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EXPERIMENT 3 : TORSION OF A CIRCULAR SHAFTS

◊ **AIM / OBJECTIVE** : The aim of experiment is to obtain torque - twist relationship for an aluminium circular shaft and compare the result with theoretical predictions.

◊ **EXPERIMENTAL METHOD (S)** :

Equipments : Torsion setup, solid circular rod of Al, Vernier Callipers

Theory : In this experiment, assumption of the metal being perfectly plastic was taken. Normally, in stress-strain relationship, the initial portion is linear i.e. the elastic region. Once the stress exceeds yield stress, the relationship ~~is~~ doesn't remain linear and deforms plastically. It is called strain hardening.

When metal shaft is subjected to sufficiently high torque, plastic deformation starts at outermost fiber first and moves inwards as torque is increased. Evidently for a particular torque value, the entire cross section is in a state of a plastic deformation. For an elastic perfectly plastic shaft, beyond this point, the shaft cannot resist further torque. This torque is called limiting torque (T_L) for the shaft. The Torque (T) - twist (θ) relation for perfectly plastic material is given by,

$$T = \left(\frac{4}{3}\right) T_y \left(1 - 0.25 \left(\frac{\theta_y}{\theta}\right)^3\right)$$

where T_y and θ_y are the torque and angle of twist at onset of yield.

Also, $T_y = (J * \tau_y)/R$ J = Polar moment of inertia.

τ_y = Yield stress in Shear

$$T_L = \frac{4}{3} T_y \quad (\theta = \infty)$$

The specimen is fitted in the machine and gauge length of 100 mm is taken. Two sensors are put at each end One end is movable while other is fixed. The machine is connected to the software which takes readings and plots automatically.

◊ BOUNDARY CONDITIONS:

- Gauge Length (L) = 100 mm
- Diameter of the shaft (d) = 10 mm
- Maximum observed angle of twist θ_{max} = 2565.190674°

◊ RESULTS:

ANALYSIS :

$T_{Y,exp}$ = Torque at which linear region ends = $\underline{24.22717094 \text{ Nm}}$

$T_{L,exp}$ = Torque in the flat region of curve = $\underline{31.66979027 \text{ N-m}}$

$$T_{L,theo} = \frac{4}{3} T_{Y,exp} = \frac{4}{3} \times 24.22717094 = \underline{32.3028946 \text{ Nm}}$$

$$\% \text{ error} = \left(\frac{T_{L,theo} - T_{L,exp}}{T_{L,theo}} \right) \times 100 = \underline{1.9598 \%}$$

Calculation of G : Done in linear region of curve.

$$G_{exp} = \frac{TL}{J\theta} = \frac{32TL}{\pi \theta d^4} = \frac{32 \times 19.45470047 \times 0.1}{\pi \times 0.0797511 \times (10^{-2})^4}$$

$T = 19.45470047$

$\theta = 4.569405079' = 0.0797511 \text{ rad}$

$\therefore \underline{G_{exp} = 24.8478 \text{ GPa}}$ $\qquad$ $\underline{G_{th} = 25 \text{ GPa}}$

$$\% \text{ error} = \left| \frac{25 - 24.8478}{25} \right| \times 100 = \underline{0.6\%}$$

$$T_{max} = \underline{31.78204155} \text{ Nm}$$

CONCLUSION :

1) The axial line marked becomes helical. which just rotated then.
2) Facture was observed near tight screws due to the effect on stress concentration.

SOURCES OF ERROR :

1) Screws might not be properly tightened causing inaccuracies in angle of twist.
2) Parallax errors in taking readings from Vernier Calliper.
3) Slipping between encoder and the metallic disk.