Development of a Portable Toughness Tester for Biological Materials

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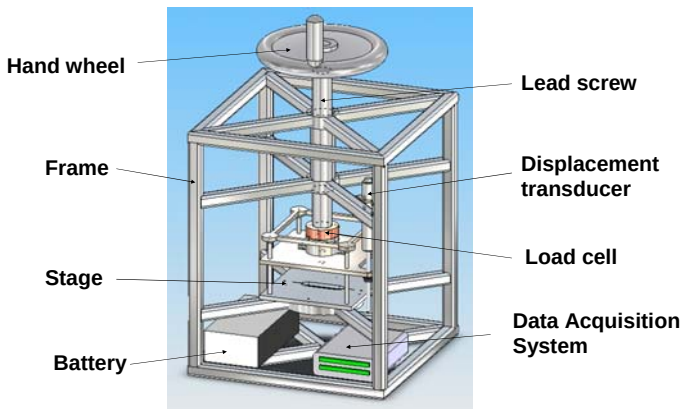
Introduction

In the field of mechanical properties testing, there are many lab-based testing machines, but fewer portable devices. A portable device allows samples to be tested in the field. This is particularly important for biological samples whose properties can change quickly once they are collected. A portable hardness tester was designed that applies a force to a sample via a hand crank. The tester then measures and records the force and displacement at the point of failure of the sample. This allows for a calculation of the toughness, or the work required for fracture, of the sample. The goal of this project was to develop a device that is durable and portable while still being accurate.

Previous Work

During the Spring 2007 term, four teams of students worked to design a portable hardness tester based on the paper *A Portable Fracture Toughness Tester for Biological Materials* by B W Darvell et al. All four designs use a hand-powered crank or press to lower a screw and apply a force to the specimen. They all improve upon the Darvell design by adding attachments that allow for multiple types of tests to be performed. This allows a greater variety of specimens to be tested. This project continues the development and construction of one design with the intent of developing a prototype testing device.

Design



•Dimensions: 13” x 13” x 16”

•Weight: 35lbs

Design Components

Lead Screw

•6.5 lbf on hand wheel generates 250 lbf

•Thrust bearing at end translates only vertical motion

Displacement Transducer

•Mounted to top plate and frame

•Measures up to 25mm ± 0.05mm

Image courtesy of http://www.omega.com

Load Cell

Image courtesy of http://www.transducertechniques.com

•Measures up to 1000N ± 1%

•Sealed

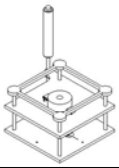
•Attached to thrust bearing

Data Acquisition System

•Mix different internal amplifiers for different input voltages

•Stand-alone option using SD card allows data acquisition without laptop

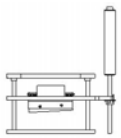
Image courtesy of http://www.dataq.com



Stage

•Troth for specimen being tested

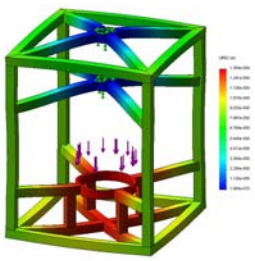
•Interchangeable fracture applicators allow for different tests



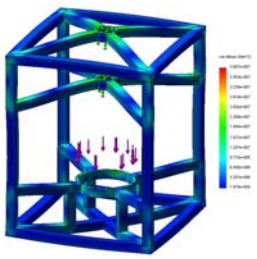
Side view of stage with blade attachment for scissor test

Frame Analysis

The frame is constructed from ¾” x ¾” carbon steel tubing. All parts are welded.



Displacement analysis of frame



Stress analysis of frame

•Stage area of frame faces at maximum 250lbs of force. This value is limited by the maximum force the load cell is able to withstand.

•Minimum factor of safety for frame is 9

•Maximum displacement of stage area of frame is 5.3×10^{-3}in. This value must be minimized so that error is not introduced into the displacement transducer measurement. Without added supports under stage, maximum displacement of the stage area was 1.3×10^{-2}in.

Conclusions/Future Work

The final design is lightweight and fits inside of a storm case, allowing it to easily be transported to a field testing site. The frame is durable and the box-shape encases all the components of the device. Each component of the system was designed or chosen based on with ability to withstand being transported as well as operated in field environments. This includes a wide temperature range as well as conditions such as high humidity. Construction of the frame has been completed. Future work includes construction of the stage and lead screw. Once all the components are constructed and assembled, testing will determine the accuracy of the system compared to lab-based devices.

Acknowledgements

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