STRESS AND STRAIN MEASUREMENT

DANGER: The Instron mechanical testing machine is a potentially very dangerous apparatus. It can be used only under direct supervision of one of the instructors!! There will be NO exceptions to this rule under any circumstances. Safety glasses are to be used at all times!!

The potentially dangerous aspect of this lab occurs when the specimens are being loaded into the testing machine. If any student feels uncomfortable using the testing machine, he or she can ask an instructor to load the specimens.

PREPARATION:

Read the document uploaded to the course wiki for this experiment.

Note that you should keep a record of all your procedures and calculations in your laboratory notebook.

OBJECTIVE:

To determine the Young’s Modulus for aluminum, stainless steel, and copper through direct measurement.

To measure the nominal stress-strain response for three different metal alloys.

To measure the hardness of the three alloys using the microhardness tester and to relate the hardness to the yield strength of the alloys.

INTRODUCTION:

Knowing the elastic constants of materials is extremely important in modern engineering. In this experiment the student will determine the Young’s modulus by applying a tensile load to samples that have strain gages mounted on them.

The yield stress of a material is the stress at which permanent plastic deformation is induced. It is a critical property that is often used in the design of devices and structures.

The hardness of a material characterizes the yield stress of a material. During the test, a small diamond tip is indented into the material and the force applied to the indenter and the depth of indentation is recorded. Since the morphology of the diamond tip is known, the depth of indentation is related to the area of the indentation. A hardness test is much simpler to perform than a tensile test to determine the yield stress.

There are several ways (i.e. Rockwell, Brinell, etc.) of reporting hardness that are used in industry which have ad hoc definitions. The most physically meaningful definition is to normalize the maximum force exerted on the diamond by the projected area of the indented region onto the original surface. The resulting quantity has units of force per area, which is the same as stress.
It can be shown using the theory of plasticity that the hardness of a material defined in this manner has a value that is approximately three times the yield stress of the material.

**APPARATUS**

- Intron Testing Machine.
- Microhardness tester.
- Sample Specimens.
- Bluehill program.

**PERFORMING THE MECHANICAL TEST**

*Note: The Intron is a potentially very dangerous device. Do **NOT** perform this test unless under the direct supervision of one of the instructors!!*

*Safety glasses are to be used at all times!!*

*The most dangerous part of the test procedure is placing the specimens in and removing them from the load fixtures!!*

- Follow the instructions listed in the course wiki and from the laboratory staff as to how to measure the Young’s modulus of the specimens using the clip-on strain gauge for three metal alloys.
- Follow the instructions listed in the course wiki and from the laboratory staff to determine the nominal stress strain response for three metal alloys.
- Follow the instructions of the laboratory staff to measure the microhardness of the three alloys. Instructions on how to use the device are on the wiki site. Make at least ten measurements of each material.

**REPORT:**

**Elastic property measurement**
In your report, plot nominal stress vs. strain curves for all three materials based upon measurement with the clip-on strain gauge. Finally, tabulate your experimentally determined elastic constants and compare to published results.

**Nominal stress-strain results**
Plot the nominal stress-strain results for each material based upon the displacement measurements. Label all points of the curves. Is the Young’s modulus obtained in this manner accurate? Why or why not? Explain.

**Hardness results**
Tabulate the results of the hardness tests. Include the mean and standard deviations. Compare the results to the yield stress for the same materials. What correlation do you find?