



Metallurgy and Mechanics:

How the Carderock Research Center is Putting it all Together

Emily Menzen

College Park Scholars—Earth, Life, and Time

Biology: Evolution Ecology Major

Emenzen@umd.edu

May 4th, 2007



My Service Site:

My practicum service site was at the Carderock Division of Naval Surface Warfare Centers in West Bethesda Maryland. I worked in the Metals Group shadowing material and mechanical engineers. The division's mission is to aid the Navy construction now but also design for our future Navy. They develop and test experiments which deal with the features of metals and alloys and the strengths and properties they exhibit under the normal wear and tear of the military. This division strives to create efficiency with alloys that possess a combination of strength, durability, flexibility, accessibility, and at a low cost to build ships and airplanes for the US Navy.

Metals Division, Code 61

Naval Surface Warfare Center, Carderock Division

9500 MacArthur Boulevard

West Bethesda MD 20817-5700

Phone: (301) 227-4995

Fax: (301) 227-5576

Email: nswccdcode61web@nswccd.navy.mil

Why is the material engineering work important?

This research is important because knowledge of the material properties of each metal created in different ways will allow the best, cost-effective material for the job.

On the smaller scale:

Carderock makes advancements for the US Navy ships by testing composites, alloys, and metals to determine the best for a particular application. Things to consider when choosing this source of support are that a metal exhibits some of these characteristics:

- A light material for faster ships
- A strong material for withstanding pressure
- A ductile material for tensile strength
- A non-corrosive material for ships in seawater
- A material that wont easily grow a crack for endurance
- A material that has a high melting point for planes

However, there needs to be a cost-effective material and method of production to be feasible.

My work and its impact:

I spent two weeks shadowing the scientists at Carderock's Metal group, experiencing first-hand what the real world of lab work is like. I learned an incredible amount of information about a very interesting topic and will share now my efforts to assist the engineers in a few of their current tasks.

An issue I worked with over the internship was analyzing a series of steel tensile test¹ data. The material was placed in a hydraulic machine which applied a certain load to the steel and pulled it apart at a specific speed. The material was hooked up to strain gauges², which read out to a computer the changes in the material over the time period of the experiment. I was responsible for processing this information and creating graphs in excel which showed the stress over strain. I was taught how to determine the stress³, strain⁴, and engineering yield⁵. It is important to know how a material reacts past the elastic level until ultimate yield and failure because all pieces of the same material will have the same modulus of elasticity⁶. To aid the scientists in their experimentation I measured dozens of specimens to exact specifications and then entered this data into the computer so that the strain gauges and hydraulics could be calibrated.

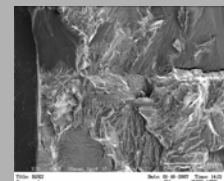
I helped another engineer with his fatigue and fracture growth tests. The idea behind testing a piece of metal for its fatigue properties is to find out at what load and after how much time a material with a crack will increase. The crack growth testing is important because scientists need to know under what stress a crack will grow and at what rate will this occur. I also calibrated the voltage meter on the machine for these experiments and ran the computer on a few tests. The big experiment designed by the Branch Head was a bolt bonded tension test. A large composite was attached to steel by five large bolts on the top and bottom and inserted into a hydraulic controlled by a large machine and computer. I aided the scientists with attaching this composite, placing strain gauges, designing an appropriate strain bar, calibrating and running the experiment. We tested the load at which the composite reached failure and where the most strain occurred on the material. We were correct in our assumptions that the place of failure was at the bolts, the weakest part of the material. This experiment is important because a piece of material needs to be as strong when connected together to another material as it is alone. I used the data from our five strain gauges to create graphs of the stress versus strain, found the slope (Young's Modulus), and determined the engineering yield. I then helped this scientist out by creating a power point brief presenting our results.

What I have learned!

After my two week internship with the metals group, I felt as if I had been given a crash-course in mechanical engineering and metallurgy. In addition to the books I was given to read about the physics, calculus, and chemistry behind the reactions I was viewing, I used them as a guide to find my engineering yield to aid with tensile test analysis. While taking a tour of the welding facilities I was given glimpses of what the future of welding will look like for many Americans pursuing that career. I am very interested in welding and am always looking for some guidance and practice so I was thrilled when the scientists from that section allowed me to hand-stick weld in the lab. Also, I learned that testing requires a lot of patience and flexibility. Our bolted bonded composite experiment took a great amount of adjustment on test day, and each person involved had to be flexible so that it would occur smoothly. It was really cool to learn how to use the scanning electron microscope and I'm grateful for being trained on it—it is a valuable skill to possess. Almost everything I did at Carderock was new to me, except for creating graphs of the results but even then I learned new techniques to represent the data. It was a lot of information to take in, but applying what I ascertained helped solidify the information in my head. The internship really made me think about my options for my future career. I had never considered engineering as a major because I thought it was out of my league, but after spending some time at Carderock, I really found an interest for this subject. The only downside is that this made it more difficult to decide my undergraduate career path!



Hard at work snapping electronic picture files of fracture surfaces on the SEM at Carderock. Photo courtesy of Keisha Sylvester.



My SEM image of a specimen which displays relatively little resistance to crack growth. Note α^8 and β^9 phases.



The bolted bonded composite experiment. Notice strain gauges and displacement flex bar.

Terms Used:

- 1—Tensile test. Measures the strength of the bonds between the atoms in the material by applying a load and pulling in the opposite direction to stretch and break the metal. The results will show at what point the metal finally breaks and how much load it took to create that final yield.
- 2—Strain gauges. Placed on the material during the experiment and used to find the strain at a certain area on the specimen. A Wheatstone bridge circuit is used and as the coil stretches due to the elasticity of the material, a change in resistance occurs which creates a change in voltage on a computer. The computer processes this information and since a voltage is calibrated to represent a certain distance, a change in voltage represents a change in distance and thus a recording of strain.
- 3—Strain. The deformation a material undergoes when a stress is applied.
- 4—Stress. The distribution of a load over a given area.
- 5—Engineering yield. The point of failure when extrapolated using Young's Modulus.
- 6—Modulus of Elasticity. Slope of the stress-strain curve, the tendency of a material to deform when a load is applied
- 7—SEM. Scanning electron microscope (otherwise know as a very expensive piece of equipment—which breaks easily and often)
- 8—Alpha. Represents low energy fracture facets
- 9—Beta. Represents higher energy, more ductile tearing

Demonstrating my on-the-job training at Carderock: welding using two different types of electrode consumables and thus two different techniques. Photo courtesy of Joe Kalp.



Acknowledgments:

I would like to extend my sincere thanks and gratitude to everyone who assisted me on my practicum research especially: my Earth, Life, and Time professors Dr. Holtz and Dr. Merck, the entire College Park Scholar's organization, my Earth, Life, and Time program, the NavSea Warfare Center Carderock Division, and my site supervisor Jeff Mercier. Also I would like to thank Jen Gaies, Joe Kalp, Chuck Roe, Amy Robinson, Dan Stiles, and Keisha Sylvester for all their support within the metals group. Thank you!

Texts Used: Introduction to Materials Science for Engineers 5th Ed. Shackelford, James F. Prentice Hall, Upper Saddle River, NJ: 2000.