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Title

Aeropropulsive Assessment of the Scramjet Hypersonic Experimental Vehicle

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Abstract

The activities of present paper are part of the research line on experimentation for hypersonic flight, aimed at creating and testing the enabling technologies for future high-speed transport systems, with the main objective of testing a propelled hypersonic aircraft demonstrator in flight. The objectives of the project are reflected in numerous initiatives born in Europe in the last 15 years: the various EU projects dedicated to hypersonic flight for passenger transport (LAPCAT I&II, ATLLAS I&II, FAST20XX, HIKARI, HEXAFLY, HEXAFLY-INT, STRATOFLY) and the national initiatives that led to the design of prototypes such as, among others, the French aircraft ZEHST, developed by MBDA, ASTRIUM and ONERA, or the English SKYLON by Reaction Engines Ltd., which despite being more oriented towards supersonic flight and access to space, respectively, already include many of the technologies necessary for hypersonic flight. Hypersonic civil transport has always had as its weak point the low cruising autonomy, essentially linked to too high fuel consumption. In recent years, a highly integrated design approach between efficient propulsion systems and high-lift configurations (LAPCAT-II and STRATOFLY configurations) is enabling the trend to be reversed.

The study on the Scramjet Hypersonic Experimental Vehicle (SHEV) starts from the experience gained thanks to the strong involvement of Italy, and CIRA in particular, in the European project HEXAFLY-INT (realization of flight tests of an aircraft without engine for hypersonic flight), and previously in HEXAFLY, posing the challenge of creating, at national level, an aircraft capable of supporting a leveled hypersonic flight thanks to the introduction of a scramjet propulsion system

The project is funded by the national programme of research PRORA and co-funded by the Italian Space Agency (ASI), with the aim of designing a hypersonic propelled demonstrator capable of performing a leveled and controlled flight at Mach 6÷8 and an altitude of 28÷32 km, in order to realize and test the enabling technologies for future civil transport systems at hypersonic speed.

This paper deals with activities that aim to verify the aerodynamic efficiency (L/D = 3÷4) and the aeropropulsive balance (T>D) at Mach = 6÷8 in controlled flight. For the purpose of verifying the above requirements, experimental flight conditions falling within the required Mach and altitude ranges were considered. Numerical viscous CFD simulations were conducted both in fuel-off conditions, thus providing us with the values of aerodynamic efficiency and mass flow of air at the combustor inlet (input for the sizing of the tanks and supply lines), and in fuel-on conditions for the verification of the aeropropulsive balance. Several reacting air-hydrogen mixture schemes have been considered at the same asymptotic conditions for the assessment of the Thrust-Drag balance. In addition, a number of CFD viscous simulations along a preliminary flight trajectory after scramjet engine shutdown (gliding phase down to Mach=2) were also performed to provide full inputs to thermal and flight mechanics analyses.