Objective

To find out the shear modulus of rods under torsional loading.

Apparatus

Torsion of bar apparatus, vernier caliper, weights.

Theory

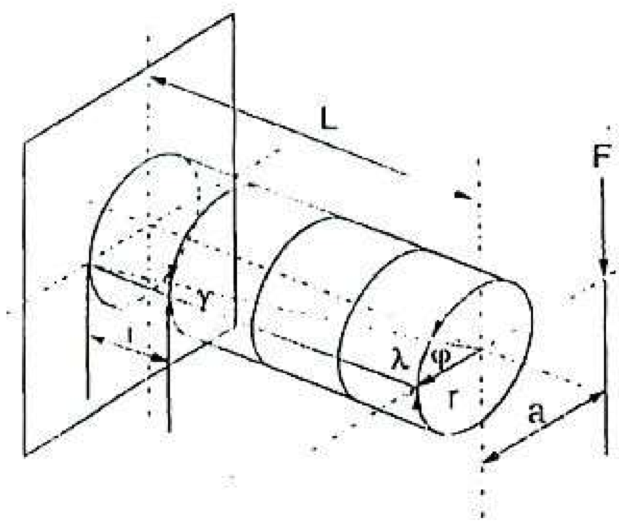

Figure 16 Torsion

L: Bar length r: Bar radius

r: Bar radius

φ:Torsion angle λ:Sector

y: Angle of slip

A cylindrical bar with length L is securely clamped at one end. If a force F is applied, which acts on the lever arm in a plane perpendicular to the bar axis, the oar is subjected to torsion by the moment

$$M = F \cdot a \tag{1}$$

Where F: Force in N
a: Lever arm in m.

This load case is the basis for the experiment. One drill chuck acts as a fixed clamp, while the other drill chuck (free end of bar) is on double ball bearings.

The lever arm is: a = 100 mm
The length of the test bar is given by the dimension between the front edges of the drill chuck clamping brackets. The tape measure suitable for internal measurements should be used to measure the length.
In some measurements, the torsion of the drill chucks or the cone shaped mandrels is negligible compared to the torsion of the test bars.
In most cases, the inherent torsion of the equipment is determined in a preliminary experiment and then taken into account.

The deflection of the load lever is so low as not to influence the measuring results.

The moment of friction in the ball bearings does not influence the measuring results.

Formula For Torsion

Shearing strain y:

The shearing strain is the shearing strain of two cross sections to one another in terms of the unit of length L.

$$y = \lambda / L \tag{2}$$

Reciprocal of coefficient of rigidity/ Reciprocal of shear modulus þ:
The reciprocal of the coefficient of rigidity is

$$þ = y / \tau_t \quad [mm^2 / N] \tag{3}$$

Modulus of elasticity in shear or rigidity G:
The glide ratio or reciprocal of coefficient of rigidity is the reciprocal value of the modulus of rigidity

$$G = 1 / þ \quad [N / mm^2] \tag{4}$$

Shear stress τ_t : Hooke's
law for torsion Shear
stress on radius r

$$\tau_t = G \cdot y \tag{5}$$

Shear stress in surface area τ_{tmax}
Where W_p: Polar moment of resistance
M_t: Torsion moment

$$\tau_{tmax} = M_t/M_p \tag{6}$$

Angle of rotation in radian measure where

Ip: Polar moment of inertia

$$\varphi = M_t \cdot L / G \cdot I_P \tag{7}$$

Angle of rotation in degrees

$$\varphi = 180^o \cdot M_t \cdot L / \pi \cdot G \cdot I_P \tag{8}$$

Specific angle of rotation
The specific angle of rotation is an angle rotation related to the length

$$\theta = M_t / G \cdot I_P \quad [o / cm] ; [1 / cm] \tag{9}$$

Polar moment of inertia for circular cross section

$$I_P = \pi \cdot d^4 / 16 \tag{10}$$

Polar moment of resistance for circular cross section

$$W_P = \pi \cdot d^3 / 16 \tag{11}$$

The Torsion Load *Lever*

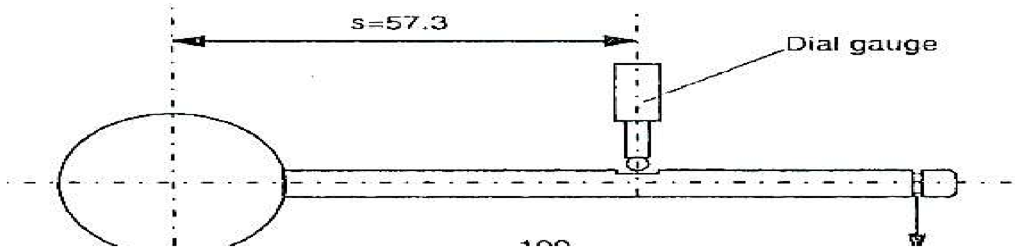

Figure 17 Load lever

The dial gauge is a distance of s =57.3 mm from the axis of rotation.

$$\varphi = b/s$$

For a small angle:
For a small angle φ, the sector b can be very accurately replaced by direct display on the dial gauge y.

$$\text{Then, } \varphi = y/s = y/57.\gamma\text{mm}$$

To simplify the conversion between degrees and radian measure, a distance of 57.3 mm has been selected.

Since: $\varphi = \varphi''$

$$\beta \cdot \pi = \gamma 60^{o}$$
$$1/57.3 = 1$$

Therefore

1mm on the dial gauge corresponds to an angle of rotation of 1^{0}

Note on modulus of elasticity in shear In many materials, the modulus of elasticity E of the material is specified rather than the modulus of elasticity in shear G.
The following relationship exists between G and E:

$G = m/2(m+1) . E$
m: Poisson's constant, for metals = $10/\gamma$
$G \approx 0.385 \cdot E$

Procedure:

1. Loosen the chucks with key.
2. Move the slider to hold the lever arm.
3. Place the test bar between the chucks by passing it from the extreme end of right hand chuck.
4. Tighten the chucks by using chuck keys.
5. Set the dial gauge at the point marked as a line which is 59.3mm from central axis.
6. Pre stress the dial gauge to 10mm.
7. Now make the slider to move away.
8. Place hanger on the slot of lever arm. Make the value on dial gauge as zero by revolving the aluminum dial.
9. Add load and find out the torsion hence shear modulus.

Observations

Sr. #	Diameter of rod d (mm)	Length of specimen between chucks L (mm)	Load added m (Kg)	Displacement on dial gauge y (mm)	Shear modulus G (N/mm^2)
1					
2					
3					

4					

Procedure (Students' own words)

Difficulties / Suggestions

Concluding Remarks / Comments

Questions

1. **What types of error can occur during experiment?**

2. **How to improve experimental procedure?**