O_1C} = \frac{\frac{d_2 - d_1}{2}}{\left(h_2 - \frac{d_2}{2}\right) - \left(h_1 - \frac{d_1}{2}\right)}$$

$$= \frac{d_2 - d_1}{2(h_2 - h_1) - (d_2 - d_1)}$$

By the same set-up, the angle of any inclined surface with vertical plane can be calculated by making the part to rest against an angle plate.

11 - To Measure the Angle of Small Work Located in a Difficult Position

This method requires the use of a gear-tooth Vernier caliper. This method is very useful in those cases where the work is small and enclosed by sides. All that has to be done in this method is to take readings at two different places. The two readings have to be noted down at one section i.e., thickness of the piece l_1 and its depth from the top surface h_1. Similarly two readings t_2 and h_2 are to be noted down at other section with the help of gear tooth Vernier caliper.



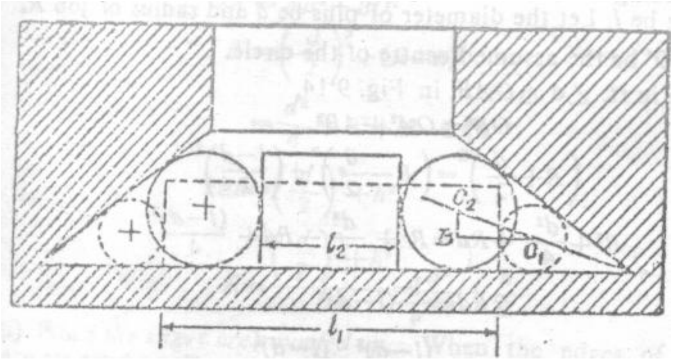
Let the angle of the taper be A.

Then in right. ∠ d Δ BCD in Fig. 12, $B\hat{D}C = \frac{A}{2}$

And $$\tan\frac{A}{2} = \frac{BC}{B} = \frac{\frac{t_2 - t_1}{2}}{h_2 - h_1}$$

Thus the angle A can be calculated.

12 - To Measure the Taper Angle of a Shallow Circular Groove.



It is actually very difficult to measure the internal angle of a shallow circular groove by any method. The method proposed below requires the use of two small balls of equal size and two large balls of equal size and slip gauges. First the small balls are placed in the hole and the slip gauges of maximum length inserted in between the balls. Then small balls are removed and larger balls inserted and again space between the balls filled up by slip gauges of maximum length. Let us assume that the diameters with the surface plate as far as possible.

Then two pins of equal diameter are placed or each side of the work as shown in Fig. 14 and the reading over the balls is taken with the Vernier caliper.

Let the reading be I. Let the diameter of pins be d and radius of job R.

Let ’O’ be the assumed centre of the circle.

Then in rt. $\angle$ d Δ OAB, in Fig. 9.14,

$$OB^2 = OA^2 + AB^2$$

Or $$\left(R + \frac{d}{2}\right)^2 = \left(R - \frac{d}{2}\right)^2 + \left(\frac{I - d}{2}\right)^2$$

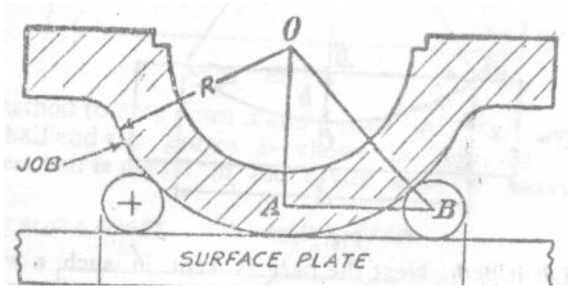
Or $$R^2 + \frac{d^2}{4} + Rd = R^2 + \frac{d^2}{2} - Rd + \frac{(1 - d)^2}{4}$$

Or $$2Rd = \frac{1}{4}(I - d)^2$$

And $$R = \frac{(I - d)^2}{4x2d} = \frac{(I - d)^2}{8d}$$

13- To find out the Radius of a Circle of any Job having a Portion of a circle

This method requires the use of surface plate, Vernier caliper, C-clamp and two pins of equal size. This method could be best applied to jobs like cap of a bearing. The job is first clamped to surface plate with the help of C0clamp. It should be clamped in such a way that central position of the circular part is in contact with the surface plate far as possible. Then two pins of equal diameter are placed on each side of the work as shown in Figure and the reading over the balls is taken with the Vernier caliper. Let the reading be l. Let the diameter of pins be d and radius of job R



