Session 2168

Application of LabVIEW for Undergraduate Lab Experiments On Materials Testing

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Abstract

This paper describes the implementation of LabVIEW, in a torsion experiment in the Mechanics Laboratory in the Mechanical Engineering Department at the University of New Haven, to allow the acquisition of real time data for display, analysis, control and storage. The input moment and the angle of twist are measured directly from torsion transducers. The real-time measurements and display acquired waveforms are displayed on a PC screen and the data associated with these waveforms are stored for later use. The aim is to be able to control and apply moment to a specimen, and collect data from the resulting deformation in the material. In the torsion test, the mechanical properties of the materials to a twisting moment are obtained by two transducers mounted on the bottom of the grips of the torsion machine. The torque and angle of twist are then acquired using LabVIEW software to obtain the yield shear stress, modulus of rigidity and the ultimate strength. The data acquisition system is provided using the following products from National Instruments: application programming interface; and LabVIEW, software development package. The Excel spreadsheet is used to analyze the results.

This work demonstrates that instrumentation experience is greatly enhanced by integration LabVIEW into the Laboratory. The incorporation of computer data acquisitions into the undergraduate laboratory provides students with a valuable tool for data collection and analysis.

Introduction

The use of a computer to imitate an instrument or device is known as virtual instrumentation. One software development package used to create virtual instruments is LabVIEW (Laboratory Virtual Instrument Engineering Workbench). LabVIEW is a graphical programming language that, when used in conjunction with a data acquisition device and personal computer, allows the user to control devices, collect, manipulate and display data. Written code is not used in LabVIEW, instead graphical representations of the circuits are constructed which are called virtual instruments (VI's). These VI's are manipulated to perform the desired tasks at hand. The VIs (virtual instruments) in LabVIEW are run from their front panels. This is the panel with all of the controls and displays. Each front panel has an associated block diagram. This block diagram is built using the graphical programming language G. The components of the block diagram represent different structures, loops and functions. The wiring of the block diagram represents flow of data between these components. A VI becomes a sub VI when it is placed inside the block diagram of another VI. These sub VIs are analogous to sub routines, and allow layering and modularity of the VIs.

Linear Elastic Theory [1]

Elementary theory predicts a state of pure shear stress on the surface of a circular torsion member. Pure shear is defined as a state of shear stress in the absence of normal stresses.

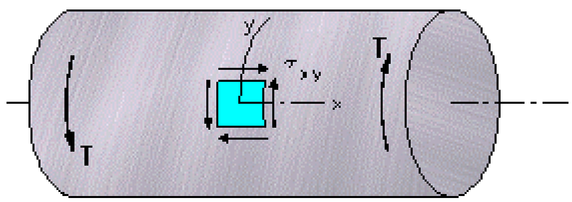

Figure 1 Torsion Specimen

On the surface of a circular torsion member (Figure 1) the state of shear stress (in the axial and circumferential directions) is given by:

$$\tau_{xy} = \frac{T\ c}{J}$$

where T is the applied torque, c is the radius and J is the polar moment of the cross-sectional area. For a solid circular member:

$$J = \frac{\pi\ c^4}{2}$$

Although the shear stress equation above contains no elastic constants, review of the derivation will show that linear elastic theory was assumed.
It is important to realize that pure shear stress can exist only for one orientation of the coordinate frame. For all other orientations normal stresses will exist, and at $\pm 45^o$ to the pure shear axes we find principal stresses (and thus no shear stress). It is easy to show with Mohr's circle (Figure 3) that the principal stresses are equal tensile and compressive stresses with the same magnitude as the torsional shear stress. The conclusion is that the state of pure shear stress is equivalent to a

biaxial state of equal tensile and compressive stresses oriented at 45° to the pure shear axes (Figure 2).

