Developments in the use of cold work steels for punching applications

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The DCT4Cut project investigated the benefits of heat treatment with deep cryogenic heat treatment and the use of special coatings for the service life of complex punching tools. Four different types of cold work steel were studied by Sirris and the Fraunhofer institute.

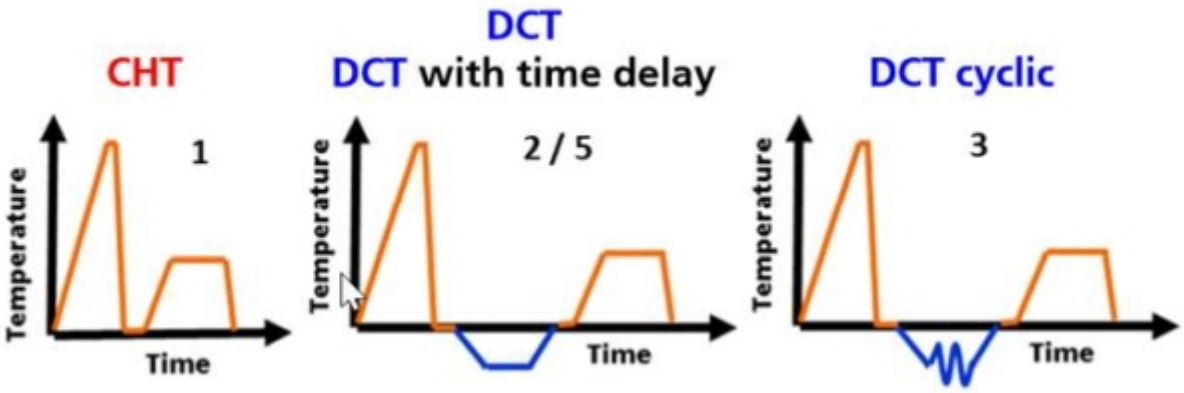
On 18 March, an online users' meeting was organised by the German professional association FOSTA (Forschungsvereinigung Stahlanwendung) and the Belgian network organisation for surface treatment (VOM) on the progress of the Cornet project DCT4Cut.

User meetings had previously been organised by country only. Due to the current Covid-19 measures, an onsite meeting could not take place and a joint meeting in the form of a webinar was the best alternative.

Structure of DCT4Cut

The DCT4Cut research project comprises a number of work packages on the use of cold work steel for punching applications. Specifically, it seeks to demonstrate the benefits of heat treatment with deep cryogenic treatment (DCT and 'cyclic' DCT) and the use of special coatings for the service life of complex punching tools.

For this study, four different types of cold work steel were preselected: a conventional molten cold work steel K110 (1.2379), an ESR-refined steel Caldie and two powder metallurgical (PM) steels - Vanadis 4E and K390. The choice of these samples is based on previous experience (gained during the completed Infiblank project), as well as on the experience of some users at home and abroad. There are, of course, other steels that can be considered for the intended application. To limit the number of tests, only four steel grades were considered for this purpose.



Sirris sent the bars to make the punches to be hardened at Ventec, where the conventional hardening method in a vacuum oven was combined with deepcryogenic treatment, carried out by Nitrotechnics, a part of VBS. The target hardness was 59+2 HRC. The hardened bars were then thoroughly characterised in terms of hardness, structure, carbide content, retained austenite, crack formation after scratch testing, etc. The bars were then transferred to Germany for lab-scale punching tests at Fraunhofer IWU in Chemnitz. Another part of the bars was sent to Fraunhofer IST in Braunschweig for testing with different coatings.

