Machining of ceramic matrix composites for jet engines

Ceramic Matrix Composites (CMC) are lightweight construction ceramics characterized by high temperature stability and low density. In contrast to conventional monolithic ceramics, CMC have a quasi-ductile and damage-tolerant fracture behaviour under tensile loading. Due to the excellent mechanical and chemical properties of CMC, they are of great interest for the turbomachinery industry. Innovative components for new jet engines are intended to be made from CMC for greater efficiency, low emissions and weight reduction.

In contrast to finishing processes of monolithic ceramics, there is only a few and sometimes contradictory knowledge regarding the machining technologies for CMC. The production of a high-quality finished surface without breaking out entire material areas and uncovering inherent porosity represents a challenge. With the aim of increasing the productivity and quality of CMC machining processes, the Fraunhofer Institute for Production Systems and Design Technology IPK/DE focuses on the development of innovative grinding and milling processes, new cutting tools, peripheral clamping devices and quantification methods for machined CMC workpieces. Optimised tools and process parameters result in favourable tool wear mechanisms. As a result, workpieces with high surface integrity can be realized with reduced tool wear rates.

Current investigations at Fraunhofer IPK show that an economical and high-quality way of machining complex CMC components can be achieved by combining NC-form grinding and milling processes. NC-form grinding with sinter-metallic and electroplated diamond mounted points for drilling and contour machining of CMC components show low radial wear rates. Even at high material removal rates no critical damage on the ground specimens is detected. By using an oscillation stroke strategy additionally low tolerance deviations and high surface quality can be achieved.

For subsequent milling Polycrystalline Diamond (PCD) tools are used allowing for high feed rates. This implies a great potential for CMC machining. Furthermore, Fraunhofer IPK is currently working on the adaptation of milling technologies and strategies used for Carbon-Fibre-Reinforced Polymer (CFRP), such as ultrasonic machining and 5-axis simultaneous milling, to transfer them to CMC machining processes.