Lab Manual for Engrd 202, Virtual Torsion Experiment (Aluminum module)

Introduction

In this module, you will perform data reduction and analysis for circular cross section aluminum samples. By plotting the torque vs. twist data for aluminum and performing analyses of the data you can infer relations between sample geometry, strength and stiffness. Seeing how the samples deform and fail will also help you to better understand material behavior under torsional loading. From the torque twist curve you can find quantities such as yield torque (for ductile materials), ultimate torque (for brittle materials), maximum torque, stiffness, and material properties such as shear strength and shear modulus. If you need, you can review the theory for data reduction and analysis for circular samples by going through the chalk-talks on basic theory and on testing of engineered materials.

Procedure

Select three data sets for aluminum. Each of the aluminum tests were performed using the same material, machined to different lengths, and inner and outer diameters. These geometries are labeled geometries 1-4 in the tables linked under "Test Data". You will find the nominal dimensions for each geometry in the tables linked under "Test Data". The actual, measured dimensions for each sample (which may differ from the nominal dimensions) are listed at the top of each individual data file. Data files are named according to the following convention: Material_Geometry_Repeat.***, where the stars are in place of the file type extension (For example AL_1_2.txt would be the text file containing data for the second test on an aluminum sample made using geometry 1).

Select one data set each from geometries 1, 2 and 3 of the aluminum tests (You may use any data set within a particular geometry since there are repeats of nominally identical samples). Plot the torque-twist curves for each data set; continue your analysis by completing tables 1 and 2, then proceed to answering the questions below and to writing your lab report. Step-by-step directions for completing the data and comparison sheets, (tables 1 and 2) are given at the end of the module

Lab Report

Your lab report should include the completed data sheets, graphs and a brief discussion of the lab procedure. The report should also provide answers to the questions below and any other discussion, observations or comments you wish to include.

Questions

1. For the aluminum tests, compare the elastic stiffness, k_{sample}, from geometries 2 and 3 to that for geometry 1. Do the relative values (i.e. ratios of k_{sample} from one geometry to the other) agree with theory?

2. Compare torque at first yield, T_y, for aluminum geometries 2 and 3. Repeat for geometries 1 and 2. When are the values different? Do the relative values of T_y agree with theory?

3. Calculate the shear modulus, G, and shear yield stress, τ_y, for the aluminum samples. Compare these to the reference values for these materials. Discuss any discrepancies between your measured values and the reference values. Do you notice any trend in the G values for aluminum as the sample dimensions change? Suggest a way to improve the measurement of G.

4. Review the virtual test for the aluminum and comment on the deformation of the sample during the test. If you were to replace this circular sample with a square sample of same length and polar moment of inertia, what difference would it make in the deformation?

Step by step instructions for completing Tables 1 and 2 for a given data set and Sample ID

a) Select the data file and open it. You may choose to use a text file (.txt) or an Excel file (.xls). The Matlab GUI (VL_1_v10.m) uses the .txt files

b) Enter the sample ID, material and the dimensions of the test sample on table 1. Use the information given in the header of the text file or Excel file. If you choose to use the Matlab program, this information will be displayed on the GUI.

c) Calculate J (polar moment of inertia) and enter this value on row 3 of table 1.

d) Plot the torque vs. twist for the sample. For this purpose, you may choose to use the Matlab GUI. In the Excel files the plots are provided to you. You may refer to 'Hints for graphing' in case of any difficulty in plotting the data.

e) Now, plot the torque vs. twist curve in the linear region. Find the stiffness (slope of the torque-twist curve). Denote this value as k_{total}, the total stiffness (slide 5 of chalk talk on engineered materials). Enter this value in row 4 of table 1.

f) Calculate the sample stiffness, k_{sample} (slide 6, 7 of the chalk talk on engineered materials). Using this value of stiffness, calculate shear modulus for the sample and enter this value in row 5 of table 1.

g) Calculate the shear modulus, G, using the relation given in slide 7 of the chalk talk on engineered materials. Enter this value in row 6 of table 1.

h) Calculate the yield torque (or ultimate torque for brittle materials) and the maximum torque (refer to slide 9 of the chalk talk on engineered materials) and enter these values into row 7 and 8 of table 1.

i) Now, calculate yield strength or ultimate strength (refer to slide 10 of the chalk talk on engineered materials) and enter these values in row 9 of table 1.

j) Look at the broken sample and comment on the type of fracture. Write your comments in row 10 of table1.

k) Follow this procedure for three of the four aluminum samples. Then transfer the data over to table 2 and complete the suggested comparisons.