Thesis Project Portfolio

Optimizing Surface Texturing for YSZ Thermal-Barrier-Coating on Inconel 718 Substrate to Mitigate High Stresses/Strains

(Technical Report)

Virginia's Nuclear Energy Solution

(STS Research Paper)

An Undergraduate Thesis

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Bachelor of Science, School of Engineering

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Executive Summary

As societal and technologic developments have been adopted in modern day societies, the carbon footprint that we as a species have enacted on the planet has increased. One such technology that has potential to reduce its carbon footprint is aerial travel. The efficiency of the engines is directly tied to the temperature at which the fuel is combusted. Additionally, reforming the energy sector is crucial as much of todays energy is produced through carbon fuels. Nuclear power stations are a promising alternative although this technology is riddled with misconceptions and doubt. Transportation and electricity production are among the largest sources of carbon emissions. To ensure society can continue benefiting from these technologies, it's essential to invest in research and development aimed at reducing their negative environmental impacts.

With efficiency scaling with the temperature of the combustion chamber, its necessary to have materials that can survive at these high temperatures. To prevent the structural metal elements from melting a thermal barrier coating is used to insulate it from the heat. The coating process is crucial, having control over its microstructure directly correlates to its performance. To have a finer control, the idea to introduce a surface topography prior to applying the coating.

The capstone project went about testing a control sample mimicking the current processing and three topographies that our team came up with. The team conducted thermal cycling and adhesion testing to evaluate performance. The samples utilized were not promising, but through investigating the failures the team discovered potential for future work. From the work conducted it was concluded that regularly spaced stress accommodating cracks could be introduced utilizing a surface topography. Additionally, it’s very important to apply the coating

utilizing optimized spray parameters and appropriate particle sizes. Finally, the thickness of the coating is crucial to preventing failure of the coating through an oxidation growth mechanism.

For my STS paper I investigated the feasibility of using nuclear power to reform the energy production sector with the state of Virginia as a case study. *The Commonwealth of Virginia's 2022 Energy Plan*, states a goal of carbon free energy production by the year of 2045. Per the report, this means decommissioning ~65% of the current energy production capacity. In the STS paper I focused on investigating if nuclear power generation was capable of replacing the fossil fuel production. This was done by conducting a literature review focused on the public perception, safety, and technological limitations of nuclear power technology.

To address the public perception, a comparative study on the death rates of various energy sources was implemented. From this study it was apparent that per kWh of energy, nuclear ranked among the safest sources. For safety, technological advancements in new reactor designs were explored. Said advancements aimed to prevent various mechanisms that had potential to cause catastrophic failure in older generation designs. Finally, the technological limitations focused on the prevention and processing of toxic waste that the plants may produce. Many of which solved the concern of weapons grade materials being produced. All in all, nuclear energy has the potential to serve as a reliable and clean energy source. This depends on a responsible and conscious approach to implementing the technology, ensuring it is done correctly rather than quickly.