EXPERIMENT

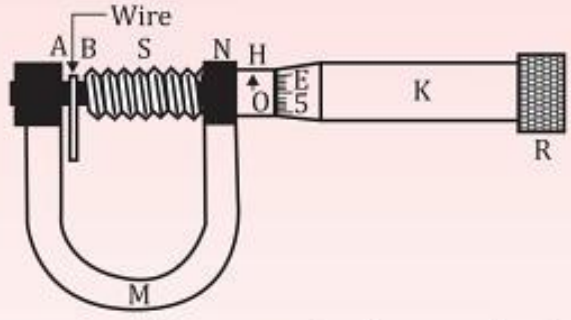
AIM

To measure the diameter of a given wire using a Screw Gauge.

MATERIAL REQUIRED

Screw gauge and wire.

DIAGRAM



Screw gauge used for measuring diameter of a wire

THEORY

The operation of the screw gauge relies on its least count. The pitch represents the linear distance covered by the screw during a full rotation of its head, and the least count of the screw gauge is determined by the ratio of the pitch to the total number of divisions on the circular scale.

Therefore,

$$\text{Pitch} = \frac{\text{Distance moved by the screw}}{\text{Number of rotations given to the screw}}$$

1. If the wire is positioned between the plane faces A and B, and the edge of the cap is located in front of the Nth division of the linear scale, the linear scale reading (L.S.R.) is equal to N. If the nth division of the circular scale is aligned with the reference line, then,
   Circular Scale Reading (C.S.R.) = n × (L.C.)
   Where, L.C. is the least count of screw gauge.
   Total Reading (T.R.) = L.S.R. + C.S.R. = N + n × (L. C.)
2. If D be the mean diameter and l be the mean length of the wire, volume of the wire,

$$V = \pi \left(\frac{D}{2}\right)^2 l$$

Note: The screw gauge has the least count of 0.001 mm or 10^{-6} m is called micrometer screw.

PROCEDURE

1. Determine the value of a single linear scale division (L.S.D.).
2. Calculate the pitch and the least count of the Screw Gauge and document the process step by step.

3. Align plane face B with plane face A, find the zero error, and repeat this procedure three times, recording the results. If there is no zero error, record it as nil.
4. Move face B away from face A, position the wire lengthwise over face A, and bring face B toward face A using the ratchet head R. Stop when R turns (slips) without causing the screw to move.
5. Observe the number of divisions on the linear scale that are visible and not covered by the edge of the cap. This reading (N) is termed the linear scale reading (L.S.R.).
6. Identify the number (n) of the division of the circular scale lying over the reference line.
7. Repeat steps 5 and 6 after rotating the wire by 90° to measure the diameter in a perpendicular direction.
8. Repeat steps 4, 5, 6, and 7 for five different positions equally spaced along the length of the wire. Record the observations in each set-in tabular form.
9. Calculate the total reading and apply zero correction in each case.
10. Determine the mean of different values of the diameter.
11. Measure the length of the wire by stretching it along a half-meter scale. Keep one end of the wire at a known mark, note the position of the other end, and repeat this procedure three times, recording the results.

OBSERVATIONS

1. Determination of Least Count of the Screw Gauge

   1 L.S.D. = 1 mm

   Number of full rotations given to screw = 4

   Distance moved by the screw = 4 mm

   Hence, pitch (p) $= \frac{4}{4} = 1$ mm

   Number of divisions on circular scale = 100

   Hence, least count, $= \frac{1}{100} = 0.01$ mm $= 0.001$ cm

2. Zero Error

   (i) _____ mm

   (ii) _____ mm

   (iii) _____ mm

   Mean zero error (e) = _____ mm

   Mean zero correction (c) = −e = _____ mm

S. No.	Linear Scale Reading (N) (mm)	Circular Scale Reading		Total Reading	
		No. of Circular division on reference line (n)	Observed $D_0 = N + n \times (L.C.)$ (mm)	Observed $D_0 = N + n \times (L.C.)$ (mm)	Corrected $D = D_0 + c$ (mm)
1.					$D_1(a) =$
					$D_1(b) =$
2.					$D_2(a) =$
					$D_2(b) =$
3.					$D_3(a) =$
					$D_3(b) =$

CALCULATIONS

Length of the wire,

l = (i)___cm, (ii)___cm, (iii)____cm

Mean diameter of the wire,

$$D = \frac{D_1(a) + D_1(b) + \ldots + D_3(a) + D_3(b)}{6} = \_\_\_\_ \text{ mm} = \_\_\_\_ \text{ cm}$$

Mean length of the wire,

$$l = \frac{l_1 + l_2 + l_3}{3} = \ldots\ldots \text{cm}$$

Volume of the wire,

$$V = \pi\left(\frac{D}{2}\right)^2 l = \ldots\ldots \text{cm}^3$$

RESULT

Based on the calculations and observations provided earlier, the diameter of the given wire measured using the screw gauge is _____ mm.

