Thin walled and light weight all oxide ceramic matrix composites (OCMC) structures as substitute for sheet metals

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Introduction

• Material basics
• Production process
• Why using OCMC instead of metal
• Structures under extreme thermo-shock
• Tubular systems with better strength and better insulating properties
• Light weight structures for unmanned aerial vehicles
• Summary
Material basics from textil based OCMC‘s produced by WPS

Fabrics and braided sleevings made of
➢ 3M™ Nextel™ 610, 3M™ Nextel™ 720
➢ Nitivy
➢ Silica

Waterbased slurry made of
➢ Binder powder: system Al₂O₃ - SiO₂ - ZrO₂
➢ Filling powder: system Al₂O₃ - SiO₂
Processing of OCMC‘s at WPS

- Ceramic fiber fabric
- Powder Al₂O₃/ZrO₂
- Water with organic binder

Desizing \rightarrow Slurry production

Slurry infiltration with knife blade coating

- Laminating on moulds
- Drying at 70-100°C
- Demoulding
- Sintering at 1200°C

Machining and finishing

Standard Layup with 3M™ Nextel™ 610 fabric type DF11

Slurry infiltration by hand with knife blade coating
Why using OCMC instead of metal?

- Fracture due to thermal gradient and high thermal expansion
- Deformation due to thermal gradient and high thermal expansion
- High temperature corrosion / scaling

- Life time is more than factor 10 of metal parts
- Lower thermal expansion (50% of steel) reduces stresses in the structure
Material characteristics from sliding carriage loaded with metal test pieces after extreme thermo-shock cycles

Dimensions:
Length: 345mm
Width: 274mm

Thermo-shock cycles:
RT to 1000-1140 °C
Heating by moving the sliding carriage into the hot furnace.
Dwell time: 1 hour
Cooling like heating
Sliding carriage after 8000 cycles extrem thermo-shock

Deformations are seen, but these are no problem for the operation of this sliding carriage.
Bending strength after extrem thermo-shock

Bending test of as produced samples
0 hours / cycles

Bending test after 8600 hours / cycles
Tensile strength of metal and OCMC at high temperatures

![Graph showing tensile strength at high temperatures for different materials.](image-url)
Tubular systems for chemical plant construction

➢ Fabric based OCMC for straight tubes
➢ Braided sleeving based OCMC for curved tubes

Tubular systems in one piece are possible
Good insulating material with a low thermal conductivity and a low emissivity

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Thermal conductivity [W/mK]</th>
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<tbody>
<tr>
<td>300</td>
<td>3.8</td>
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<tr>
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<td>900</td>
<td>2.3</td>
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<tr>
<td>1100</td>
<td>2.02</td>
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Extremely complex exhaust manifold for a racing car for the Formula Student „Bodensee Racing Team“ Constance
Light weight structures for unmanned aerial vehicles (1)

- Low density 2.8 g/cm³ compared to metal with a density of 7.8 g/cm³
- Thin-walled structure with a wall thickness of about 1.5mm
- Large self supporting structures are possible
Light weight structures for unmanned aerial vehicles (2)

➢ Large self supporting and moving structures are possible
➢ The weight of the small metal swivels is in the same range than the thrusters and the tube.
Summary

- Due to lower thermal expansion than steel, cracks and deformation can be avoided.
- Due to thin wall thickness and low thermal expansion a good thermo-shock resistance is reachable.
- OCMC has higher tensile strength than standard high temperature steel.
- For some applications the good low thermal conductivity is helpful.
- Due to the possibility to produce thin wall thicknesses and due to the low density of OCMC, ultra-lightweight structures for flying vehicles are possible.
Thanks for your attention

Solar absorber D=2.5m H=2.5m