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Abrasive machining of advanced technical ceramics

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Abstract – The high cost of ceramic components can be associated with complex and time-consuming postmachining, which is currently done by using abrasive machining processes. The IWF and Fraunhofer-IPK are undertaking research activities in the field of abrasive machining which aim at developing and optimizing technologies to expand the application field and to increase productivity of high-performance materials. This article gives an overview of innovative grinding concepts such as Speed-Stroke Grinding, Double Face Grinding with Planetary Kinematics and Abrasive Flow Machining. These processes have shown significant potential for the efficient machining of advanced technical ceramics. Additionally, examples of numerical simulations of abrasive processes are given.

Advanced technical ceramics are already being produced for rolling and sliding bearings, brake disks and medical implants. For machining and finishing of functional surfaces on these components, there are various technologies employed. Due to their high hardness and wear resistance, these materials can only be machined using abrasive tools with diamond grains. Requirements such as high quality of components and low production costs make the development, selection and optimization of finishing processes for the machining of advanced ceramics difficult.

High-Speed and High-Performance Double Face Grinding with Planetary Kinematics is an example of an innovative abrasive machining process for advanced ceramic components. The procedure of Double Face Grinding particularly distinguishes itself by the very precise fabrication of plane-parallel functional areas economically [1]. Recent investigations have shown that optimal cutting conditions for advanced ceramics could be achieved by increasing the cutting speed. **Figure 1** emphasises that in comparison with conventional machine systems a reduction of machining time by more than 80% could be realised by applying the Double Face Grinding with Planetary Kinematics of carbon fiber reinforced silicon carbide (C-SiC). This material is used for the fabrication of carbon-ceramic clutch plates. Remarkable features of the analysed components consist in excellent plane-parallelisms, even surface profiles and low tolerances refering to the dimensional accuracy.

Another innovative abrasive machining technology is Speed-Stroke Grinding. This process has shown a high potential when in terms of reducing manufacturing costs which results from the considerably improved performance of the machine tool system in combination with an improved process analysis. With a table speed up to v_{ft} = 50 m/min a low depth of cut at a high material removal rate could be detected. As shown in **Figure 2**, it is now possible, to reach a feed rate of more than 150 m/min, to significantly decrease the specific grinding energy (e_c) [2].

Abrasive Flow Machining (AFM) is a unique machining method to produce a high surface quality on inner contours or outside edges that are difficult to access. Moreover this processing technology is appropriate to create defined edge rounding on workpieces. The tool being applied for AFM of advanced ceramic materials is a fluid consisting of a polymer carrying superabrasive grains. Through the development of a process model, it is possible to anticipate results of complex-shaped workpiece geometries using Computational Fluid Dynamics (CFD) Simulation.

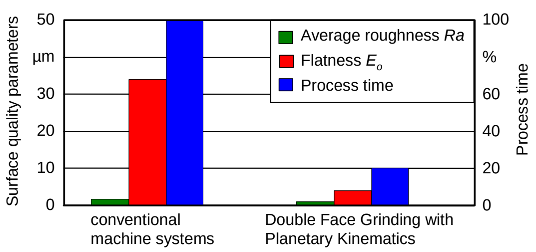

Figure 1: Double Face Grinding with Planetary Kinematics for the machining of C-SiC in comparison to the conventional face grinding.

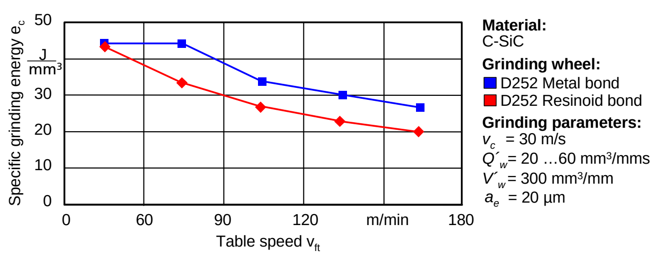

Figure 2: Influence of the feed rate on the specific grinding energy during speed stroke grinding of C-SiC with grinding wheels with different bonds systems.

[1] Uhlmann, E.; Ardelt, T.: Influence of Kinematics on the Face Grinding Process on Lapping Machines. Annals of the CIRP 48/1 (1999), S. 281-284.
[2] Sammler, C.; Uhlmann, E.: Einsatzpotenzial innovativer Hochleistungsschleifprozesse. Berliner Industriearbeitskreis Fertigungstechnik und Werkzeugmaschinen, Tagungsband, PTZ 2009.