Paper ID: 69736
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IAF SPACE PROPULSION SYMPOSIUM (C4)
Hypersonic Air-breathing and Combined Cycle Propulsion, and Hypersonic Vehicle (7)

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CONCEPTUAL DESIGN PREDICTION OF PROPULSIVE PERFORMANCES AND POLLUTANT EMISSIONS FOR HYBRID AIR-BREATHING/ROCKET ENGINES: A STUDY ON SABRE

Abstract

New developments in the field of access to space systems are driven by the evolution of the launching technologies. The current trend is to design reusable systems able to drastically reduce the specific cost of access to orbit, at least in LEO. In this field, Reaction Engines Limited is one of the most active European players, with the current design of the SABRE, which has the potential to be a revolutionary breakthrough in this sector. SABRE stands for Synergetic Air-Breathing Rocket Engine and it is a particularly innovative propulsion concept developed to power the proprietary SSTO spaceplane Skylon. SABRE works as a precooled air-breathing engine during the first phase of the ascent up to an altitude of 25 km, at which the atmospheric air becomes eventually too thin, making the switch to a pure rocket propulsion necessary until the orbit achievement. In the technical literature, only few analyses of this special kind of propulsive system are available and, in particular, none exists which is suitable to a conceptual design phase. Thus, in this work, different computational models were developed in order to predict the performances of SABRE and in general of the propulsive architectures using a similar air-breathing cycle, with a particular attention on the applicability to initial phases of design when commercial tools are not usable due to the high number of requested input data. A route of increasing complexity was followed, aimed to provide different alternatives that could be used at different steps of the design, based in particular on the level of knowledge of the design and input parameters that can be implemented in the developed models. The results were then compared to the data published by the Reaction Engines Limited, showing a good agreement and proving the reliability of the considered method. Finally, an analysis of the rocket phase was carried out based on the data available regarding the trajectory and mass of Skylon, in order to mature a complete understanding of the propulsive system. The models were coded in the MathWorks®Matlab software and included in a user-friendly Graphical User Interface in order to be then added in the ASTRID-H, a conceptual design tool developed at the Politecnico di Torino to estimate the high-speed vehicles performances. The model representing the engine can also be used as a baseline for further analysis such as environmental impact assessment of the propulsive system.