SPACE PROPULSION SYMPOSIUM (C4)
Propulsion System (2) (2)

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PROGRAM AHRES AND ITS CONTRIBUTION TO ASSESS FEATURES AND CURRENT LIMITATIONS OF HYBRID ROCKET PROPULSION

Abstract

In the year 2011 the German Aerospace Center (DLR) has started the program AHRES (Advanced Hybrid Rocket Engine Simulation) with the aim to develop software engineering tools and CFD tools for conceptual design and optimisation of hybrid rocket engines (HRE). To provide high accuracy software tools, the AHRES program includes complex experiments with hybrid rocket engines in laboratory and prototype scale, for pressures up to 70 bar. For this purpose an existing test facility at DLR test site Trauen (former EUROPA 2 upper stage test range) was enhanced, in order to conduct tests with HRE. In this paper a short description of the operational test bed is given, which is equipped with sophisticated measurement techniques, including pressure transducers, 3 dimensional force sensors, eroding thermocouples, a pyrometer, gas analysers and an ultrasonic regression rate measurement system. The HRE test bed is currently equipped with an oxidiser supply system for high test peroxide (HTP) and gaseous oxygen. The solid fuel grains are based on hydroxyl-terminated polybutadiene (HTPB) mixed with different metallic additives to improve performance. Currently conducted tests are aimed to characterise the HRE's combustion processes and to generate an experimental data base to develop above mentioned simulation tools. Simultaneously the data base enables the estimation of the engine's characteristic parameters (specific impulse, density impulse, characteristic velocity, coefficients of efficiency etc.).

The preliminary results and conclusions are presented, including specific impulse, combustion efficiency, temperatures, exhaust plume gas composition and achievable regression rate dependent on fuel composition. The last factor is of tremendous importance to determine the achievable thrust level of a hybrid rocket engine. This again, determines whether a HRE can be used as an upper stage or as a booster as well.

Based on experimental test data, calculations based on developed simulation tools and literature sources a comparison with solid and storable liquid rocket engines is made. To illustrate the possibility of HRE at present state of the art two design concepts are outlined and compared with existing solid rocket engines. The first concept is related to a suborbital sounding rocket for high altitude atmospheric research. The second concept is related to a HRE which could be applied as an upper stage. As example for comparison the third stage "Zefiro 9" of the VEGA launcher is taken. The results are presented graphically and in table form, analysed and commented.