Thesis Project Portfolio

Design of User-Friendly Electrodes for Real Time Coating Condition Monitoring

(Technical Report)

Material Transition: How Naval Materials Improved Over Time

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Victor Ismael Villanueva

Spring, 2023

Department of Materials Science and Engineering

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Executive Summary

One of the constant engineering challenges that humans have always had to deal with, from our early beginnings to the modern age, is material choice. We learned early on that you cannot use the same material for all applications, with varying levels of consequences. Using an incorrect material could lead to increased cost and repair, to catastrophic failure and loss of life. Since the issue of material choice is applicable to any and all engineering fields, my projects will narrow this problem down to material choice for things in seawater. My technical topic explored material choice in terms of investigating corrosion damage, which is a huge issue for any vessel or aircraft operating in this environment. I worked with a team to analyze different materials, by looking at their material properties and important characteristics, to determine their viability in corrosion damage testing. My STS topic took a more historical approach, by looking into material choice for ships in general, and analyzing when and why most ships when from wood to metal. I approached this question by viewing ships in a technological frame, as well as drawing from Actor Network Theory, in order to see the many different social groups that were at play and that had to be pleased in order for metal ships to take precedence over time-tested wooden ships.

My technical project was motivated by the importance of corrosion in seawater operations. Seawater creates a particularly corrosive environment for materials, and this must be studied extensively to ensure proper material performance. My team worked with Luna Labs to develop an idea for corrosion damage control. Currently, corrosion effects are usually analyzed when planes come back to their bases, but damage can evolve over time and become critical quickly, thus a method for real-time analysis would be invaluable. One method used to analyze corrosion damage is Electrochemical Impedance Analysis (EIS). EIS is an electrochemical test that uses a varying applied potential to induce and measure a potential change in the sample. One method for EIS shows accurate results via the use of three electrodes, which are counter, reference, and working electrodes. My team designed, produced, and tested pairs of electrodes that could be used as reference and counter electrodes in this process, with the working electrode being the material of interest. These electrode pairs were created from 4 different materials and in 4 different shapes. Two of these shapes were to test for corrosion damage on a general coated surface, and the other two were designed specifically for testing around fasteners, as these areas are hotbeds for corrosion. In the end, the best material and shape design for each area of interest was submitted, via comparisons of material properties and manufacturability, as well as user experience, wettability, corrosion resistance, and cost of material.

My STS Thesis wished to investigate an astronomically important material transition that happened in the 1800s, that being the major transition from wood to iron in shipbuilding. I was curious to learn about the important factors that led to and drove the transition, especially because in this period, shipping was still a major method of transport, communication, and warfare, and so any major innovation had huge impact on the entire world at the time and future world events. I also wished to investigate this transition in order to dispel the opinion that innovation will always happen no matter what; using STS frameworks we see that technology has to win over many groups in order to be successful. Even though we can now look into the

past and say that metal is clearly better than wood for ships, we have to put ourselves in the shoes of the people at the time, and see what the advocates and opponents had to say. After looking into many different sources from and about the time, we can now see that the backlash against wooden ships was actually pretty heavy, and the advocating engineers and designers had to work hard to convince wooden shipbuilders and many lawmakers. We also see that the Industrial Revolution played a huge part in this transition, and that steam power is intertwined with the developments in ships at the time. This was a very interesting use of STS frameworks, and shows how useful and enlightening they can be when applied to historical innovation.

These two projects really highlight the importance of material choice, even though they were done with different approaches. My technical topic allowed me to illustrate quantitatively why material choice is important, as well as allowed me to see how the material properties are intertwined with many other things like cost and manufacturability. My STS topic allowed me to delve into an interesting technological innovation with huge implications, and see exactly what factors were for and against the material transition. It is important to see that the consequences of material choice extend much farther than its technical aspects, as we see materials and their uses have major impacts on the public. Both projects ended with very interesting results, overall showing just how important engineering is for all aspects of society.