Paper ID: 25991
poster

SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Technology (1) (3)

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STATUS AND FUTURE PERSPECTIVES OF THE CMC ROCKET THRUST CHAMBER DEVELOPMENT AT DLR

Abstract

DLR offers within its Black Engine program a large portfolio of fiber reinforced structure systems for functional components in rocket thrust chambers. These new material classes show high application potential for several space propulsion systems, e.g. orbital space propulsion or high performance rocket engines. Load carrying structures made of CFRP are of high interest focusing on high performance engines. They are promising future design candidates because of their general weight reduction potential accompanied by high material strength. Up to now the CFRP load shell structures, used in representative tests, could be proved as cryogenic hydrogen tight with regard to typical test bench requirements. CMC materials stand in the major focal point. Firstly they are highly applicable as hot structures for inner liners in the subsonic combustion chamber component. Secondly they can be used for self-sustaining structures for supersonic nozzle extensions. Beside this typical target courses they also can be used in the injector component. Within relatively easy manufacturing processes highly sophisticated channel patterns can be applied in CMC injector elements. Apart from this constructive property the CMC design is very interesting with regard to requirements due to fabrication tolerances. Naturally CMC injector elements are suited for hot injection as well as for cold injection. At the end of 2013 first hot gas tests with a new ceramic injector design could be performed successfully at DLR's P6.1 technology test bench. A lot of CMC material development effort in the last years led to specific material selections in terms of thermo-chemical resistance under the ambitious hot gas conditions in high performance LOX/LH2 operation. Beside multiple numerical works concerning cooling methods extensive test campaigns have been conducted at DLR's P8 and P6.1 test facilities. Principal goals could be reached: High efficient hot gas operation of transpiration cooled inner CMC liners in subscale LOX/LH2 demonstrators (90 bars) compared under scaling aspects to standard thrust chambers; Damage free operation under relevant hot gas conditions; Structurally reliable light weight design showing high ratio of thermal and mechanical load de-coupling. In matters of cooling principles all standard methods seem to be interesting in conjunction with the CMC technology. Apart from the excellently working transpiration cooling, first evaluations are ongoing considering regenerative cooled CMC wall structures, but also radiative and film cooled systems targeting on the 500 N apogee motor classes, combined with new structural design approaches, show promising perspectives for future applications.