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THE INTEGRATION OF AN AEROSPIKE NOZZLE WITH HIGH-TEST PEROXIDE MONOPROPELLANT SYSTEMS

Abstract

This paper presents an experimental and computational investigation of aerospike nozzle design in a liquid monopropellant rocket thruster. An aerospike nozzle performs significantly better than the standard bell nozzle in terms specific impulse, meaning that combining it with a green propellant such as High-Test Peroxide (HTP), known for its high density and storage stability, promises a leap in propulsion system effectiveness.

The concept of aerospike nozzles dates back to the 1950s with the Lockheed Martin X-33 project which led to the development of the Rocketdyne XRS-2200 linear aerospike engine. Despite numerous successful tests, the project was discontinued due to budget constraints and technological complexities.

Aerospike nozzles outperform traditional propulsion systems as their design allows exhaust expansion to be optimized in changing atmospheric pressures, ensuring maximal thrust without the efficiency losses typical in bell nozzles due to over or under-expansion. This adaptability results in superior performance through all phases of flight and together with HTP's reliable and clean-burning properties, there is potential to revolutionize rocket engine efficacy. However, there is a notable lack of experimental data on combining aerospike nozzles with HTP monopropellant systems, a gap this study aims to fill.

In this work, the aim is to build and test a liquid monopropellant rocket thruster with particular focus on the integration of an aerospike nozzle with a HTP monopropellant system. Various aerospike nozzle designs with integrated cooling channels are investigated through additive manufacturing techniques, to address the thermal challenges posed by HTP decomposition, with a focus the tip of the aerospike plug as is it placed under the most thermal load. The fabrication and design of the rocket thruster as a whole is done at a laboratory scale to enable prototypes to be built and tested. Performance evaluations are centred on thrust output, specific impulse, and fuel efficiency. Initial simulations and design optimizations suggest that integrating HTP with aerospike nozzle technology could significantly improve thermal efficiency.

Improving the efficiency of rocket engine nozzles means that less propellant is needed to send the rocket to its desired destination, thus the payload ratio of suborbital and orbital rockets can be substantially improved. This advancement enables rockets to carry more load using less fuel, becoming more cost-effective while leveraging the benefits of a low-toxicity propellant. Such advancements promise to streamline satellite and spacecraft launches, marking a significant leap forward in space exploration capabilities.