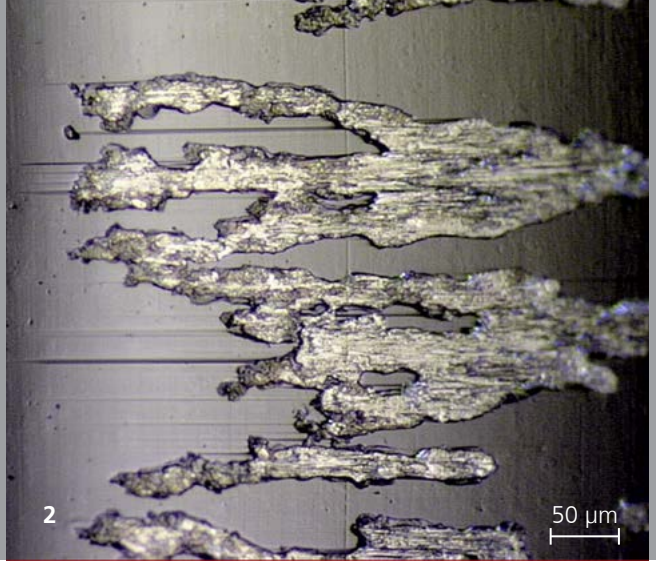
1



2

DLC COATINGS FOR FORMING

Coatings of amorphous hydrocarbons (a-C:H), also known as diamond-like carbon coatings, (DLC) are outstandingly suited for the low-lubricant forming of metals, and here due to their low adhesion tendency, in particular for the forming of aluminum. However, due to their incredible hardness and minimal layer thickness, they are also more susceptible to damage. In the AiF Cornet project "Development of DLC-based duplex coatings for highly loaded forming tools" at the Fraunhofer IST a combination of nitriding and DLC coating is used to increase the resistance of the DLC coatings, particularly on tools. In this regard, particular emphasis is placed on adapting the procedure to tools with a complex shape. The project is undertaken in cooperation with the Centre de Recherches Métallurgiques in Belgium.

Resistant but demanding – DLC coatings on tools

With hardness of up to approx. 2000 HV, DLC coatings offer significantly higher resistance against abrasive wear than does hardened tool steel (approx. 800 HV). The low coefficient of friction of approx. 0.1 – unlubricated under standard conditions against steel – in addition enables use in friction pairings that are either minimally lubricated or not lubricated at all. However the incredible hardness also makes them more susceptible to damage prone to the so-called eggshell effect. This means that local overloads result in excessive punctiform tension stress of the coating and of the underlying material. The consequence is a collapse of the maximum 5 µm thick DLC coating into what is usually the significantly softer base material.

For the coating of tools the existing radii and edges pose a special challenge, since the quality of the precipitating coatings is considerably influenced by the geometry. Under real implementation conditions rarely do the nominal load conditions pose the greatest challenge in ideal operation. But rather it is the irregularities in operation, such as misalignment or contamination that generate the cited punctiform loads and thus cause fatal coating damage.

Support effect through case hardening

One possibility of avoiding the coating damage is to intensify the support effect of the steel material underneath the coating through case hardening, for example. Therefore, in the project described the tool surface was plasma-nitrided prior to actual coating, and thus resistance to plastic deformation was increased. At a thickness of up to 1 mm, the edge zone of the steel hardened in this manner to 1400 HV, reduces susceptibility to the eggshell effect. This result is a significant improvement of coating adhesion and the resistance to punctiform-overload on all steels. Different test methods, such as the scratch test or an impact endurance test, confirmed the results.

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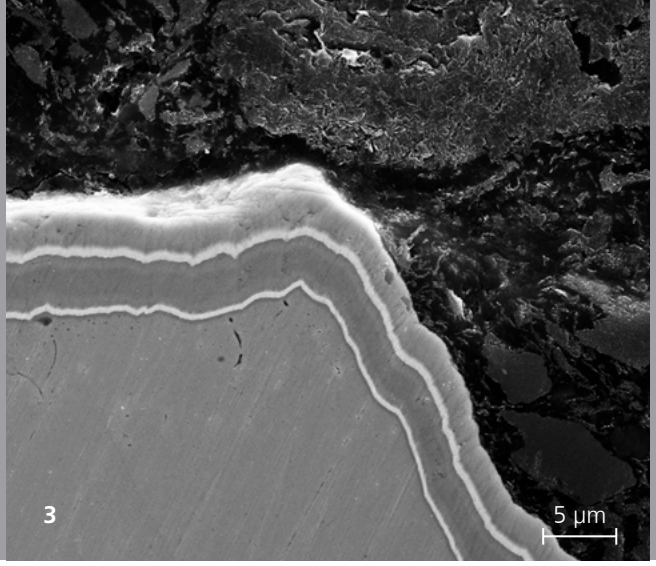

1 *Forming processes (here: clinching) subject tools to high stresses.*

2 *Local peak loads result in spalling of the coating.*

3 *Precision nitriding and coating on contours is a basic prerequisite for tools that can withstand high stresses.*

In the further course of the project the steels most frequently used in forming tools were systematically tested for their suitability and the specific needs for this process. Their specific compositions and morphological properties essentially determine the nitriding result and the behavior of the coating under load.

Outlook

In collaboration with the companies in the project-accompanying committee and the Belgian cooperation partner, in the forthcoming phase of the project the results should be transferred to tools in industrial use. In this regard the tools made available with adapted combination processes will be treated and tested under real implementation conditions. First and foremost the complex application situations often require a high level of stressability, particularly in the function areas of the tools. Moreover the complex shapes of their surfaces pose a technical coating challenge, since curved surfaces, radii, edges, and depressions influence the nitriding and coating results.

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