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HYBRID AUTOPHAGE PROPULSION FOR SPACE LAUNCH VEHICLES: A PROMISING CONCEPT

Abstract

In this article, hybrid autophage propulsion for space launch vehicles is being investigated. This novel architecture uses the launcher's propellant as structure, removing the need for tanks and staging altogether. The resulting single-stage-to-orbit (SSTO) vehicle offers improvements in design complexity, production costs and logistics. Smaller payload capacities are also accessible as a result of the reduced dry mass. In the current context of rapid growth in the number of small satellites, maturing this technology could lead to more affordable and resource-efficient launchers.

In 2008, Yemets et al. began ground-testing a solid autophage engine. This technology was made possible by the excellent mechanical properties and combustion performance of modern thermoplastics (ABS, HDPE, PP, etc.), allowing their use as both rocket fuel and structure. This paper presents the first autophage concept relying on hybrid propulsion. During the flight, both solid fuel and liquid oxidizer are inserted into the engine to produce thrust. The vehicle shortens until only the rocket engine and the payload remains. The main insertion phenomena are modeled within this paper.

During steady combustion, the solid fuel is continuously replaced as it burns, making the chamber geometry constant and solving the O/F-shift problem. The O/F ratio now becomes a geometrical parameter of the combustible structure. An overall launcher performance model is built to optimize the main design parameters (e.g. mission profile, launcher aspect ratio, chamber length and operating pressure). Results for a representative micro-launcher are presented and compared to a competing commercial launch vehicle.

To develop efficient autophage launch vehicles with optimal performance, several challenges are identified and discussed:

- the mechanical properties of the plastic structure,
- its behavior while sliding on the chamber wall,
- the balance between fuel insertion and regression,
- the impact of variable launcher length on aerodynamics and structural dynamics,
- engine throttling, which is crucial for SSTO launch vehicles.