PRECAUTIONS

1. Ensure the screw is rotated using the ratchet R rather than the cap K to prevent undue pressure.
2. Confirm that the screw moves freely without encountering any friction.
3. Take note of zero correction, including its proper sign, and add it algebraically with precision.
4. When obtaining the same set of observations, consistently move the screw in the same direction to prevent back-lash errors.
5. Measure the diameter of the wire in two perpendicular directions at each location and calculate the mean of the two measurements.
6. Obtain readings for at least five different positions, equally spaced along the entire length of the wire.
7. Avoid errors caused by parallax during readings.

SOURCES OF ERROR

1. The screw may experience friction.
2. The screw gauge might exhibit back-lash errors.
3. Circular scale divisions may not be uniformly sized.
4. The wire may lack uniformity.

VIVA VOCE

Q1. What is a 'micrometer screw gauge'?

Ans. The device which is used to measure the linear dimensions of small objects, e.g., diameter of a wire. This instrument has the least count of 0.001 m (i.e., 10^{-6} m) and therefore is called micrometer screw gauge.

Q2. State the principle used in this experiment.

Ans. Screw gauge works on the principle that linear distance travelled by an accurately cut screw which is rotating in closely fitting fixed nut, is directly proportional to the number of rotations given to it.

Q3. How the zero error can be corrected?

Ans. Zero error can be corrected by subtracting zero error from the observed reading with suitable sign.

Q4. How can you define the term 'least count'?

Ans. Least count is the ratio of pitch to the total number of divisions on the circular scale.

Q5. How will you find the diameter of a wire if its length is given to you?

Ans. If the length of the wire is given to us, then firstly, the diameter of the wire will be found with the help of screw gauge, then its volume is calculated by the formula, $V = \frac{\pi d^2 l}{4}$.

Q6. If the reading of the wire is given, how can you calculate its area of cross-section?

Ans. Since, if the reading of the wire is given, then its area of the cross-section can be calculated by.

Q7. Mention the name of the metal of which the screw is made of?

Ans. The metal of which the screw is made up is gun-metal.

Q8. Can you tell me about the reasons for zero error?

Ans. The wear and tear of the screw and the defect in manufacturing can be the reasons for zero error.

Q9. Why does a screw gauge develop backlash error with use?

Ans. Since, when the thread on the screw and that on nut gets tightly fit with each other, then with the repeated use of the threads of both the screw and the nut may get worn out. So, as a result, a gap gets developed between these two threads, which is called play, and this introduces an error in measurement of screw gauge and this error is called backlash error due to which the screw slips a small linear distance without rotation.

Q10. Is the screw gauge with the smaller least count always better? So, if you are given two screw gauges, one with 100 divisions on circular scale and another with 200 divisions, which one would you prefer and why?

Ans. Yes, the screw gauge with the smaller least count is always better. Since, we know that:

$$\text{Least count} = \frac{\text{Pitch}}{\text{Number of divisions on circular scale}}$$

So, if we are given a screw gauge with 100 circular scale divisions and another with 200 circular scale divisions, then we would prefer the screw gauge with 200 circular scale divisions because as per the formula, if number of circular scale divisions is more, then the least count will be less and lesser is the least count, more accurate will be the reading and ultimately an accurate desired value is obtained.

EXPERIMENT NO. 2-B

AIM

To measure the thickness of a given sheet using a Screw Gauge.

MATERIAL REQUIRED

A screw gauge, some required sheets of paper and a magnifying glass.

DIAGRAM

Same as in experiment 2A.

THEORY

Same as in experiment 2A.

FORMULA USED

If d is the thickness of n pieces of sheet of paper, then thickness of sheet of paper is,

$$t = \frac{d}{n}$$

PROCEDURE

Determination of Least Count and Zero Error Measurement

To begin with, ascertain the pitch, least count, and zero error as computed in Experiment 2A, following steps 1 to 4.

