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UOWD
ENGG103-Materials in Design Laboratory

EXPERIMENT 3 –Torsion Test

1. Objectives

Engineers need to know how different materials behave when stressed under torsional loading, and accordingly use the right materials and sizes suitable for their designs.

The objectives of this experiment is to investigate and analyze the relationship between shear stress and shear strain and to estimate the modulus of rigidity for various materials.

2. Theory

The Shear Modulus or Modulus of Rigidity (G) is a measure of the rigidity of the material when in 'shear' - when it is twisting. It is a ratio of the shear stress (τ) and the shear strain (γ) of the material:

$$G = \frac{Shear\ Stress}{Shear\ Strain} = \frac{\tau}{\gamma}$$

Polar moment of Inertia (J) shows ability of a circular cross-section beam or specimen to resist torsion (twisting). A higher polar moment of inertia shows that the beam or specimen can resist a higher torsion or twisting force. The diameter (D) of the beam determines polar moment of inertia. A larger diameter gives a larger polar moment of inertia.

$$J = \frac{\pi D^4}{32} \quad [m^4]$$

The general equation for the torque in a circular cross-section beam or specimen is:

$$\frac{T}{J} = \frac{G\theta}{l}$$

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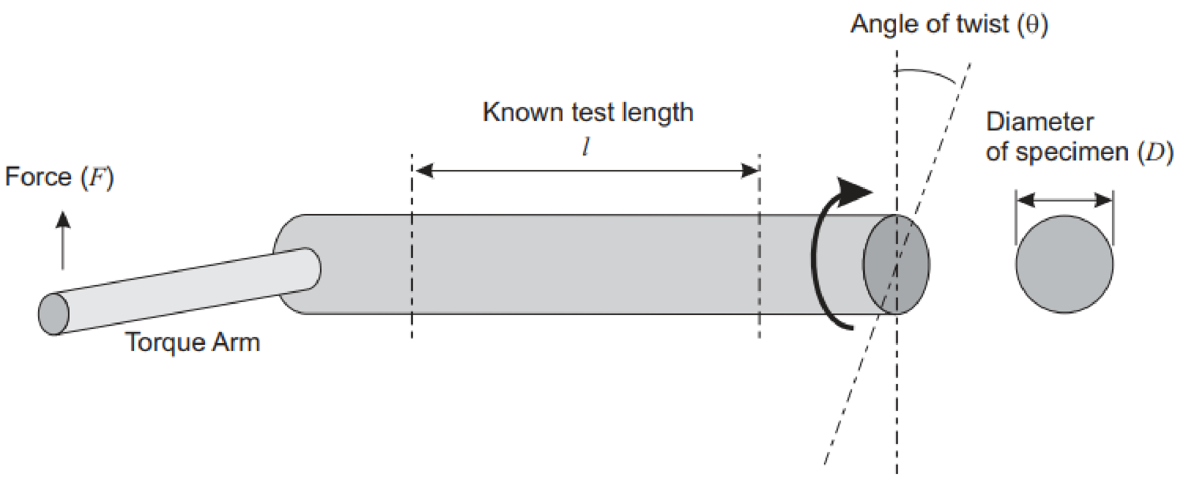
where (θ) is the angle of twist in radians and (l) is the specimen gauge length.



The twisting force (torque) at the end of a specimen is the moment of force on the torque arm:

$$T = F \times (\text{Torque arm length})$$

The theoretical shear stress for a solid circular bar is:

$$\tau = \frac{TD}{2J} \quad [Pa]$$

The theoretical shear strain for a solid circular bar is:

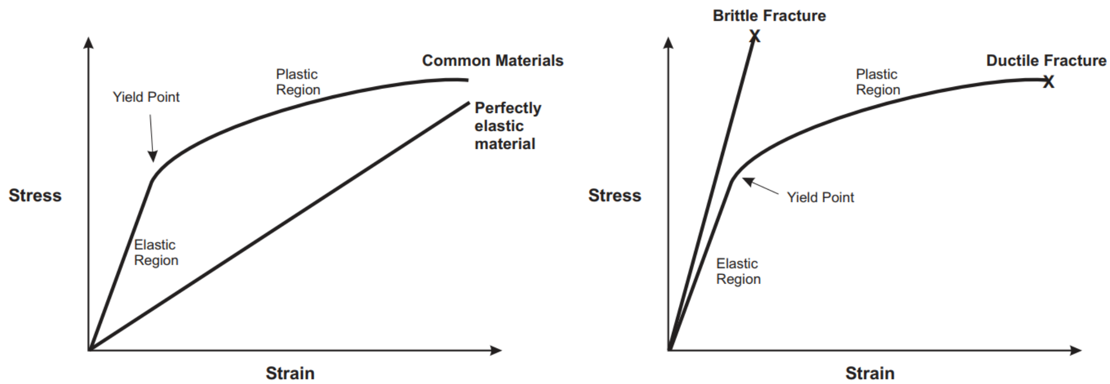
$$\gamma = \frac{\tau}{G} = \frac{r\theta}{l}$$

A rearrangement of the Shear Modulus therefore gives:

$$G = \frac{(TD)/(2J)}{(r\theta)/l}$$

Elasticity and Plasticity

A material is perfectly elastic if it can be compressed or stretched (deformed) by any amount, and then return to its original shape when the stress is removed. Its atoms have not moved, but the bonds between them have stretched, then returned to their original position.



A material is plastic if it can be compressed or stretched (deformed) by a small amount, and then not return to its original shape when the stress is removed. Its atoms have actually moved and will not return.

