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ADVANCEMENT OF ROCKET ENGINE PERFORMANCE THROUGH NOVEL APPROACHES FOR THRUST CHAMBER DESIGN

Abstract

The long lasting effort of the German Aerospace Center DLR in developing transpiration cooled thrust chambers made from ceramic matrix composites (CMC), lead to novel approaches for designing the thrust chamber. A first innovation is a novel contour geometry, which is predicted to provide desirable properties in terms of peak heat flux and total heat load. Other innovation relate to the wall design and material. There approaches promise advantages in the following areas: a) Film cooled orbital propulsion. The reduction of the peak heat flux reduces the necessary extend of film cooling and thus leads to a significant increase of the specific impulse and/or life time of the engine. b) Expander cycle engines. The increase of the total heat flux at equal surface areas / thrust chamber volumes enables shorter thrust chambers. This allows for a reduced stage weight. c) Classical gas generator engines. Using the new chamber contour, wall design and materials, the pressure loss caused by chamber cooling does not exist anymore. This seems to be the most significant improvement of the new design approach. In conjunction with thermally safe inner wall surfaces, the latter allows for a high redundancy in terms of heat exchange management. In case of liquid oxygen / methane operation for instance, the potential of cost reduction is enhanced, because the engine efficiency does not depend on extremely clean methane. Liquid natural gas will not significantly affect the engine performance by decreased heat exchange management, caused by lower fuel quality. Additionally, several thermo-physical monitoring systems inside the hot gas plenum can simultaneously be operated safely, because the inner wall surface will not see any critical temperatures. Such improvements could make CMC high performance rocket thrust chambers exceptionally attractive regarding a future growing market of governmental as well as private commercial space transportation.