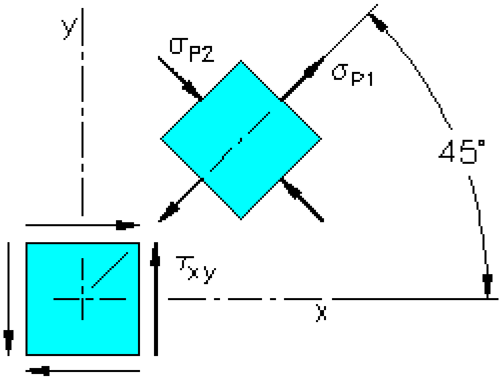

Figure 2 Torsion Stress States

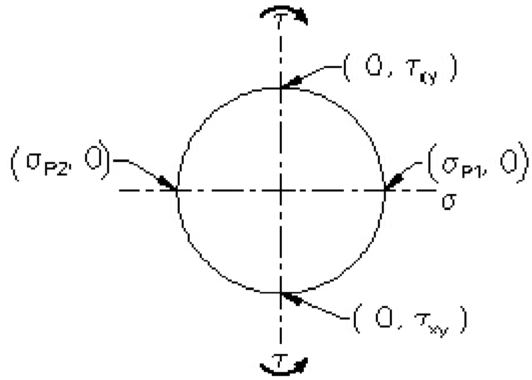

Figure 3 Mohr's Circle for Torsion

$$\sigma_{P1} = \left|\sigma_{P2}\right| = \tau_{xy}$$

The surface shear strain associated with the axial-circumferential directions is given by:

$$\gamma_{xy} = \frac{c\ \theta}{L}$$

Equipment setup

The equipment was set up as shown in Figure 4. The VIs were written and run with LabVI 6.0 Student Edition. The Torsion VI worked in conjuction with the Tinius Olsen Lo-Torq Bench Model Testing machine . A serial interface is used to collect data from the 290 Display.

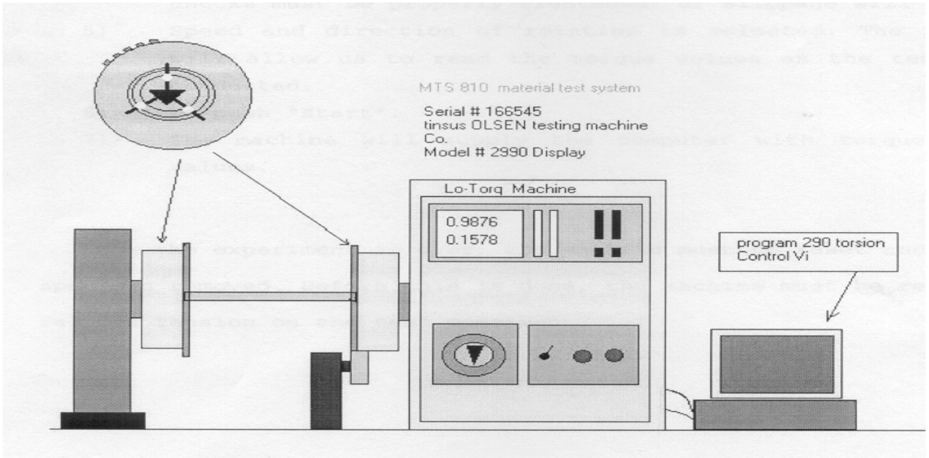

Figure 4: Equipment setup

The 290 Torsion Control VI , shown in Figures 5 and 6 interfaces with the Tinius Olsen Lo-Torq Bench Model Torsion Testing Machine with a Model 290 Display. This VI will collect the torque and twist angle data, calculate shear stress and shear strain and write all of this data to a file, which can be later opened with a spreadsheet program. The user must first enter a file name, to which the data will be saved, the time interval for the collection of data, and the diameter and length of the specimen.