Most materials have both elastic and plastic properties. When stressed by a small amount, they behave like an elastic material, up to their elastic limit or yield point. When stressed by a large amount (that takes them past their elastic limit), they behave like a plastic material. Rubber and flexible materials usually have more elasticity than more brittle materials like metal or ceramics.

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3. Experimental Procedure

Accurately measure and record the dimensions of your specimen.

Check the distance across the flats at the ends of your specimen, then choose the correct socketsto fit your specimen (12 mm or 3/16” Whitworth).

Fit the sockets to the torque head and the gearbox output, as shown in Figure 12.
SM1001 30 Nm Torsion Testing Machine

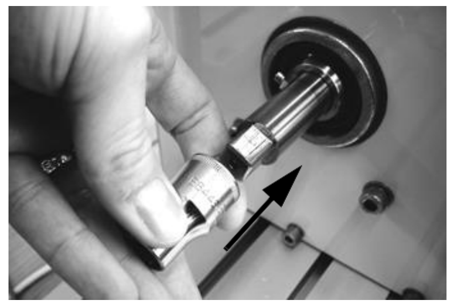


Figure 12 Fit the sockets to the Torque Head and the Gearbox Output

Fit the specimen (with Torsiometer if fitted) to the sockets. Slide the gearbox output shaft along sothat

the specimens ends fit fully into each socket.

Figure 13 Fit the Specimen

Switch on both Digital Meters, and press their ‘Press to zero’ buttons.

Fit the clear guard around the specimen

To remove any mechanical error (or ‘backlash’), slowly turn the Gearbox Hand Wheel until the load display starts to show a small value of torque, then use the ‘Press to zero’ buttons to set all displaysto zero.

4. Test equipment and specimens

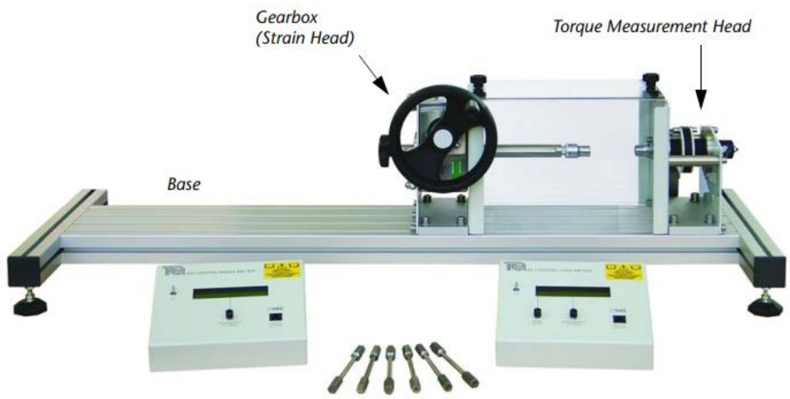
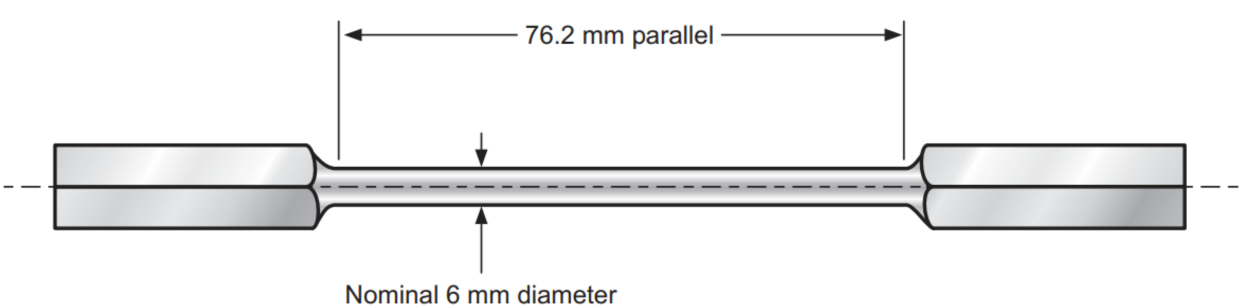


Figure The 30 Nm Torsion Testing Machine

TR1010 - Code MT15 0.15% Carbon Steel (as drawn)	Shear Modulus: 79 GPa Dimensions as shown in Figure 5.
TR1011 - Code MT15N 0.15% Carbon Steel (normalised at 900°C)	
TR1020 - Code MT40 0.4% Carbon Steel (as drawn)	
TR1021 - Code MT40N 0.4% Carbon Steel (normalised at 860°C)	
TR1040 - Code MTX CZ121 Brass (60% Copper, 40% Zinc)	Shear Modulus: 40 GPa Dimensions as shown in Figure 5.



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Results

The experiment will provide us with the Torque (Nm) and the Angle of Twist (degrees), which will be used to obtain the Shear Stress and Shear Strain. The use of VDAS software makes it easy to acquire data points and store them in Excel format tables.

Angle (degrees)	Torque (Nm)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

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Report requirements

1- **Cover page**

-Includes your name, ID, course title and code, name of teachers, etc.

2- Results (7 marks)

- Use the data sheets supplied and perform the calculations to obtain the Shear Stress and Shear Strain for all tested samples. Plot the shear stress vs shear strain curves of all materials on a single graph. **(2.5 marks)**

- Take the linear elastic region of the previous curves, plot them on a separate figure and display the slope of each of the lines **(2.5 marks)**

- Tabulate your results showing the material type, experimental shear modulus and theoretical shear modulus. **(2 marks)**

3- **Discussion (3 marks)**

1. Provide a comprehensive discussion of your results, show their significance and importance.
2. Compare the materials you obtained. Also, comment on the effect of normalization heat treatment on the samples' strength and ductility.
3. Discuss the difference between the experimental and theoretical shear modulus and state the possible sources of errors in this experiment.