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Ramjet Engine Preliminary Design for Missile Range Extension

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Abstract

This paper introduces a comprehensive set of numerical tools employed for the preliminary design of ramjet missiles based on liquefying fuels. The development process follows the guidelines set forth by the European Cooperation for Space Standardization. The Brazilian Navy has been considered as the leading customer, providing the necessary requirements for the surface-to-surface missile system. The main code employed in this study employs a two-degree of freedom model for flight mission analysis, encompassing the ascending, cruising, and descending phases of a supersonic missile powered by a solid-fuel ramjet. Additionally, an internal ballistic code aids in the design of the ramjet engine. Correlations published in existing literature for various missile help define the basic geometry and mass of warhead, guidance-control and integrated propulsion for a given system mission. Warhead and guidance-control masses are kept constant while the booster and ramjet engines are iteratively upgraded. Through the execution of ECSS phase zero, the results demonstrate the development of a medium-range supersonic missile whose ramjet has 253 kg, 4,000 mm in length, with an external diameter of 300 mm. This missile carries a high explosive payload of 100 kg with a range exceeding 160 km in less than four minutes. During the cruising phase, the missile operates at altitudes of about 13,000 m, achieving speeds up to 2.8 Mach.

Keywords: Aerodynamics, liquefying fuels, ramjet missile, solid-fuelled ramjet propulsion, surface-to-surface missile