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DEVELOPMENT OF A VALIDATED MODULAR DESIGN TOOL FOR ABS-NITROUS HYBRID ROCKET ENGINES

Abstract

This study concerns the ABS-Nitrous hybrid engine development performed at Delft Aerospace Rocket Engineering (DARE). DARE is a student rocketry society associated with the Delft University of Technology. Its goal is to provide hands-on experience to complement the theoretical material taught at the university's faculties. This project started during the development of DARE's Stratos IV rocket, directly after the breakup of Stratos III. A small propulsive roll control system was suggested to remedy the problem. The high-power requirement of a monopropellant system encouraged the DARE team to explore the restartable ABS-Nitrous hybrid system option as a low-power alternative.

Some key features are it is non-toxic, requires no pyrotechnics for ignition, utilizes a low-power ignition source, has a simple system architecture, is restartable through a hydrocarbon seeding effect, and has consistent fuel grain production through the FDM process. It comes at a performance marginally lower than HTPB. These unique properties of 3D-printed ABS make it a suitable candidate for applications where hybrids are not. For example, in an engine ignition system, a satellite attitude control, orbit maintenance, or orbit transfer system; a sounding rocket roll control system, or its main engine.

This study aims to make restartable ABS-Nitrous hybrid engines more accessible for future engineering applications by developing a validated preliminary design tool to generate the required geometry for a particular application. Different existing engineering models in literature have been collected that include multiple models of self-pressurized propellant tank dynamics, multi-phase injection models, and several regression rate models. The combination of these models will need to be validated using practical data. The infrastructure and hardware required to fire variable motor sizes are present within DARE. Preliminary results show that the system performs nominally, but iterations are essential to prove consistent and reproducible results.

Hybrid engines, commonly used by student teams, are now attracting companies with the new space mentality that leverage their low-cost benefits and simplicity. So, the right time to further explore this technology. This study will finish by comparing the developed system to alternative solid or liquid propulsion options to evaluate its applicability and performance. It could show some potential use case benefits in certain domains of the aerospace industry. The validated rapid development tool enables future projects to use this concept and lower the threshold required to get started on a design while getting new students acquainted with the topic and expanding the body of knowledge.