

THESIS PROJECT PORTFOLIO

Electrochemical Post-Processing of Zn-Ni Deposition on Steel Substrate for Reliable Composition

(Technical Report)

Modern Day Oppenheimer: How the Race to Mach 10 Can Result in a New Destroyer of Worlds- The Geopolitics of Hypersonics

(STS Research Paper)

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Table Of Contents

Sociotechnical Synthesis

Electrochemical Post-Processing of Zn-Ni Deposition on Steel Substrate for Reliable Composition

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STS advisor: Dr. Pedro Francisco

Prospectus

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Sociotechnical Synthesis

The complex intersection between technology and politics has defined the defense industry since its creation, one often pushing or pulling on the other to create sociotechnical systems not easily understood. My technical research is investigating the feasibility of utilizing the preferential dissolution of zinc (Zn) in a zinc-nickel (Zn-Ni) coating to achieve a specific electrochemical potential region of interest. This research is of interest to our industry partner, Rolls Royce, as a possible method of corrosion mitigation on their jet engines. My STS research explores the complex geopolitics surrounding the development of hypersonic weapons technology. This research is of utmost importance to understanding the intricate intersection between politics, science, and technology and critically highlights the factors necessitating the hypersonics arms race. The application of my technical research, corrosion research in the aerospace industry, is adjacent to current discussions in the hypersonics community regarding high-temperature structural materials. The intersection of these two topics lies in their specific application to an industry demanding innovation in order to keep up with a heated geopolitical climate: aerospace-based defense.

Technical report I

This technical research is a proof-of-concept investigation to determine if the preferential dissolution of Zn in a Zn-Ni coating will result in an electrochemical potential in the region of interest specified by Rolls Royce. The capstone team made multiple attempts to identify a replicable selective dissolution process to reach the potential range of interest, which involved the variation of electrochemical processing parameters. Other investigative methods, such as

SEM, EDS, and XRD, were used for pre-processing and post-processing of electrochemically tested specimens.

Technical report II

The capstone team's several attempts to identify a replicable selective dissolution process to reach the potential range of interest was successful. A viable technique to reach the potential range of interest was discovered and tested multiple times to determine replicability. After electrochemical testing, specimens were extremely shiny and metallic where the dissolution process had occurred. Further characterization via SEM found that all successful specimens had their Zn-Ni coatings completely stripped down to the substrate, regardless of any difference in coating morphology or thickness. Thus, it appears that the change in open circuit potential (OCP) was not a result of the selective dissolution of Zn from the coating but rather induced by exposure of the more electrochemically noble substrate material. In conclusion, for the conditions used, it appears that the coating was completely dissolved from the substrate. This does not indicate that the experimental procedure is flawed as much as it shows that it is not viable given our constraints.

STS Research Report I

The research question presented in my STS research thesis is as follows: how has geopolitics necessitated a race for hypersonic weapons? As geopolitics are affected by the war industry, the war industry is shaped by geopolitics. The pace of the changing strategic environment is set by other countries, and the U.S is struggling to keep up due to technological and fiscal limitations. This geopolitical dynamic is the main catalyst for the urgency behind developing hypersonic technologies, especially given the existing tensions between the United States and other powerful

entities such as China and Russia. To investigate this complex research question, several topics were extensively researched and compiled into a detailed literature review.

STS Research Report II

The evidence contained in the literature review supports the assertion that the race for hypersonic weapons is a result of the current, tumultuous geopolitical climate. The Policy of Mutually Assured Destruction in tandem with historical precedents regarding technological advantage have created a climate of constant technological competition. The use of hypersonic weapons in the present-day Russo-Ukrainian war has only highlighted the United States' disadvantage at the same moment that American ideals are changing. A majority of Americans are beginning to believe that the United States should pay less attention to problems overseas and concentrate on domestic issues- a shift that is not only a result of the war in Ukraine but also a byproduct of the slew of domestic issues and civil unrest Americans experienced during the COVID-19 Pandemic. But despite this change in public opinion, geopolitical tensions between the United States and China have only risen since the COVID-19 Pandemic. This tension, combined with the threats of China's supreme hypersonic capabilities, their economic position in the world order, and their capacity for systematic disruption, has resulted in the Department of Defense (DOD) declaring hypersonic technology a critical technology for development. The race is on.