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Machining for highest quality of CFRP and Inconel components

Optimizing the production of CFRP parts

For many years, lightweight construction has been a major topic in aerospace and other industries in order to reduce the weight of structural components and with it the fuel consumption while maintaining strength and rigidity. Carbon fiber reinforced polymer (CFRP) is primarily used for this purpose – often as a composite with conventional metallic materials, which is referred to as a stack.

CFRP components are often more difficult to machine than all-metallic workpieces, for example, because the process chains are not yet as efficient and robust as for other material classes. In particular finishing, such as cutting components to size or drilling holes, poses a challenge when processing these materials. In addition to component damage such as fraying, delamination or splintering, which impair the quality of the products, the tools are subject to considerable wear and tear, which limits the profitability of production and therefore of the products. Effectively, there is considerable potential for improvements in terms of quality and safety as well as efficiency and profitability.

Aviation-certified CFRP and aluminum
with cutout of an aircraft cabin window

Competence

With the FiberCut Initiative, the Institute of Production Engineering and Photonic Technologies (IFT) of TU Wien has set itself the goal to acquire sound basic knowledge in the field of CFRP machining and know-how in the practical execution of finishing operations. In collaboration with a broad partner consortium ranging from raw material, component and tool manufacturers to machine manufacturers, knowledge and skills have been acquired that contribute to improvements in the process chain.

Within the scope of regular tool benchmark tests, market-leading products and innovations of the tool manufacturers are compared in confidential practical tests. These tests are scientifically sound and agreed with the manufacturers, each company being eligible to participate. In an anonymous ranking, the tools are objectively assessed and ranked according to their achieved component quality. The respective category winners are awarded. For this purpose, a quality index was developed in cooperation with the tool manufacturers that takes into account the various damage mechanisms of delamination, fraying and splintering.

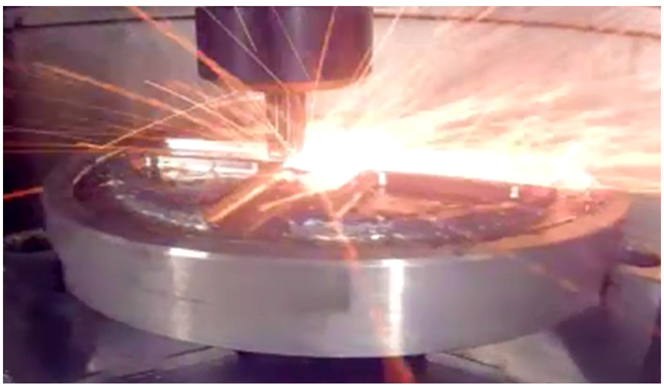
High-speed machining of Ni-based alloys

New high-performance materials are increasingly being used in application areas of modern mechanical engineering where conventional materials reach the limits of their capabilities. The aerospace industry uses corrosion-, highly heat-resistant materials such as titanium and nickel-based alloys in the high-temperature range of engines. The properties of titanium and nickel-based materials – low thermal conductivity, low modulus of elasticity and high tensile and high-temperature strength and hardness – place high demands on manufacturing and on machining technologies. Currently, in particular the material Inconel 718 is rapidly attracting increasing attention, e.g. in the construction of turbine engines.

Competence

The IFT is intensively involved with these new materials and the selection of the right machining strategy, the right tools and the optimum cutting parameters for specific products.

A particular focus is on the machining of nickel-based alloys with ceramic end milling tools, with the first ceramic end milling tools not being available on the market until around 2011-2012. They are characterized by high heat resistance and the ability to reach their optimum operating temperature at high temperatures. In principle, this type of tool may increase productivity by a factor of 5 to 10.



High-speed machining of Inconel 718
Precision part with sophisticated geometry – one sector after finishing operation

Important findings

The machining processes that work with ceramic end milling tools generate a high self-induced machining heat, which leads to a local and partial softening of the material structure in the vicinity of the tool cutting edge. And with a softer structure the tool encounters a lower machining force. The material changes in this workpiece edge zone were investigated in microstructural examinations. It was found that, despite the high thermal load, a significant structural change only extends up to a maximum of 75 µm into the workpiece edge zone. This damaged surface layer is removed by a subsequent finishing process with small removal rates.

Your benefits

TU Wien has more than 40 years of experience with innovations in the field of machine tools and machining. The findings from a large number of scientific projects and cooperation enable highly competent consulting and efficient implementation of innovations. TU Wien supports and offers you:

- comprehensive improvement of individual manufacturing processes – with multidimensional objectives
- optimization of the entire production chain taking into account machining processes, logistics, energy consumption and operational efficiency
- access to a diverse network of experienced tool and machine manufacturers
- trustful and efficient cooperation
- rapid implementation of your innovation idea

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