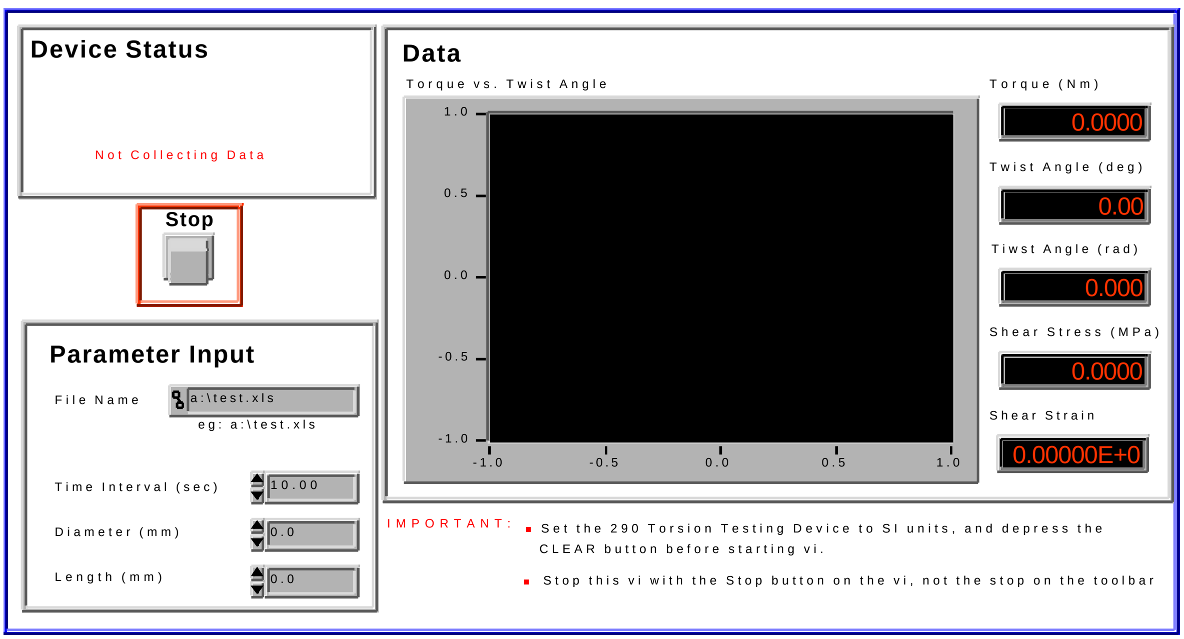

Figure 5 Front panel of the 290 Torsion Control VI

The VI begins by zeroing the first channel and then collecting data from both channels of the Model 290 Display at the specified interval. This data is displayed in both numerical and graph form. The graph allows the user to observe the relationship between the applied torque and the angle of twist. The diameter and length of the specimen are utilized in the calculations of shear stress and shear strain.

