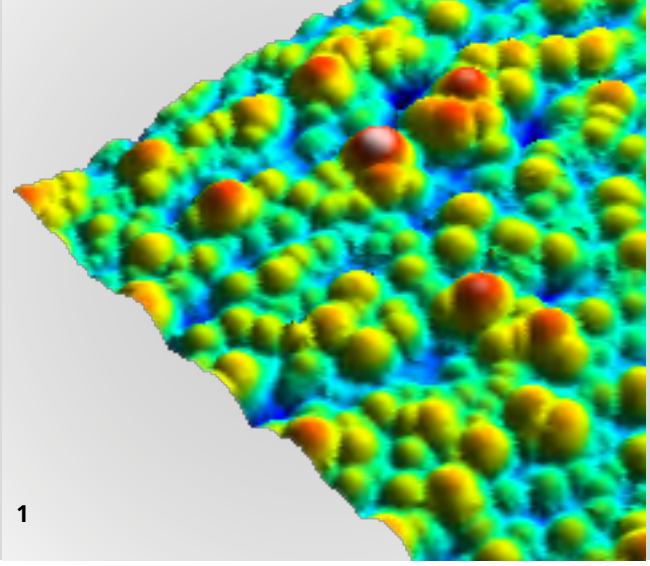

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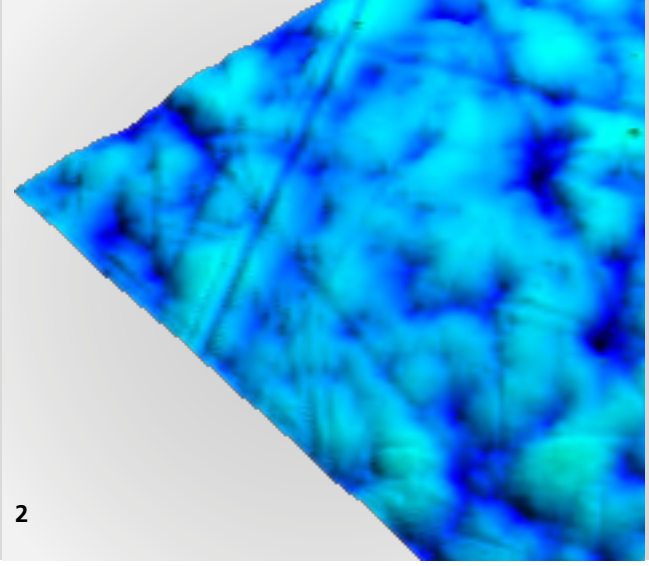

2

LUBRICANT-FREE COLD FORMING OF ALUMINUM SHEETS

Aluminum alloys are utilized in numerous fields of application on account of the favorable weight-strength ratio, whereby the cold forming of sheet metal semi-finished products is the most common application. Due to the strong adhesion tendency of aluminum, lubricants must currently be used in order to achieve a sufficiently long tool life and high component quality. This does not only result in an increase in working material and disposal costs but also often requires laborious procedures for the subsequent lubricant removal. An approach for the economically and ecologically more efficient configuration of the production process is provided in the form of a tool coating on the basis of amorphous hydrocarbon (a-C:H), developed at the Fraunhofer IST.

Current tool coatings

For the coating of tools for the cold forming of aluminum sheets, a wide variety of hard thin films have been established. As lubricants are currently applied in order to reduce adhesion, these tool coatings are not only optimized with regard to high resistance to abrasive wear but also with respect to bonding and interaction with the additives contained in the lubricant. At present, there is a development trend towards reducing the lubricant consumption. There are, however, no established industrial tool coatings which could enable a complete renouncement of lubricants. With the current technological status, even layers of diamond-like carbon (DLC) cannot completely prevent adhesive tool wear.