Measurement of Thickness for Given Sheets

1. Due to the inherent thinness of a single sheet, accurately measuring its thickness poses a challenge. Consequently, divide the sheet into multiple smaller pieces (denoted as n such pieces) and proceed to determine the thickness of these individual pieces.
2. Place the paper sheet pieces, whose thickness is under examination, between the screw and the stud. Then, maneuver the screw using the ratchet until a distinct clicking sound is heard, and the ratchet becomes unengaged.
3. Record the main scale reading (in mm) along with the number of divisions on the circular scale coinciding with the reference line.
4. Calculate the thickness of the sheets by multiplying the circular scale division by the least count, adding the result to the main scale reading. The formula is given as,

   Thickness of sheets = Main scale reading + (Number of divisions of circular scale coinciding with the reference line × Least count)
5. Repeat steps 3 to 4 to determine the thickness at four different locations.
6. Determine the mean observed thickness of the paper sheet pieces.
7. To obtain the accurate thickness, subtract the zero error with the appropriate sign from the observed thickness of the total number of sheets.

8. Finally, to determine the thickness of one sheet, divide the correct thickness by the total number of sheets, represented as $t = \frac{d}{n}$.

OBSERVATIONS

Same as in experiment 2A.

TABLE FOR THE THICKNESS (z)

S. No.	Linear Scale Reading (N) (mm)	Circular Scale Reading		Total Reading	
		No. of Circular division coinciding (n)	Value $[n \times (L.C.)]$ (mm)	Observed $z_0 = N + n \times L.C.$ (mm)	Corrected $z = t_0 + c$ (mm)
1.					z_1 =
2.					z_2 =
3.					z_3 =
4.					z_4 =

CALCULATIONS

Measurement of Thickness

1. The observed thickness,

$$Z_0 = a + (b \times LG) = \ldots\ldots\ldots \text{ mm}$$

2. The corrected value of thickness,

$$z = Z_0 + C = \ldots\ldots\ldots \text{ mm}$$

where, C is the observed zero error.

3. Mean corrected value of thickness of given sheets,

$$d = \frac{Z_1 + Z_2 + Z_3 + Z_4}{4} = \ldots\ldots\ldots \text{ mm}$$

Therefore, thickness of the given sheet $= \frac{\text{Thickness of n sheets}}{\text{Number of sheets}} = \frac{d}{n}$

$= \ldots\ldots\ldots \text{ mm}$

RESULT

Upon computation, the thickness of the provided paper sheet equals _____ centimeters.

PRECAUTIONS

Same as in experiment 2A.

SOURCES OF ERROR

Same as in experiment 2A steps 1 to 4.

VIVA VOCE

Q1. Is it possible to find the thickness of a thin paper by screw gauge?

Ans. Yes, it is possible to find the thickness of a thin paper by screw gauge. To find the thickness of paper, firstly we will find the thickness of 30 sheets of paper, then divide this value by 30 to get the thickness of a paper.

Q2. How can we correct the screw gauge itself for the zero error?

Ans. To correct the screw gauge itself for the zero error, the fixed stud is adjusted by screwing it, in or out.

Q3. How can you define the term pitch of the screw gauge?

Ans. The distance moved by the screw in one complete rotation is known as the 'pitch' of the screw gauge. It is equal to the distance measured between the consecutive threads of the screw.

Q4. What is the most important precaution that should be followed while performing this experiment?

Ans. It is very necessary to check the instrument for zero error and along with this, the spindle should be wiped clean as dust particles cause false readings.

Q5. Mention the formula for the least count of a screw gauge?

Ans. Since, least count of a screw gauge is the distance moved by the screw when it is rotated by one circular scale division.

$$\text{Least count} = \frac{\text{Pitch}}{\text{Total number of divisions on circular scale}}$$

Q6. What do you mean by ratchet?

Ans. The arrangement inside the milled head connected at the end of the screw through a weak spring is known as ratchet. It helps in preventing the screw from getting under pressure.

Q7. In which way, you can attain a screw gauge with smaller least count?

Ans. Since we know that least count of a screw gauge can be given as:

$$\text{Least count} = \frac{\text{Pitch}}{\text{Total number of divisions on the circular scale}}$$

So, by decreasing the pitch of the screw and increasing the number of divisions on the circular scale, we can attain a screw gauge with a smaller least count.