Project Title:	*Joint Project:* **3DOxOxTurbine** - Increase of energy efficiency and environmental compatibility of stationary gas turbines through the use of 3D braided oxide ceramic matrix composites *Sub-Project:* **Development of pressure-castable 3D braided Al_2O_3 reinforcement textiles**	
Consortium:	▪ Lippert GmbH & Co. KG ▪ Industriekeramik Hochrhein GmbH ▪ B&B AGEMA Gesellschaft für energietechnische Maschinen und Anlagen Aachen GmbH	
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Mission Statement

A key element for the successful implementation of the energy turnaround lies in the transformation of the German power plant fleet, which is dominated by fossil fuels, towards sustainable energy production from renewable energy sources. Gas turbine power plants can contribute to this, as their high degree of flexibility ensures that the base load supply is secured in the event of weather-related fluctuations in renewable energy sources. An increase in efficiency and reduction of exhaust gas emissions, especially the minimisation of CO_2 emissions, is possible through the use of new turbine materials. 3D fibre-reinforced oxide ceramics offer great potential for turbine application. Thanks to their high oxidative resistance in combination with outstanding structural-mechanical properties at high temperatures, 3D-braided ceramic matrix composites (CMC) can increase the performance of thermal processes. This enables the development of new generations of turbines, so that efficiency-enhanced and low-maintenance turbines fired with synthesis gases (e.g. renewable hydrogen and biogas) can be used for energy conversion.

The 3DOxOxTurbine research project comprises the development of a 3D-braided $Al_2O_{3(f)}/Al_2O_3$-CMC and the necessary manufacturing technology for the production of corresponding composites. The performance-enhancing potential of the new material for turbine applications is determined on the basis of material parameters by means of comparative structural analyses and process simulation. For this purpose, the material characteristics are determined in mechanical short-term tests at high temperatures and in tests to determine thermophysical properties. In order to demonstrate the industrial application of the new material, the project concludes with the production of a demonstrator turbine component, such as a combustion chamber lining or a turbine blade.

Approach

The project will implement the development of a suitable pressure casting slip based on alumina (Al_2O_3) for the production of 3D-braided CMC. In parallel, the development of suitable forming tools for the production of CMC green parts will be carried out. The testing of machine concepts is initially based on the production of simple, 2D-fibre-reinforced CMC geometries and flows iteratively into the development of complex forming tools for the production of 3D-braided CMC.

Braiding parameters are determined for the production of the required 3D-braided alumina fibre-reinforcements. These allow the near net shape production of 3D-textiles, which are used for the reinforcement of corresponding demonstrator components. In order to achieve the homogeneous and fibre-friendly impregnation of the textiles within the pressure slip casting process, the influence of the textile porosity on the flow resistance of the 3D-braids during impregnation is investigated. For this purpose, a degenerable distribution medium is introduced into the braids to increase the porosity of the textiles.

With the help of the developed composite components, 3D-braided CMCs are formed using the pressure slip casting process. The hardened ceramic matrix composite is then examined for its mechanical and thermophysical properties.

The determined material characteristics are incorporated into the development of a structural-mechanical model of the 3D-braided CMC. In addition, the characteristics are used to calculate the performance of the gas turbine process when using 3D-braided CMC in the hot gas section.

Finally, the aim of the project will be achieved by manufacturing a complex demonstrator in the form of a hot-gas turbine element and the evaluation of the developed 3D-braided CMC with regard to its future use in gas turbine applications.

[Source: ITA | RWTH Aachen University]

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