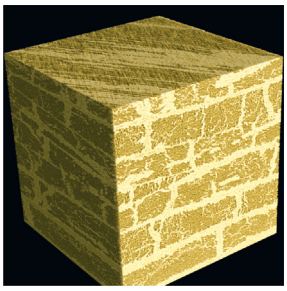
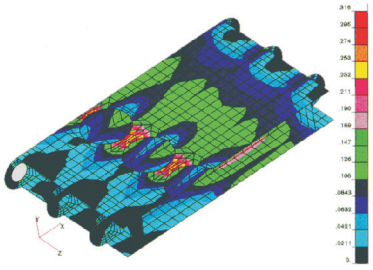
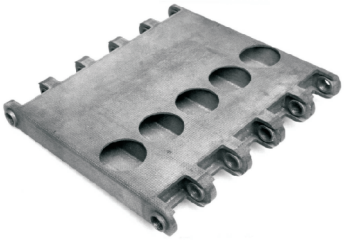
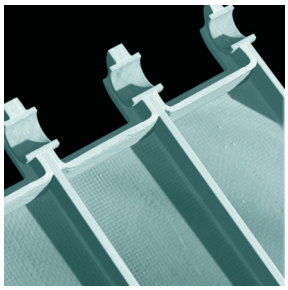
Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Ceramic Composite Structures









CMC process chain - From the material to the component:
- Materials (3D CT of a typical C/C-SiC microstructure)
- FEM analysis (C/C-SiC intake ramp)
- Prototype (265 x 265 x 35 mm³)
- Quality assurance (CT of joining area)

In the department „Ceramic Composite Structures" fibre reinforced ceramic materials as well as lightweight CMC (Ceramic Matrix Composite) structures for extreme applications have been developed since the late 1980`s. The complete process chain is available: Material and process development, design and analysis, the manufacture of structural parts in original geometry, as well as destructive and non-destructive testing and qualification.

Fibre reinforced ceramics are a new class of materials which combine the well known, superior properties of monolithic ceramics, like high temperature and chemical resistance, hardness and wear resistance, with very uncommon qualities like extreme thermal shock resistance, damage tolerance and quasi-ductile fracture behaviour.

At the Institute of Structures and Design, CMC materials were originally developed for thermal protection systems of reusable spacecraft. These so-called C/C-SiC materials are manufactured via the LSI (Liquid Silicon Infiltration) process, also developed at the Institute.

Compared to the conventional CMC production processes, like CVI (Chemical Vapour Infiltration) and LPI / PIP (Liquid Polymer Infiltration / Polymer Infiltration and Pyrolysis), the LSI process offers both, technological and economic advantages and opened new application areas for CMC materials beyond aerospace. As an example, ceramic brake disks for automobiles, could be introduced into serial production and currently are available in several sports and upper class cars.

Innovative C/C-SiC parts have been developed in governmentally funded projects as well as in direct cooperation with industrial partners. Successful developments are transferred and licensed to industrial manufacturers. One example for a successful technology transfer are brake pads for high speed elevators, developed in cooperation with Schindler Elevator Ltd., which are now produced by FCT Ingenieurkeramik GmbH.

Substantial experience is on hand in the following areas:

- Light weight thermal protection systems for reusable space vehicles
- Friction materials and components for automotive and mechanical engineering applications
- Thermally stable and highly stiff structures for optical systems and measuring devices
- Rocket components for extreme thermal and abrasive loads
- High temperature heat exchangers for power generation
- Lightweight armour systems based on biomorphic SiSiC materials
- Technology transfer of successful developments into serial production

Current research in CMC technology is focused on:

- Novel CMC materials on the basis of high temperature stable fibres.
- Novel manufacturing methods for CFRP preforms (filament winding)
- Complex CMC structures
- Quality assurance (CT) and non destructive evaluation (NDE)
- Simulation (FEM, Effects of Defects)

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