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ta-C COATED MACHINING TOOLS FOR CFC AND GFC COMPOSITE MATERIALS

THE TASK

Through the rapid technological development and the influence of international competition, an increasingly more cost-effective production with increasingly more demanding materials can be observed in the field of machining. In particular, in the area of lightweight construction materials and plastics, increasingly difficult to machine materials such as glass and carbon fiber composites (GFC and CFC) are being developed. The machining of laminates, consisting, for example, of GFC, CFC and card-board or metal poses a special challenge in that the tool is subjected to quickly alternating processing conditions.

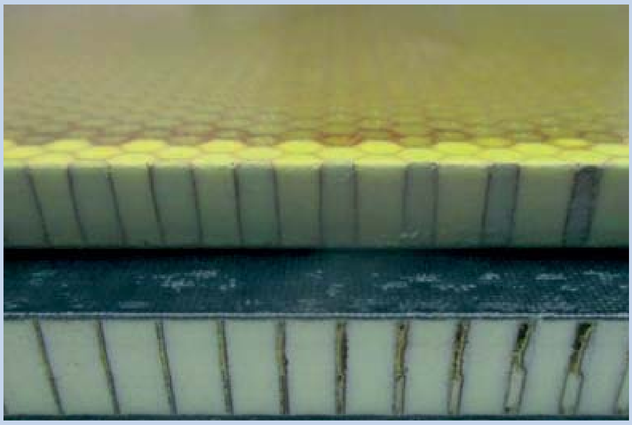
In order to cope with these demands, machining tools must always be improved. The key for that is in an appropriate surface functionalization of the tools, through a PVD coating for example. Among PVD layers, the classic TiN and the newer TiAlN and TiCN coatings are commonly used.

Applications with highly abrasive cutting edge wear are increasingly relying on crystalline or nanocrystalline CVD diamond coatings. Next to the comparatively high costs compared to PVD coatings, the high coating temperatures in the CVD process and the often observed leaching of cobalt from the hard metal substrate presents disadvantages for this coating.

OUR SOLUTION

A more affordable alternative to diamond coatings are superhard tetrahedral amorphous carbon coatings (ta-C). Their production succeeds with the Laser-Arc process at temperatures under 150 °C and is therefore suited to more applications than just coating hard metal tools. With hardnesses of up to 70 GPa, ta-C coatings nearly reach the hardness of nanocrystalline diamond coatings. This results in an unusually high resistance to abrasive wear, above all in the machining of challenging composite materials. At the same time, the carbon surface reduces adhesion of material and causes very low friction between the tool edge and the cutting chips. The combination of hardness and low friction provides ta-C coatings with a special advantage for the processing of composite materials.

Milled sandwich plate with honeycomb core comprising a honeycomb core with GFC or CFC skins



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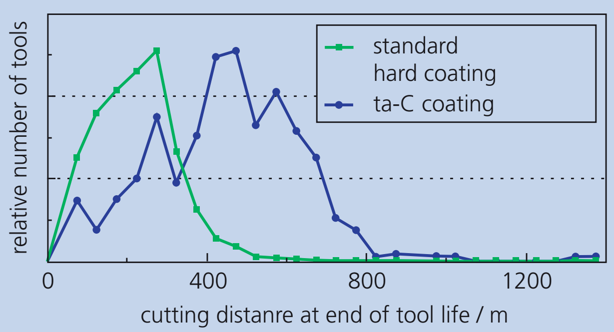
RESULTS

For machining tests in real manufacturing environments of clients, 340 hard metal multi-tooth milling tools with a diameter of 6 mm and an approximately 1.2 µm thick ta-C coating were provided (Fig. 3). The coating was deposited with the Fraunhofer IWS-developed filtered Laser-Arc technology. A 0.1 µm thick chromium film served as an adhesion promoting layer. The hardness of the ta-C coating amounted to approximately 67 GPa. The sandwich plates to be worked on consisted of a honeycomb core with GFC or CFC skins (see Fig. 2). The results of the large-scale trial are summarized in Figure 4, which plots the achieved cutting distance at the end of the tool life.

Results of the large-scale machining trial with standard hard coating and ta-C coating in comparison



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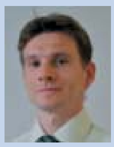
The very heterogeneous machining tasks (different sheet types, different milling jobs and menus, …) led to very different tool lifetimes. Clear effects of the influence of the tool coating appear therefore only after a large number of trials. While 2430 tools with hard coatings were tested, the diagram in Figure 4 reflects data for just 340 ta-C coated tools, which is why the ta-C results are somewhat scattered. Despite that, a prolonging of the average tool lifetime is clearly noticeable. The average cutting distance increases from 177 m (standard) to 412 m with ta-C coated tools. This is equivalent to an improvement of 132 percent.

Encouraged by these positive results, a further large-scale test of a complete monthly production volume exclusively with ta-C coated tools was subsequently carried out. In this test with approximately 1000 tools, the tool lifetime was increased by a factor of 2.4. The production was subsequently converted to using ta-C coated tools.

1 PVD system with Laser-Arc module for ta-C coating of tools

3 Hard metal multi-tooth milling tools, coated with ta-C

CONTACT



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