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FEASIBILITY STUDY AND PRELIMINARY DESIGN OF AN INNOVATIVE GREEN PROPULSION CONCEPT BASED ON SELF-PRESSURIZED PROPELLANTS

Abstract

Green Propulsion is a prevalent trend in the space industry. The purpose of research on green propellants is the identification of valid alternatives to typically used propellants that, despite having a long and successful heritage, are problematic in the handling and cause excessive related costs. For clear reasons, research on propellants with reduced handling problems and costs, non-toxic and non-cryogenic, to be utilized for spaceborne propulsion systems, is very active. This study focuses on propellants characterized by minimal handling requirements and relatively low cost. Utilizing these propellants, in conjunction with cutting-edge and cost-efficient manufacturing techniques, is expected to result in a design that is both affordable and easily customizable to meet diverse needs.

Among the numerous alternatives of green propellants, including some already present in the market and many in current development, a specific class of compounds is emerging as promising for various applications. These propellants operate in saturated conditions, exhibiting high vapor pressure at operating temperatures. This inherent feature provides the fluids with feeding pressure in the pipelines, eliminating the need for external devices to push and inject them into the combustion chamber. This property is known as self-pressurization. Nitrous oxide is the most utilized propellant with self-pressurization behaviour, commonly used as an oxidizer in rocket applications and as an anaesthetic for civilian use. In available systems on the market, nitrous oxide is frequently paired with light hydrocarbons that share similar self-pressurizing characteristics and are widely available such as propylene or ethane.

The present study explores the coupling of self-pressurized propellants and liquid non-self-pressurized compounds. To preserve the major advantage of not requiring an external pressurization system, the study investigates the possibility of using the high-vapor-pressure propellant to pressurize the other compound. The study examines various aspects, including the safety of the proposed system and potential challenges. Different combinations are evaluated to identify the optimal alternative. The theoretical framework that describes the system's operation is analysed to confirm the concept's feasibility, while also addressing safety concerns related to the close proximity of fuel and oxidizer. Proposals for mitigating these risks are presented.

The core objective of this study is to conceptualize a propulsion system that is inherently simple, straightforward to produce and operate. By leveraging on a simplified design and capitalizing on the minimal handling and management procedures of the chosen propellants, the aim is to significantly reduce the design-to-test cycle to a duration of a few months.