Advanced Design Concepts for Ceramic Thrust Chamber Components of Rocket Engines

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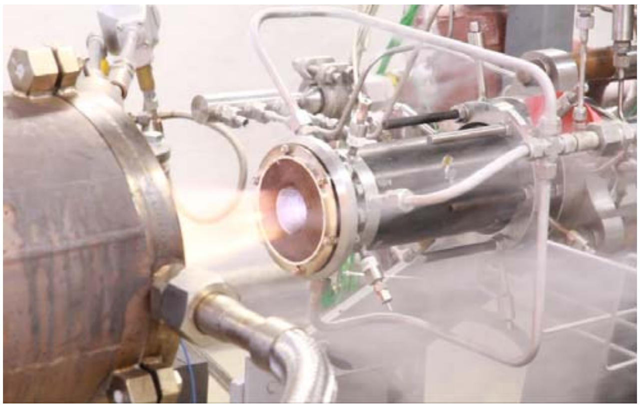
In the past DLR's development effort concerning Ceramic Matrix Composite (CMC) rocket thrust chambers was focused primarily on transpiration cooled inner liner structures. Latest empirical investigations in two firing test campaigns at the P6.1 research test bench at DLR Lampoldshausen in 2012 confirm expectations regarding efficient chamber operation using available thermo-mechanically resistant CMC materials. Damage free stable hot runs could be conducted applying coolant mass flow ratios down to 6.5 % related to the total chamber mass flow in model combustors with 50 mm of inner chamber diameter. Due to the high characteristic chamber length of about 1.8 m, and the favorable geometric scaling effects, a significant reduction of the required coolant mass flow ratio in full scale operation is to be expected.

Beyond the transpiration cooled engine process upcoming new design approaches open further application potentials of CMC's in such a field. Recent design options enable on the one hand the introduction of specific material skills into other process environments of rocket engines like regenerative and radiation cooled chamber structures and on the other hand they allow reasonable application scenarios of CMC's in injector components.



Cryogenic ignition test of the ceramic cone-injector component at the P6.1 test bench (November 2012).

Apart from the subsonic inner liner structure and the injector component, DLR currently develops lightweight materials for load carrying outer chamber structures as well as mechanical joining methods of fiber reinforced high performance structures. In 2010 the use of a chamber housing made of carbon fiber reinforced plastics (CFRP) could be demonstrated as well as a suitable interface method for joining CFRP and Metal structures in cryogenic and high pressure environments. To complete the feasibility demonstration of continuously integrated CMC rocket thrust chamber designs finally the combination of the subsonic CMC chamber section and wrapped CMC nozzle extensions will be investigated in the near future. In conjunction with this challenge new and efficient joining methods will be the focus of future research.

The paper will give an overview of current works and results, targeting new application potentials of CMC structures in rocket thrust chambers as the latest consequence of DLR’s development effort on this field.