Determination of Shear Modulus of an aluminium rod using Torsion Test

(AS2100: Basic Aerospace Engineering Lab)

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Like Bending, Torsion is an important type of loading that can produce critical stresses in engineering applications. Torsion test is a classical test which can be used to determine Shear Modulus (G) of a material. Figure 9 shows the apparatus for the torsion test, where the rod is fixed at one end and the other end is free to rotate. At the free end a disc of radius d is attached to the rod which act as a lever, which also has a provision to hang weights. To The experiment was performed by 5 different groups using instruments with same precision and each experiment consists of 20 cycles of measurement. Each cycle of measurement in an experiment corresponds to increasing the load from 0 to a maximum value m_{max} in fixed steps of Δm and decreasing from m_{max} to 0 with same step size of Δm. The Δm and m_{max} values for each group is fixed but different groups can have different value. The applied load and corresponding value of angle measurement reading are given in the file 'P8_TorsionTest.mat'. The value of D- rod diameter ,L- rod length, d- length of lever are known to be same for all the 5 experimental setup and known exactly. The rod is made of an aluminium alloy. Use the following parameters wherever necessary:

- Length of beam ,L = 1m
- Diameter of the rod, D = 0.01m
- Length of lever, d = 0.1m
- Acceleration due to gravity, g = 9.81 m/s^2

The data set `P8_TorsionTest.mat` contains,

- Applied masses for each experiment in kg (each variable is an array of size 13, as there are 7 sets of weights and each cycle consist of loading and unloading the weights)

  $\Longrightarrow$ `"m_exp1", "m_exp2","m_exp3","m_exp4","m_exp5"`

- Corresponding angle of deflection in radians (each variable is a 10×20 matrix, as there are 23 cycles for each loads per experiment)

  $\Longrightarrow$ `"theta_0exp1","theta_0exp2","theta_0exp3","theta_0exp4""theta_0exp5"`

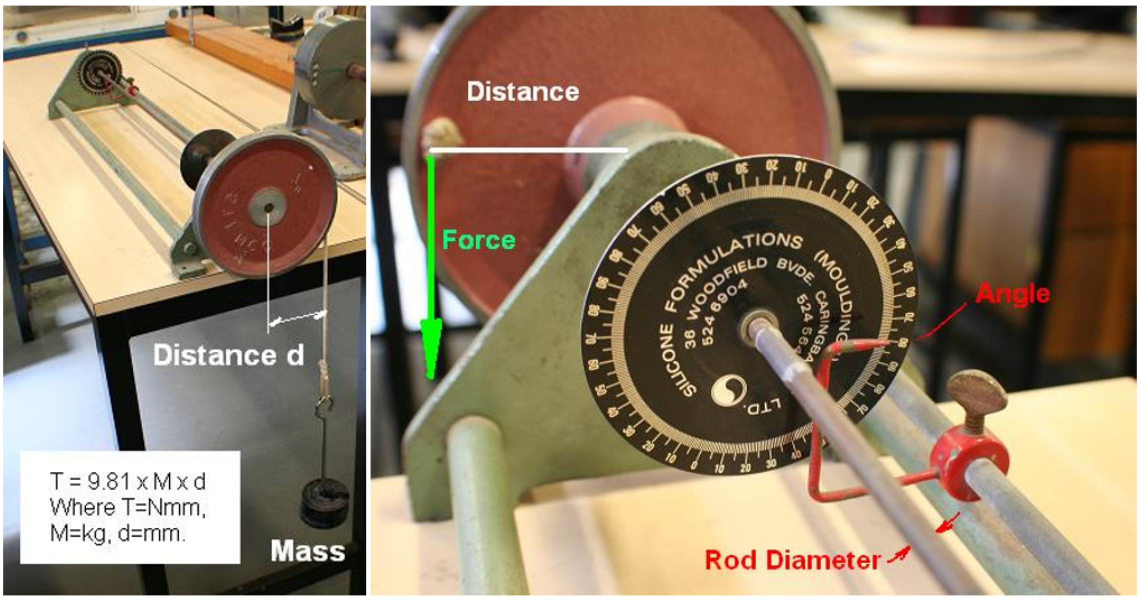

Figure 8: Torsion test apparatus

1. Explain the theory behind the experiment and give the experimental procedure.
2. What are the possible sources of errors in the experiment and how to minimize them?
3. Derive the relation between applied mass m and angle of deflection ($theta_o$) for a simply supported beam.
4. How does changing the number of cycles per experiment affect the mean value of G ? Also does mass increment value (Δm) have any effect in accuracy or precision of the G for a given m_{max}?
5. Using the dataset `P8_TorsionTest.mat`, make plots of Shear stress vs shear strain for each experiment for the first cycle and find the best linear fit using least square method . What does the slope of the best fit curves represent?
6. Find the best estimate of G for each cycle for all the 5 experiments.(i.e, from each experiment you get 20 values for G)
7. Using the values of G obtained in question-5 plot normalised histograms of G for all the 5 experiments. Also plot the smoothened probability density function trends over the histogram plot.
8. Find statistical quantities μ ,σ of G for each experiment and plot Gaussian probability density functions for G using the above obtained quantities and compare with the corresponding smoothened plots in question-7
9. From literature find the graph of torsion vs angle of twist and compare it with the plots obtained in the experiment. Upon careful examination it was concluded that the results from one experiment violated some of the basic assumptions of the experiment. Which experiment is that? and why ? (hint: Shear modulus is a modulus of elasticity)
10. Find the best estimate of G from all the experiments.(express your final answer inclusive of the associated error in terms of $\pm 1\sigma$). Compare your result with the published value of the G for aluminium 6061.
11. What are the short comings of the current experiment? Suggest better experiments to measure shear modulus of a material .

In addition to answers to the above questions each report should also include introduction about the experiment , schematics of the experimental setup, a results and discussion section and a conclusion section.