

## Torsion Testing of Structural Metals

### Standards

- *ASTM E143: Shear Modulus at Room Temperature*

### Purpose

- To determine the shear modulus of structural metals

### Equipment

- *Tinius-Olsen Lo-Torq Torsion Machine* (figure 1.2.1)
- Computer with *LabVIEW*<sup>®</sup>
- Twist gauge
- Caliper to measure dimensions of specimen
- Permanent marker
- Specimens: 1018 steel (tube) and 6061-T6 aluminum (rod)
- Safety glasses



Figure 1.2.1. *T-O Lo-Torq* torsion machine

### Experimental Procedure

1. Obtain one steel and one aluminum specimen and label them for your group and draw a straight line along the specimen using the marker.
2. Using the caliper, find the mean diameter using at least five measurements. From the diameter, calculate the mean radius,  $r$ . Calculate the corresponding polar moment of inertia,  $J$ .

$$J_{solid} = \frac{\pi}{2} r^4 \quad (1.2.1)$$

$$J_{tube} = \frac{\pi}{2} (r_o^4 - r_i^4) \quad (1.2.2)$$

3. Ensure that the twist gage is set to  $0^\circ$ .

- Place the specimen in one of the grips so that you can see the line and “lightly” tighten the wedges using the provided hex wrench. Slide the torque meter/grip toward the motor until the free end of the specimen is fully inserted into the other grip and tighten the wedges (figure 1.2.2). Tighten the grip slide mount. Calculate the gage length of the specimen by measuring the distance between the faces of the grips and adding 14 mm.

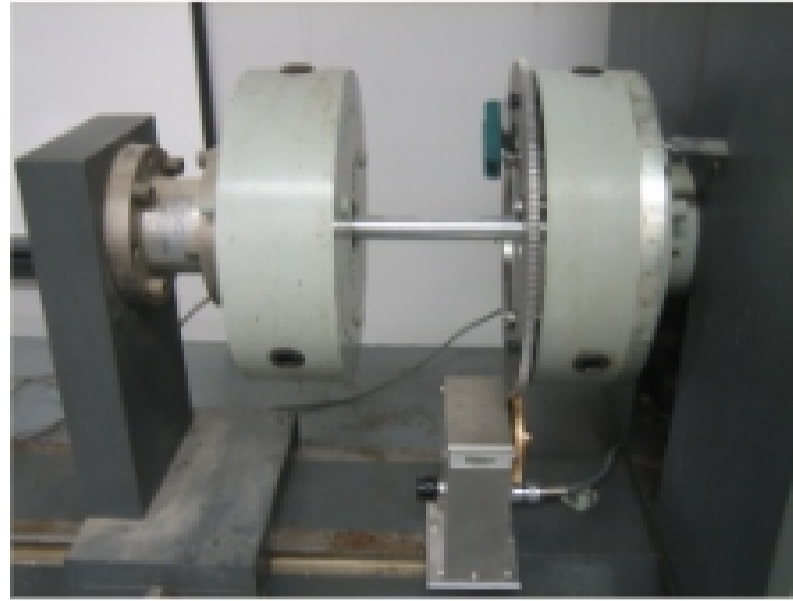


Figure 1.2.2. Specimen mounted in grips.

- Type initial data into the torsion test program (figure 1.2.3). Click Run.

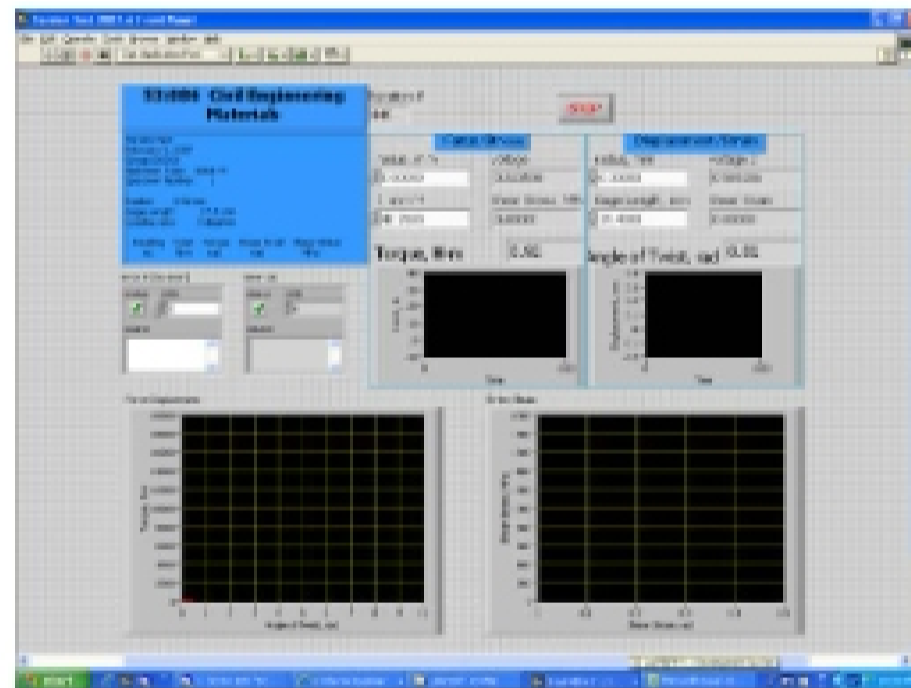


Figure 1.2.3. Screenshot of program.

- Set speed to  $\sim 5^\circ/\text{min}$ , zero the torque and start test (figure 1.2.4).



Figure 1.2.4. Torsion controls.

7. When the specimen reaches the plastic range (permanent deformation), stop the machine. Notice the line is now twisted. Remove the specimen.
8. Obtain the data/results file from the computer and copy it to your own disk.

### Analysis and Results

- For each measurement of torque and angle of twist, the shear stress and shear strain are calculated.

$$\tau = \frac{Tr}{J} \quad (1.2.3)$$

$$\gamma = \frac{\theta r}{L_0} \quad (1.2.4)$$

where:

- $\tau$  = shear stress, MPa (psi)
- $\gamma$  = shear strain, radians
- $T$  = applied torque, N·m (in·lb)
- $\theta$  = angle of twist, radians
- $J$  = polar moment of inertia, mm<sup>4</sup> (in<sup>4</sup>)
- $r$  = mean radius, mm (in)
- $L_0$  = gage length, mm (in)

- Plot the shear stress versus shear strain curve.
- If possible, determine yield shear strength,  $\tau_{yd}$ , using the 0.2% offset method.
- Calculate the shear modulus.

$$G = \frac{\tau}{\gamma} \quad (1.2.5)$$

where:

- $G$  = shear modulus, MPa (psi)
- $\tau$  = shear stress, MPa (psi)
- $\gamma$  = corresponding shear strain, radians

- Calculate the Poisson's ratio. Recall:

$$G = \frac{E}{2(1+\nu)} \quad (1.2.6)$$

where:

- $E$  = modulus of elasticity (found in lab 1.1), MPa (psi)