Experiment-:4 Determination of Shear Modulus using Dynamic Method

Objectives:

1. Understand how a torsional pendulum works.
2. To determine the sheer modulus of the element of wire by the method of oscillation with the prior knowledge of Angular force and Simple Harmonic motion.

Apparatus:

A uniform wire, a cylindrical bar, suitable clamp, stopwatch, screw gauge, slide calipers, meter scale.

Theory:

A torsion pendulum consists of a mass suspended from a thin wire. When the mass is twisted about the axis of the wire, the wire exerts a torque on the mass, tending to rotate it back to its original position. If twisted and released, the mass will oscillate back and forth to its original position executing a simple harmonic motion.

For example, a cylindrical mass is suspended by a vertical wire of length l and radius r as shown in Fig. 1.1. The axis of the wire passes through its center of gravity. If at any instant the angle of twist is θ, the restoring torque exerted by the wire will be proportional to the angular displacement,

$$\tau = -C\theta \tag{1}$$

And the time period for torsional oscillations will be,

$$T = 2\pi\sqrt{\frac{I}{C}} \tag{2}$$

where I is the moment of inertia of the cylindrical body and C is the couple per angle of twist.

Given by, $I = \frac{1}{2}Ma^2$, 'M' and 'a' are the mass and radius of the cylinder respectively.

$$\text{and } C = \frac{\eta\pi r^4}{2l} \tag{3}$$

η is the modulus of rigidity of the material of the wire, l is the length of the wire, r is the radius of the wire. From above equations, we get

$$T^2 = \frac{4\pi^2 I}{C} = \frac{8\pi I l}{\eta r^4} \tag{4}$$

by rearranging the expression, $$\eta = \frac{8\pi I l}{T^2 r^4} \tag{5}$$

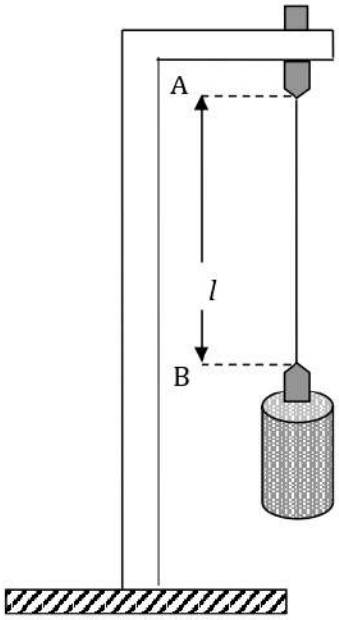

Fig 1 Torsional Pendulum

Procedure:

1. Find out the value of one smallest division of the main scale and the total number of divisions of the Vernier scale of the slide calipers and calculate Vernier constant ($V.C$).
2. Find out the value of pitch (the distance along the linear scale traveled by circular scale when it is completed one rotation) and the total number of divisions of the circular scale of the screw gauge and calculate least count ($L.C$).
3. Measure the radius, a of the cylinder by using the slide calipers.
4. Measure the mass, M of the cylinder. Calculate moment of inertia, $I = \frac{1}{2}Ma^2$.
5. Measure the radius, r of the wire by using the screw gauge.
6. Measure the length, l of the wire from the point of suspension and the point at which the wire is attached to the cylinder with a meter scale.
7. Twist the cylinder from its equilibrium position through a certain angle and release so that it begins to oscillate. Measure the time for **10** complete oscillations with a stop watch. Find out time period (T) of the oscillation.
8. Calculate the value of the modulus of rigidity (η) of the material of the given wire.