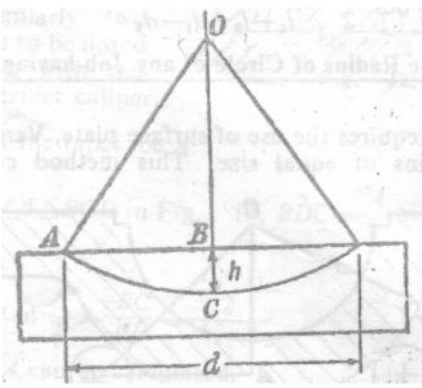
14 - To find out the Radius of a Concave Surface

(i) When the edges are well-defined.

(ii) When the edges are rounded up.

(i) When the edges are well-defined. This method is applicable to those parts which have large radius of curvature. This requires the use of a surface late, angle plate, height gauges depth micrometer, slip gauges and a C-clamp.

The part to be tested is kept on a surface plate and with the help of a depth micrometer the maximum depth of the cavity is determined. Let it be h. Next the part is kept in such a way that cavity is resting against are angle plate and the part is then clamped in this position. The hole is then measured from edge to edge with a height gauge having a sharp scribing arm. Let the maximum reading, i.e., diameter of the hole be d (Fig. 15).



Let O be the assumed centre of the cavity and R the radius of curvature.

Then in rt. $\angle$ d Δ OAB,

$$OA^2 = AB^2 + BO^2$$

Or

$$R^2 = \left(\frac{d}{2}\right)^2 + (R-h)^2$$

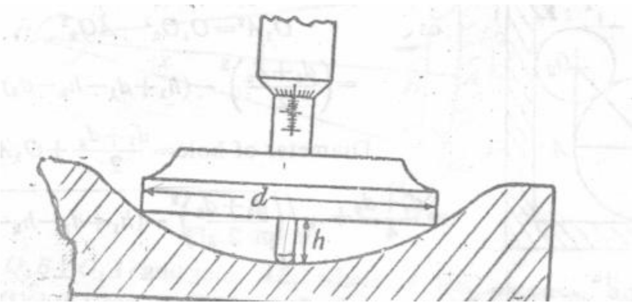
$$= \frac{d^2}{4} + R^2 + h^2 - 2Rh$$

or

$$2Rh = \left(\frac{d}{2}\right)^2 + h^2$$

$$R = \frac{\left(\frac{d}{2}\right)^2 + h^2}{2h} = \frac{d^2}{8h} + \frac{h}{2}$$

(ii) When the edges are rounded up. When the edges of the cavity are rounded up, then the radius of curvature can be measured by a depth micrometer and slip gauges. The width of the depth micrometer base is measured with the help of slip gauges. Let it be d. then it is placed in the cavity till it fully rests in the cavity, its frame touching all the sides of cavity (Fig. 16). The measuring tip is then lowered down till it touches the base. The reading is then noted on the thimble and let it be h. now the case is similar to previous one and the radius of curvature R can be found out by the same formula.



Other method to note down d and h is by using a heavy steel block, a steel ball and slip gauges as shown in Fig. 17. In this method the steel ball is placed in the cavity and the heavy steel block also put the cavity. The space between the block and ball sis filled up by a suitable length of slip gauges so that block is just touching the sides of cavity.

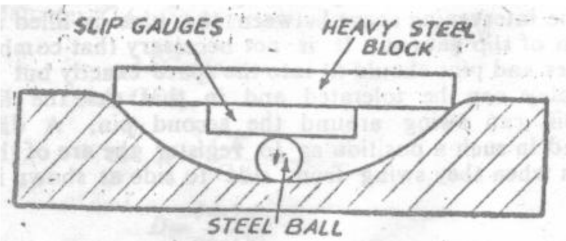


Fig. 17

Here length of block is d and length of slip gauges and diameter of ball constitute h. The formula for finding the radius of curvature remains the same.

