Astrium's LOX/LCH$_4$ Gas Generator Development Programme

S. Soller, Ch. Maeding, B. Kniesner, R. Blasi

To prepare the development of future European liquid rocket engines, Astrium Space Transportation's business division Propulsion & Equipment developed a gas generator for an open cycle engine using the propellants liquid oxygen (LOX) and liquid methane (LCH_4), see Figure 1 for a design example.

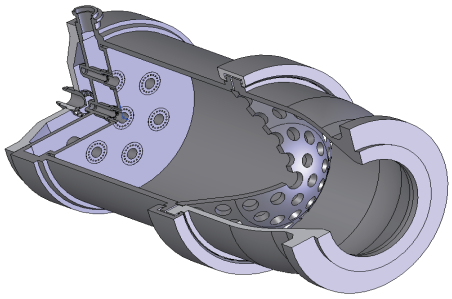

Figure 1: LOX-CXH4 Gas Generator Setup

The requirements for the gas generator were derived from an engine study for an open-cycle engine, operated with LOX and CH4 and delivering a vacuum thrust of 500 kN. The development activities comprised a number of milestones to demonstrate key technologies for the mastering of such a combustor setup, such as advanced CFD model development, design of injectors for injection, ignition and combustion of LOX and CH4 at fuel rich conditions. In several subsequent steps, these key technologies were developed and demonstrated in hot fire tests.

Different subscale hot fire test campaigns were used to provide data for model validation and to support the design process for the full scale gas generator. Tests performed by DLR in Lampoldshausen within the framework of the European FP7-program ISP-1 provided data to validate Astrium's CFD tools to describe film cooling in LOX-CH4 combustion chambers. Additionally, the ISP-1 programme provided data of a number of single element hot firing tests with different injector types for LOX-LCH4 injection performed on ONERA's MASCOTTE test bench to investigate in detail the combustion process in the near field of the injectors.

Astrium is presently conducting a R&T programme to extend its capabilities in combustion devices towards gas generators for liquid rocket engines. This strategic effort is supported by the German space agency DLR. In this context, a test campaign was performed to characterise potential injector configurations for the later application in a single-element setup (see Figure 2).

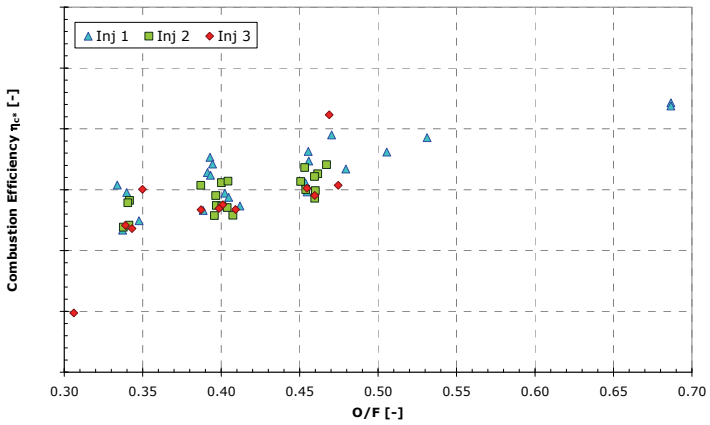

Figure 2: LOX-CH4 injector screening results: combustion efficiency

The tests were also used to record additional data on film cooling and to characterise different features of the envisaged full scale setup. The lessons learned during performing and analysing the different test campaigns were taken into account when defining the test program for the full scale gas generator, which is scheduled to be tested on the test bench P8 in Lampoldshausen in spring 2013. The tests with the full scale design of the gas generator will not only demonstrate the robustness of the chosen design and verify the requirements for a potential application, but will additionally be used to provide information on the effect of the chosen configuration on combustion stability, combustion efficiency and temperature stratification.
The full-length paper is going to give an overview over the different activities and is going to report on the results and their relevance future engine development programmes.