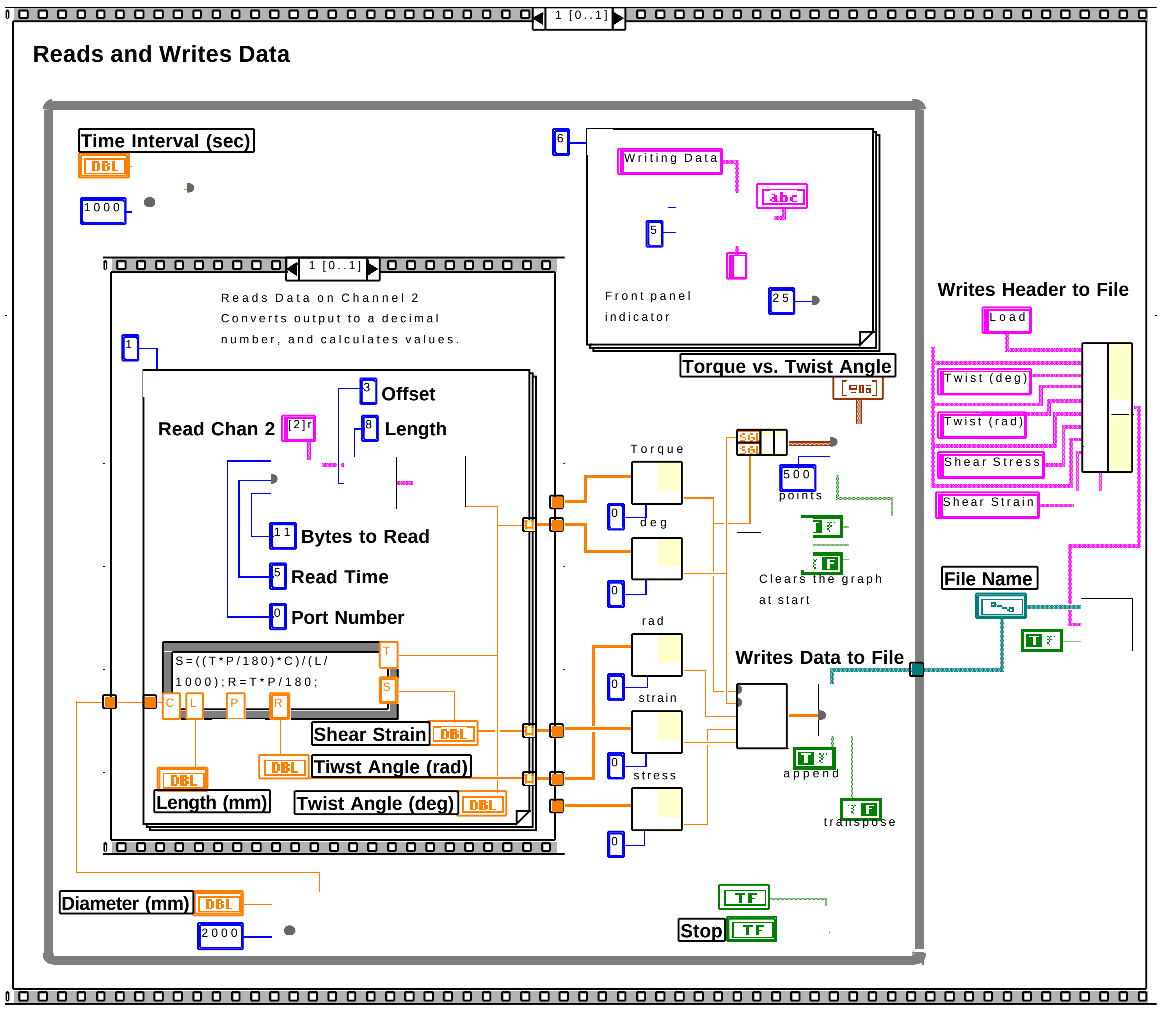

Figure6 Block diagram for the 290 Torsion Control VI

Depressing the Suspend button allows the user to interrupt the collection of data. With the Suspend on, the VI will write zeros to the file at the specified time interval. Depressing the Suspend button once more resumes the collection and writing of the data. The Stop button on the VI ends the collection of data and terminates the running of the VI.

Results

During this experiment the LabVIEW software was constructed to allow the necessary experimental data to be computed and recorded into an excel spreadsheet. This stored data was analyzed by MS Excel. Figure ***7*** shows the relation between torque and the angle of twist for aluminum (6061 T651). Figure 8 indicates the relationship between shear stress and shear strain.

