"Technology Status of Fuel Cooled Ceramic Matrix Composites for Dual-Mode Ramjet (DMR) and Liquid Rocket Engine (LRE) Applications"

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Advanced fuel cooled structures have been studied worldwide for application to heat exchangers, high speed vehicles, dual-mode ramjets and liquid rocket engines. Especially the heat exchanger of a dual-mode ramjet with integrated fuel injection strut design, wing leading edges and the air intake reach temperatures which require high temperature materials with outstanding properties and lightweight design concepts to withstanding the requirements. Using Ceramic Matrix Composites (CMC´s) a benefit of 30% in weight compared to metallic structures was analyzed for dual-mode ramjet. Additional heat transfer analysis to determine maximum wall temperatures and cooling temperatures were performed using CFX and ROCFLAM calculation in addition to other computational methods previously used.

The benefit to use fuel cooled ceramic composites is under investigation for nozzle extensions of liquid rocket engines. Lower coolant mass flow, lightweight structures and a new nozzle design approach based on a dual-bell contour makes the CMC´s interesting. By the use of hydrogen as coolant a gastight outer shell of the nozzle is demanded. Astrium use their adapted galvanic plating process for the metallization of the composite to guarantee no hydrogen leakage.

MBDA France, Astrium Space Transportation and EADS Innovation Works have been working on the development of a particular technology for such structures taking advantage of the background of MBDA France in the field of dual-mode ramjet and fuel-cooled structures and of Astrium Space Transportation in the field of high temperature composite materials for liquid rocket engines. This generic monobloc technology is called "PTAH-SOCAR". They have developed an innovative technology for fuel cooled ceramic structures based on Astrium´s CARBOTEX® (r-CVI/LSI 3D C/C-SiC) and SICARBON® (PIP 2D C/SiC) material and process technique to manufacture the heat exchanger with integrated fuel injection struts and for the nozzle extension inner wall. Ultra-High-Temperature Coatings (UHTC´s) for extreme temperature areas are under development at EADS Innovation Works.