15 - To Measure the Diameter of a Recessed Hole

It is impossible to measure the diameter of a recessed hole by micrometer or any of the conventional instruments. A lot of difficulty is generally experienced in measuring the diameters of the recessed hole. A simple method of measuring the diameter by two balls of different diameters is given below.

The two balls are placed up to each other as shown in Fig. 18, i.e. balls must be touching each other and also the sides of the walls. With the help of a depth micrometer the distance from top surface to the top surface of both the balls is measured. Let these distances be h_1 and h_2 and the diameter of the balls d_1 and d_2 respectively.

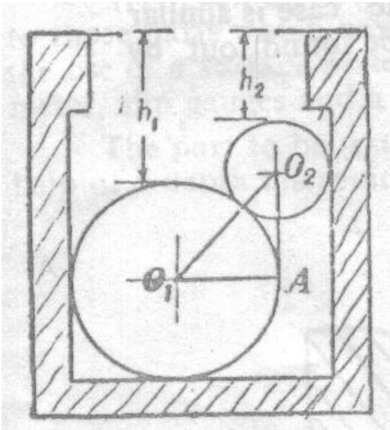


Fig. 18

O_1 and O_2 are the centers of the two balls.

In ft. - $\angle$ d Δ O_1AO_2,

$$O_1A^2 + AO_2^2 = O_1O_2^2$$

Or $$O_1A^2 = O_1O_2^2 - AO_2^2$$

$$= \left(\frac{d_1 + d_2}{2}\right)^2 - \left(h_1 + d_1 - h_2 - d_2\right)^2$$

Diameter of hole = $\frac{d_1 + d_2}{2} + O_1A$

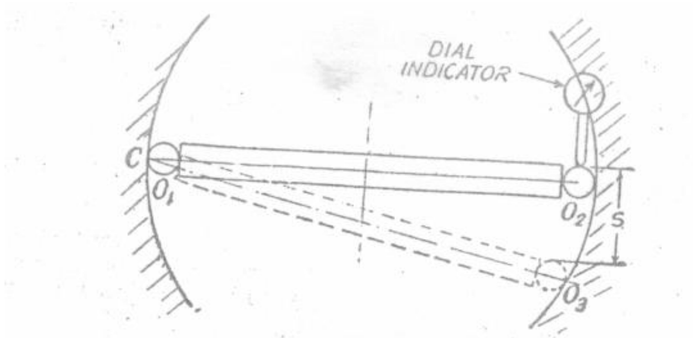
=

$$\frac{d_1 + d_2}{4}\sqrt{\left(\frac{d_1 + d_2}{2}\right)^2 - \left(h_1 + d_1 - h_2 - d_2\right)^2}$$

16 - To Measure the Diameter of a Large Hole Accurately

This method requires the use of two pins, C-clamps, slip gauges and a dial indicator. The work is clamped on the surface plate with C clamps.

Two pins of equal diameter are placed against the inside edge of the circle and the intervening space between the pins is filled in with a combination of slip gauges. It is not necessary that combination of slip gauges and pins should fit into the space exactly but a slight amount of play can be tolerated and in that case the slip gauges and one pin can swing around the second pin. A dial indicator is clamped in such a position as to register the arc of the pin and slip gauges when they swing from side to side as shown in Fig. 19.



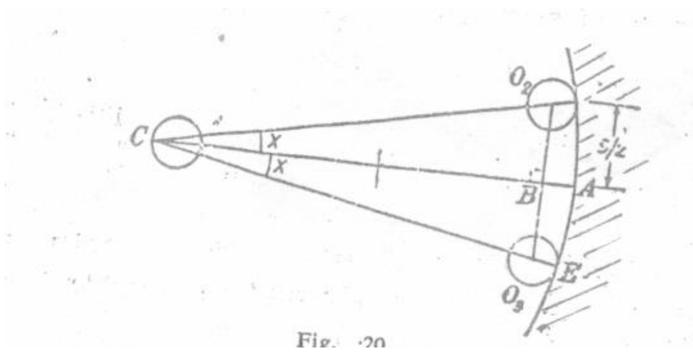


Fig. 20