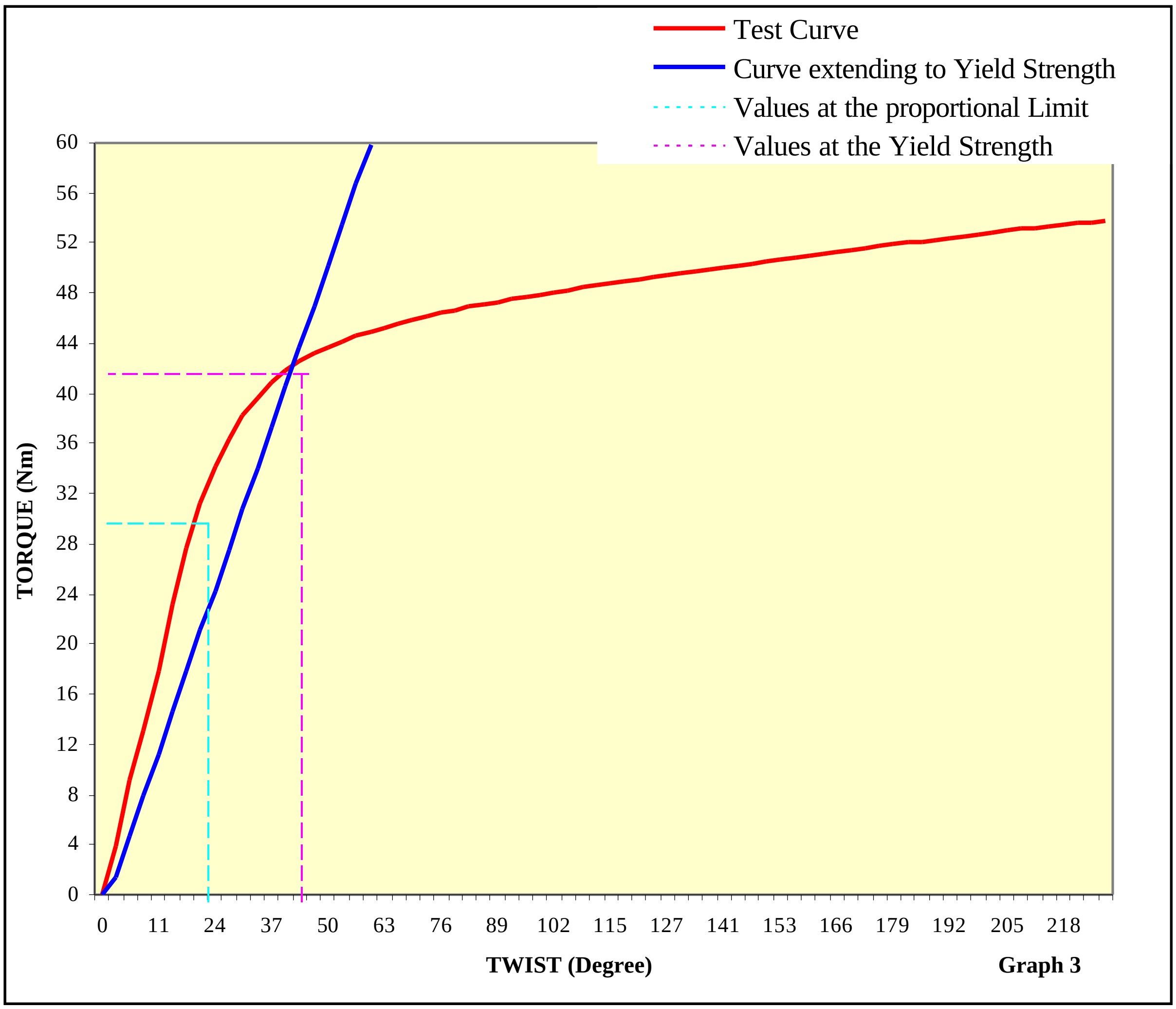

Figure 7: Torque and angle of twist diagram
(6061-T651 ALUMINUM SPECIMEN)

