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Ducted rockets: propellant development for boost and climb missions

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Abstract
High-speed atmospheric missions require high specific thrust propulsion units. In this regard, ramjet technology compares favorably with both rockets and turbojet engines. On the one hand, high specific impulse performance allows weight savings with respect to standard rockets. On the other hand, operating ranges of Mach number and altitude can be wider than the ones obtained by turbogas-based propulsion devices. Within the ramjet category, the class of ducted rockets (or air-augmented rockets) is a merge between solid-propellant propulsion systems and air-breathing units. High energy-density granted by this technical solution favors the design of compact systems [1].
In general, ducted rockets are based on two combustion chambers. A gas generator burns an oxidizer-lean propellant. Its fuel-rich combustion products are exhausted into the secondary chamber (ram burner) where the introduction of the ram air completes the oxidation. The performance of ducted rockets depends on the interaction between the gas generator and the incoming ram air. The understanding of burning properties for oxidizer-lean compositions becomes of fundamental importance in the definition of the mission profile. Several options can be considered so far, spanning from metal/non-metal addition (aluminum, boron, magnesium), or hydrogen carriers in the shape of metal hydrides [2].
This discussion aims at exploring various options in the operating capability of ducted rockets. Ideal performance computations will be used to support an exploratory analysis upon compositions and operating ranges (altitude and Mach number). The discussion will include a panorama on experimental results obtained for the development of aluminum-based pyrolants.

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