DETERMINE THE MODULUS OF RIGIDITY 0F THE MATERIAL OF A ROD BY DYNAMIC METHOD

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INTRODUCTION

Modulus of rigidity or shear modulus (ŋ) is a measure of shearing stress which produce the shear strain. Its simply the ratio of shear stress to shear strain. It tells us about the shear deformation undertaken by a body on exposure to shearing forces of different magnitude. As the name suggests it tells us how 'rigid' the body is i.e. resistant to shear forces.

PURPOSE OF THE EXPERIMENT

Modulus of rigidity, or the shearing modulus, is used to determine how elastic or bendable materials will be if they are sheared, which is being pushed parallel from opposite sides. This property becomes the useful part of many calculations, and it is called the co-efficient of elasticity during sharing.

DEFINATION OF MODULUS OF RIGIDITY

Modulus of rigidity is The co-efficient of elasticity for a shearing force it is define as: “The ratio of shear stress to the displacement per unit original length”.

OBJECTIVE, APARATUS & DIARAM

Objective(s): To determine the rigidity modulus of the material of a wire by dynamical method.

Apparatus: A screw gauge, one meter scale, stop watch, slide calipers, rigidity modulus experimental set-up etc.

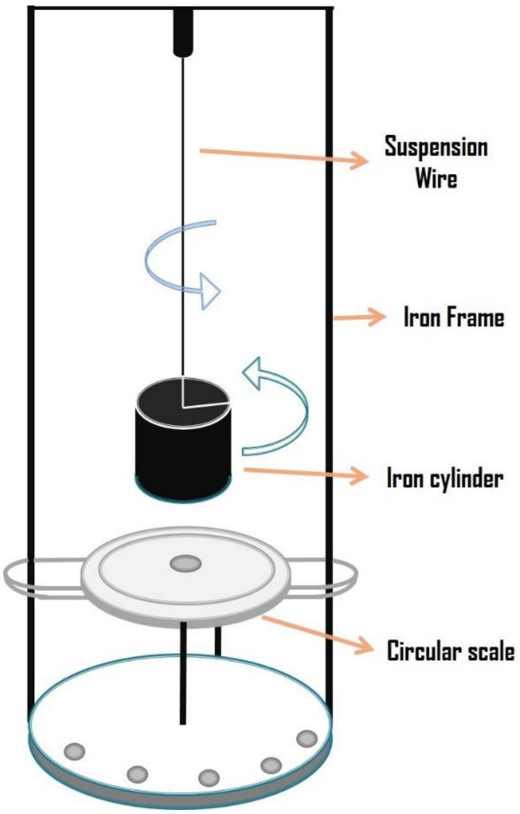

Diagram of Experimental Set Up

WORKING FORMULA OF THE EXPERIMENT

$$\boxed{\eta = \frac{8\pi L}{T^2 r^4}\left(\frac{1}{2} MR^2\right)}$$

Where, η = modulus of rigidity
L = length of the wire
R = radius of the cylindrical bob
r = radius of the wire
T = time period of the cylindrical bob
M = mass of the cylindrical bob

THEORY OF THE EXPERIMENT

Theory :

Within the elastic limit of a body, the ratio of tangential stress to the shearing strain is called rigidity modulus of elasticity. The time period (T) with which the bob of a torsion pendulum oscillates with its suspension wire as axis, is given by

$$T = 2\pi\sqrt{\frac{I}{C}}, \quad \text{or} \quad c = \frac{4\pi^2 I}{T^2} \quad \text{.................(1)}$$

Where I is the moment of inertia of the suspended cylinder about its own axis and i given by

$$I = \text{(mass)} \times \text{(radius)}^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Here c represents the restoring couple exerted by the suspension wire of length l for one radian twit at its free end and is given by,

$$C = \frac{ŋ\pi r^4}{2l} \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Where ŋ is the rigidity of the material of the wire, while l and r are respectively length and radius of the suspension wire. From equation (1) & (3) we get

$$\frac{ŋ\pi r^4}{2l} = \frac{4\pi^2 I}{T^2} \qquad \text{Or. } ŋ = \frac{8\pi I l}{T^2 r^4} \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Calculate I from equation (2) and by measuring l , r and T experimentally, we can find the rigidity employing the relation (4). If l, r are put in centimeter, I in gm-cm^2 then it will be dyne/cm^2.

First of all, measure the radius (r) of the wire 'a' using a micrometer. Now measure the radius of the cylindrical block, 'R‘ using a vernier scale. Now, note down the mass of the metal block. Knowing the mass M and radius R of the cylinder, its moment of inertia ***I*** about its own axis is calculated by using the formula

$$I = MR^2/2.$$

After this, fix the wire in such a manner so that the free length *L* be 45 cm.

To measure the period of oscillations, pull the attached mass slightly to rotate in a torsional motion. Be cautious, to keep the small amplitude of vibration. Otherwise, the SHM approximations no longer valid. Use a stopwatch to measure the time it will take to complete 30 periods of oscillation. After dividing the recorded time by 30, an accurate measure for the time period, T is calculated in seconds. If the vibrating wire does not complete 20 cycles, you can also measure ten periods to calculate an approximate period of oscillation. Now, repeat the previous steps using wires of different lengths (55 cm, 65 cm, 75 cm, 85 cm) and find out the modulus of rigidity by using formula {(ŋ= 8πIL)/$T^2 r^4$}.

EXPERIMENTAL OBSERVATION (s)

Table for least count of screw gauge:

Pitch of the screw (p) (cm)	No of circular scale division (n)	Least count =p/n (cm)

2. <u>Determination of vernier constant of vernier callipers :</u>

Smallest division in the main scale (x): ------------ cm
No. of division in the venire scale (n): ------------
No of coincident main scale division (m): ------------
Venire constant: x (1- $\frac{m}{n}$) cm= ------------ cm

TO DETERMINE THE RADIUS OF WIRE USING SCREW GAUGE

No OF OBS	M.S.R. (cm)	C.S.R. (cm)	TOTAL (cm)	MEAN (cm)	AMOUNT OF ERROR (cm)	ACTUAL DIAMETER (cm)	ACTUAL RADIUS(r) (cm)
1							
2							
3							

TO DETERMINE THE RADIUS OF CYLINDER USING VERNIER CALLIPERS

No OF OBS	M.S.R. (cm)	C.S.R. (cm)	TOTAL (cm)	MEAN (cm)	ACTUAL RADIUS(R) (cm)

DETERMINE OF TIME PERIOD OF CYLINDER

NO OF OBS	NO OF OSCILLATION OBSERVED (n)	TIME TAKEN FOR OSCILLATIO T_n (SECOND)	TIME PERIOD $T' = \frac{T_n}{n}$ (SECOND)	MEAN TIME PERIOD (T)
1				
2				
3				

CALCULATION

Length of the experimental wire = $\frac{L_1+L_2+L_3}{3}$ cm = --------cm

Radius of the experimental wire = $\frac{r_1+r_2+r_3}{3}$ cm = --------cm

Radius of the cylinder = $\frac{R_1+R_2+R_3}{3}$ cm =--------cm

Time period of the cylinder = $\frac{T_1+T_2+T_3}{3}$ sec = -------- sec

Mass of the cylinder = ----- kg = ----- gm

RESULT AND CONCLUSION

Modulus of rigidity of the given material = --------dyne/cm^2.

CONCLUSION:

1. From the value of modulus of rigidity we know about the strength of the material.
2. Modulus of rigidity doesn't depend on the length, breadth, depth, and radius of the material. It is depend only the property of the material.
3. The modulus of rigidity varies from one material to another.