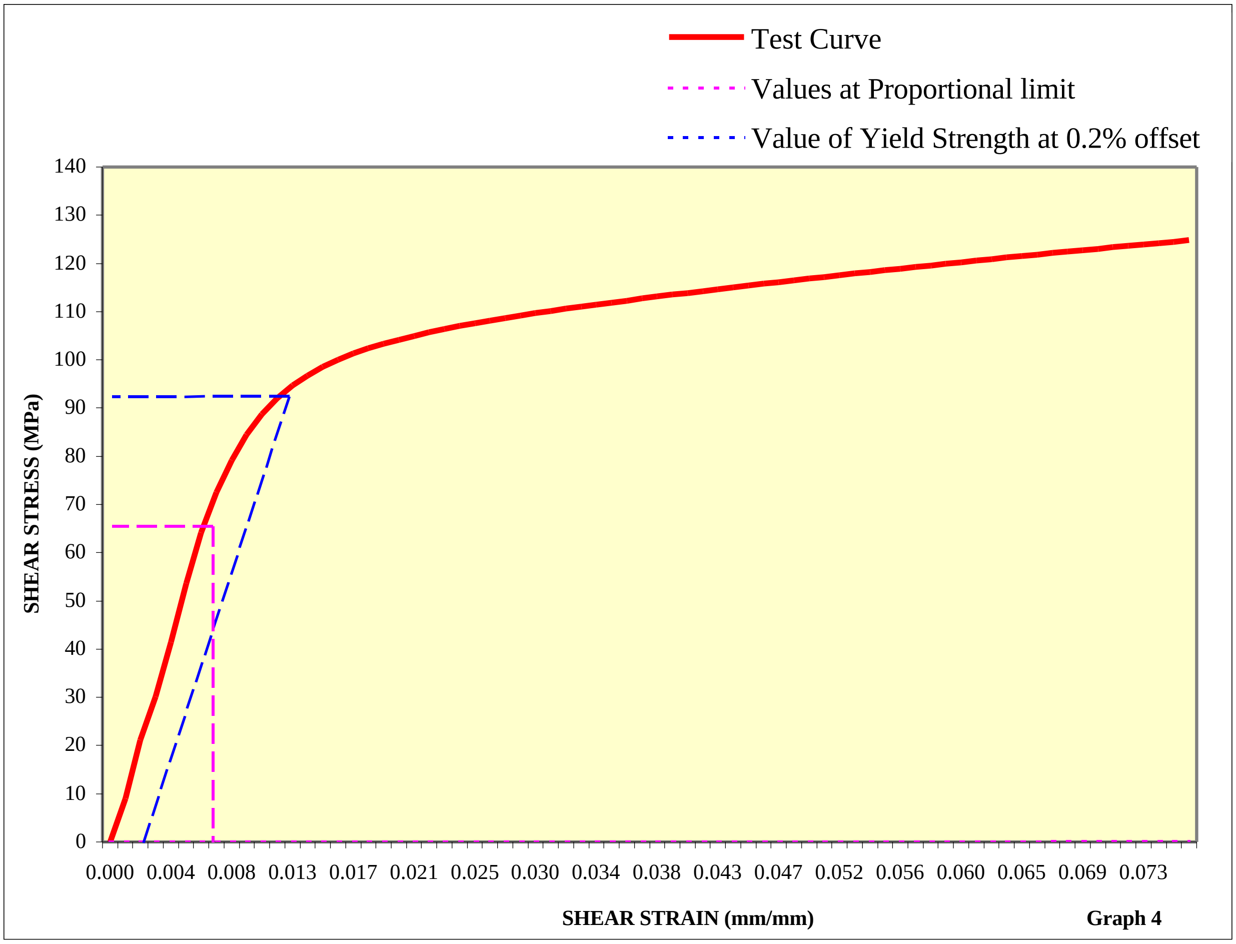

Figure 8: SHEAR STRESS VS SHEAR STRAIN
(6061-T651 ALUMINUM SPECIMEN)

Discussion

Once the equipment was set up the VIs were easy to use, and in a matter of minutes the experiment had been executed and the data recorded. The data is displayed on the VI, and calculations are made using this data and parameters set by the user. Data and calculations are written to a file which can be opened using a spread sheet program such as MS Excel This saves considerable time over the method of using the 290 display to capture the signal, making the measurements of the data, and performing the calculations.

Comparison of the results, as shown in Figures 7 and 8, indicate that the mechanical properties of Aluminum are comparable to the published data.

Conclusions

In this experiment, virtual instruments created with LabVIEW were used to investigate the mechanical properties of materials subjected to twisting load.. A LabVIEW VI and a number of subVIs were written for the experiment. The use of virtual instruments created with LabVIEW allows the user to quickly investigate and gather data, and also serves to introduce many students to the use of virtual instruments. The time student takes to complete the experiment are significantly reduced by using computer data acquisitions. This work demonstrates that the capability to rapidly acquire, display and analyze data provides a valuable tool to students.

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Biographical Information

ISMAIL I. ORABI, Professor of Mechanical Engineering at University of New Haven. He received his Ph.D. from Clarkson University, and his MS degree from the State University of New York and B.S. from Cairo Institute of Technology, all in Mechanical Engineering. In the past 10 years, He has established three Laboratories: the Materials Testing laboratory sponsored by the NSF, the Engineering Multimedia Laboratory supported by AT&T Foundation and the Space Dynamic Systems Lab funded by United Technologies and the Yankee Ingenuity of the State of Connecticut. He has published over 25 technical articles in refereed journals and conference proceedings. His research interests include dynamics of linear and nonlinear structural systems, numerical simulations and seismic analysis and design.