Layer development

Within the framework of the Priority Program SPP 1676 from the Deutsche Forschungsgemeinschaft (German Research Foundation, DFG), the Fraunhofer IST carries out further development of amorphous hydrocarbon layers (a-C:H) with the realization of lubricant-free aluminum forming as its objective. Over the course of the latest developments, it was possible to verify that the nanoscopic surface roughness is a significant influencing factor on the adhesion tendency of a-C:H layers. Adhesive layer wear can be prevented and low friction (see Figure 2) can be achieved in the lubricant-free contact with aluminum through a reduction in the nanoscopic surface roughness as shown in Figure 1. For the deposition of correspondingly smooth a-C:H coating systems, various strategies for action, consisting of an optimized coating process and a subsequent surface treatment, were developed and qualified for actual application.

Transfer of results to industrial forming processes

The roughness requirements represent another optimization variable in addition to the coating properties which have formed the focus of attention so far, e. g. hardness, wear resistance, adhesion, etc. Furthermore, the surface quality of the forming tool plays an important role in the transfer of development results to real forming processes. In order to fulfill these requirements, a holistic optimization of the layer-tool bond is necessary. The selection of the tool material, the manufacture of the tool, the actual coating process and the post-treatment of the a-C:H tool coating must thereby

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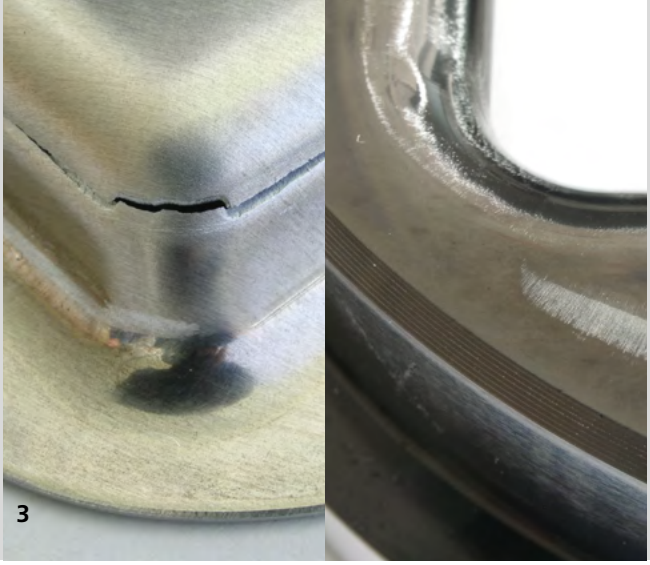
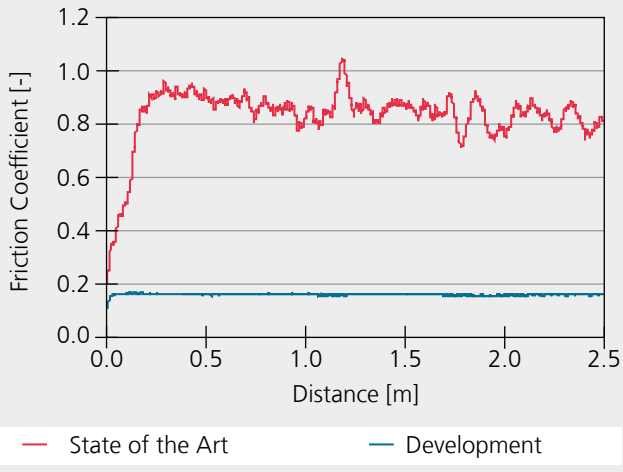


1,2 *AFM images of an a-C:H layer in accordance with the current technological status (left) and the developed a-C:H layer (right).*

3,4 *Photo overview of a-C:H-coated cup drawing tools following lubricant-free application tests with aluminum sheets made from EN AW-5083: Adhesion formation on an a-C:H layer in accordance with the current technological status (left) and the developed a-C:H layer (right).*

be included. The Fraunhofer IST has acquired many years of experience in comprehensive tool optimization with numerous industrial partners. As a result, it has already been possible to demonstrate the lubricant-free deep-drawing of high-alloy aluminum sheets in initial application tests (see Figure 3).

Friction coefficient curve for the developed a-C:H layers in lubricant-free friction contact with aluminum EN AW-5083.



Outlook

The Fraunhofer IST plans to implement the described results in the industrial manufacture of aluminum components.

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