ANALYSIS AND OPTIMIZATION OF HIGH SPEED PROPULSION CYCLES

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Combined propulsion cycles gather different type of engine technologies: rocket propulsion units, a turbojet, a ramjet/scramjet, and other specific elements such as heat exchangers (see Figure 1-left). This combination reduces the propellant mass penalty and poor specific impulse inherent to the sole use of rocket engines while extending the flight envelope of air breathing engines through a wider range of Mach numbers. A turbojet cannot reach high flight Mach numbers and a ramjet/scramjet is not capable of sea static operations. Clearly, combined propulsion cycles offers advantages that are recognized since a long time, however very few of them have actually been built and used in-flight. The growing interest in hypersonic vehicles and reusable launch vehicles has recently driven several research programs to investigate novel combined cycles for high-speed propulsion. In this context, thorough studies must be performed to evaluate their feasibility and the requirements to optimize the different components. Consequently, an accurate cycle analysis and optimization tool is of the utmost importance.

The objective of this thesis is to develop a modular software tool, powerful and versatile enough to perform numerical simulations. The developed tool will be used to evaluate the performance of several combined cycles that are now being considered as possible power plants for the next generation of reusable launch vehicles. The Sabre cycle (Figure 1-right), designed by Reaction Engines Ltd. to be the power plant of the Skylon space plane, is currently one of the cycles being currently analyzed. In order to achieve the desired versatility, an object oriented approach is believed to be the most adapted. Libraries of components have to be developed that afterwards can be assembled to construct the desired cycle layout. Inside the components, the necessary fluid flows, heat exchanges, mechanical interactions and chemical reactions are described analytically in a way that allows steady state as well as transient simulation. In a later stage of the project, an optimization module will be developed based on genetic algorithms and artificial neural networks. In the frame of an ongoing research project ESA has offered technical support. Consequently, some of the work is being carried out at the ESTEC ESA research center in the Netherlands, offering the opportunity of direct interaction with the potential users of the cycles.

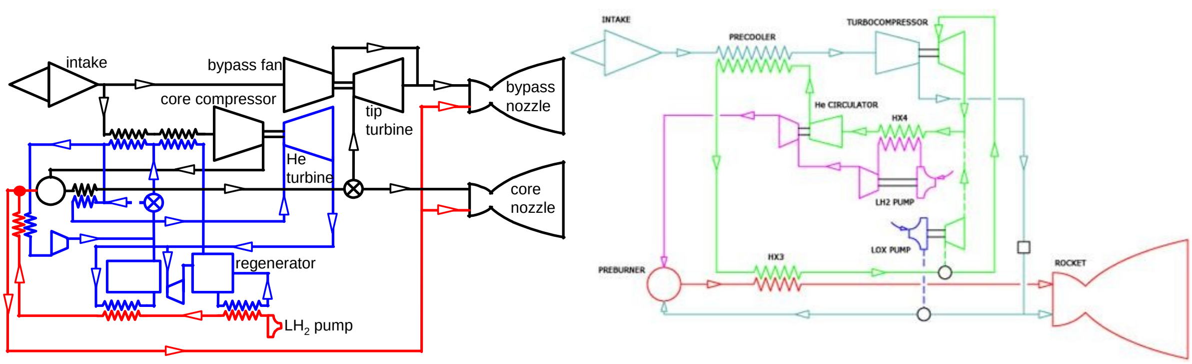

Figure 1. Left - The Scimitar thermodynamic layout. Right - The Sabre cycle