SIMULATION OF COMBINED CYCLES FOR HIGH SPEEFD PROPULSION

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Airbreathing engines benefit from a superior performance in terms of specific impulse but lack the wide operational range and high thrust to weight ratio that rockets have. The air turbo rocket is a concept that combines a Brayton and a rocket cycle for an improved operational range (Mach 0 to 3) and thrust to weight ratio, while maintaining the high specific impulse that characterize the turbojet. This combined cycle engine allows the reduction of the propellant mass required for a given mission such that it can be used as the first stage of a launch vehicle or during the acceleration of a vehicle that cruises at a higher speed. A further increase in operational range is achieved by Scimitar, a variable combined cycle engine which operates a different cycle depending on the flight speed: a turbofan from take off to Mach 2.5, a combined ramjet - air turbo rocket for the acceleration above Mach 2.5 and a pure air turbo rocket at Mach 5. This adaptability maintains a high propulsive efficiency during both cruise regimes at Mach 0.9 and 5, Fig. 1. The air turbo rocket and Scimitar are the propulsive plants of respectively the conceptual aircrafts MR2 and A2 intended for supersonic transport of passengers in the frame of the European project Long Term Advanced Propulsion Concepts and Technologies II.

The analyses of the performance (specifics impulse and thrust, thrust to weight ratio) of these air turbo rocket and Scimitar concepts at each flight condition is the first objective of this research. In Fig. 2, the operational envelope of each engine is bounded by the contour of limiting points where engine operation is not feasible and is unique for each engine design, which is defined by the engine geometry and control laws. The search of that design being able to operate throughout the prescribed aircraft trajectory while showing an optimum performance is the final target of this work.

The physical behavior of these engines is represented by a system of differential-algebraic equations which is handled and solved by means of EcosimPro. This simulation environment incorporates an object oriented language for the modular building of the engine models, which are based on the European Space Propulsion System Simulation. This is a set of libraries that comprise the mathematical description of the most common aerospace engine components (combustors, nozzles, heat exchangers) and the thermodynamical and transport properties that characterize the working fluids (He, H_2 and air). The geometry and heat transfer characteristics of the heat exchanger components are modified to better represent the physical behavior of these engine units under study, whereas new turbomachinery components are developed to better simulate their off design performance.

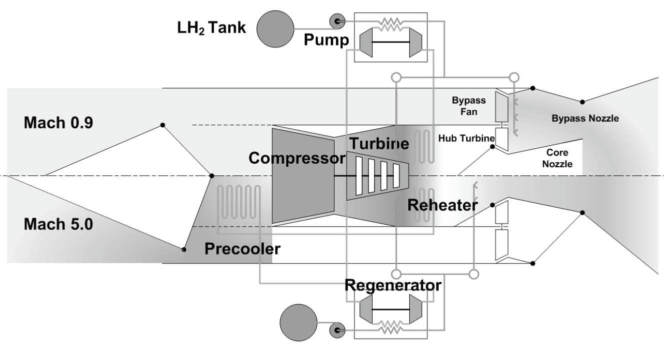

Figure 1 : Scimitar engine subsonic cruise (upper half) and supersonic cruise (lower half) configurations

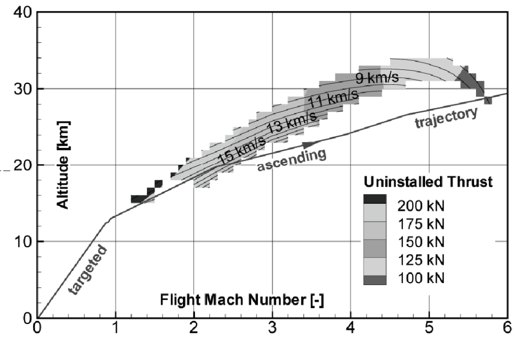

Figure 2 : Air turbo rocket operational envelope showing the isocontours of thrust and specific impulse