Project title:	OFC: Oxide ceramic fibre composites with three-dimensional reinforcement architecture	
Partners:	CME (Ceramic Materials Engineering of Bayreuth University), ITA (Institut für Textiltechnik der RWTH Aachen University)	
Term:	04/2015 – 04/2019	
Funding agencies:	DFG (German Research Foundation)	

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28.09.2018

Mission Statement

Structural materials such as oxide fibre composites (OFC) are increasingly used in energy conversion, transportation and metallurgy due to their high operating temperatures of over 1000°C, their chemical resistance and inherent oxidation stability. Due to their low density of less than 3 g/cm³ and their mass-specific mechanical properties, which are higher than those of metallic super alloys, they are ideally suited as lightweight construction materials for demanding tasks. A major challenge so far has been the setting of damage-tolerant fracture behavior.

Solution

The project comprises the development of oxide fiber composite ceramics with improved mechanical properties through a specifically adapted matrix design and a load-compliant three-dimensional reinforcement structure. The production of a three dimensional structure with locally almost arbitrary fiber orientation on a 3D braid. In this context, research is being carried out into the generation of fracture toughness and fault-tolerant material behavior using the concept of the porous matrix. Porosity is achieved by the freeze-casting process, where the pores are formed by the growth of ice crystals. Since the porosity of the matrix reduces the mechanical properties, the present research project aims to eliminate this disadvantage on the one hand by a load-compliant three-dimensional reinforcement structure and on the other hand by a specifically adapted matrix design. If successful, an oxide fibre composite material will be available for the first time that can be used in gas turbines, heat exchangers or in medical technology (see Fig. 1). The production of suitable three-dimensional structures with locally almost arbitrary fiber orientation is only possible on a 3D braider. However, fiber damage occurs due to the process. Another goal is to realize a 3D braided structure with oxidic fibers for the first time.

Fig. 1: OFC component manufactured using the freeze-casting process

The focus here is on the adaptation of 3D braiding for processing extremely brittle ceramic fibres. For the 3D rotary braid, new clappers are being developed which are suitable for processing brittle ceramic oxide fibres. The clappers are designed, developed and tested on the basis of tribological investigations of the fibres. At the same time, a 3D-OFC production route for ceramic materials (CME) is being developed at the University of Bayreuth. The infiltration of the fiber preforms with ceramic slurries, as well as the supply of a matrix systems. As soon as they are available, 3D braided preforms with a new clapper concept will be produced at the Institute for Textile Technology (ITA) of the RWTH Aachen University and processed at the CME. In the final stage, material parameters for the newly developed, 3D long-fibre-reinforced oxide composite ceramic are determined and compared with fabric-reinforced OFC, variants with round braids as fibre reinforcement and with the state of the art. All in all, this work provides important concepts and findings in fiber processing and production of OFC.

Acknowledgement

The Institut für Textiltechnik (ITA) of the RWTH Aachen thanks the German Research Foundation DFG for the financing of this project and our partner the Ceramic Materials Engineering of Bayreuth University (CME) of the University of Bayreuth for their support.

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