Testing of coatings

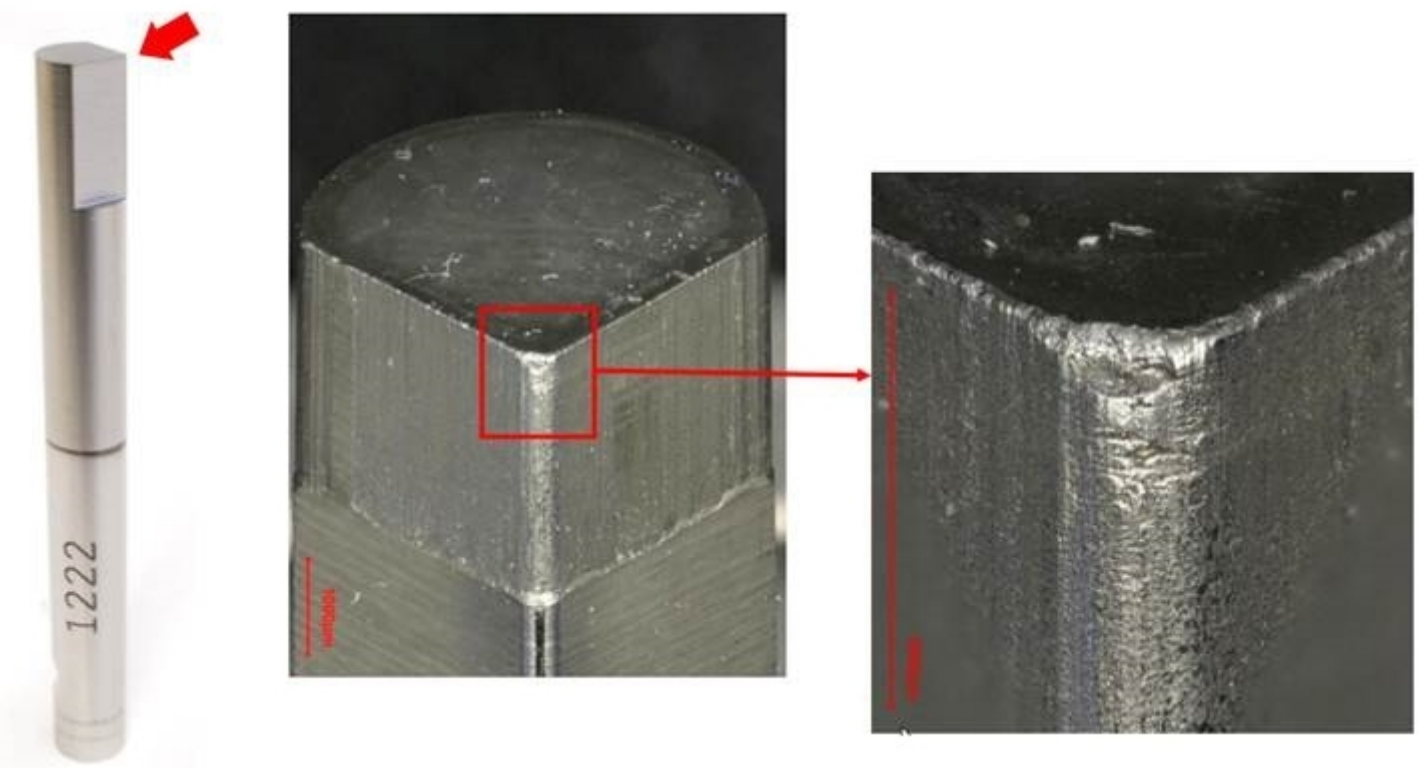
Fraunhofer IST particularly studied the influence of the hardening strategy: the application of deep chilling either before or after tempering and coating ('post-DCT'). The coatings consisted of advanced PVD layers, such as WC-DLC and CrTiAlSiN, deposited with and without prior plasma nitriding treatment (PN). This last treatment is recommended to increase the adhesion and resistance of the coatings. The influence of DCT, performed before nitriding, showed little difference in the adhesion of most PVD layers, verified by scratch tests. The cryogenic treatment after the application of the TiAlSiN and CrAlTiSiN coatings, however, did produce a difference: an increase in the microhardness and in the Young's modulus.

Lab test results

The first punching tests at Fraunhofer IWS were carried out using 5 mm diameter round punches made by EDM from hardened rods in K390, and stainless steel sheet 0.6 mm thick as punching material. These tests showed that the round geometry of the stamp does not allow for sufficient differentiation between different steel grades and treatments. For this reason, this geometry was changed to a partly triangular, partly round shape ("Dreieck geometry").

With these stamps, the four materials were compared in both the conventionally hardened, and in the hardened and cryogenic condition. In the conventionally hardened condition, Vanadis 4E and K390 were found to cause the least amount of wear at the corners of the punches. After deep cryogenic treatment, a lower wear of the cutting edge) could be seen on the conventional K110 steel and on Caldie. The stamps had then undergone more than 100,000 strokes.

Afterwards, new stamps were hardened and subjected to the cyclic DCT performed by the Austrian firm CoolTech. The cyclic DCT is a variant of the ordinary DCT, in which the temperature varies cyclically between -197 °C and a higher temperature, instead of at a constant temperature of -196 °C. With the K110 and Caldie steels, as with the ordinary DCT, a reduction in wear was observed, while no difference was found with the PM steels Vanadis 4E and K390.

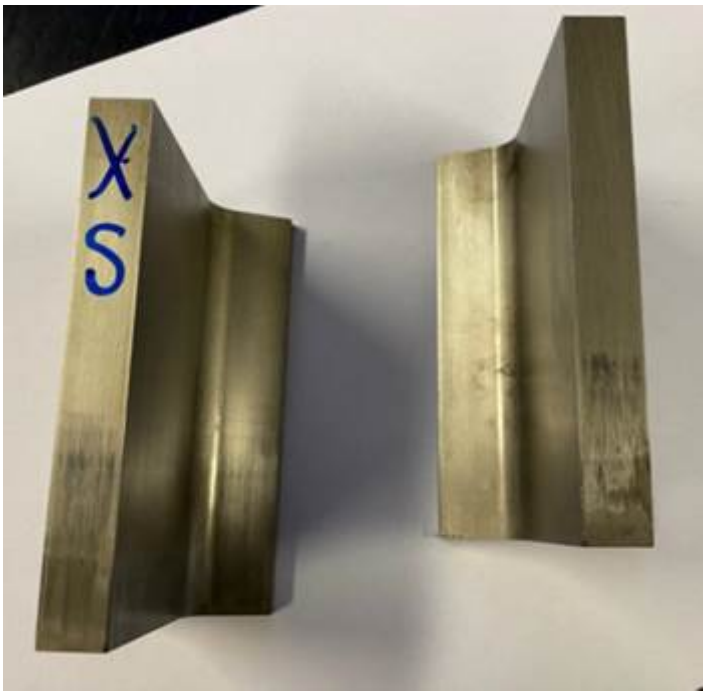


Finally, punching tests were carried out with ordinary and cyclic deep-cryogenic treatment and coated punches in the four steel grades. The wear was compared with the uncoated condition in each case. It was found that the wear on K110 steel, hardened with DCT and with a CrTiAlSiN coating and underlying plasma-assisted nitriding was almost non-existent. The same result was obtained with the Caldie ESR steel, as well as with the other steels, which actually also scored well without coating.

In order to check the effect of plasma-assisted nitriding, a comparison was made between hardened and cyclic deep-chilled and coated punches in Vanadis 4E and K390. The adhesion of the CrTiAlSiN coating was found to hold even without PN, with no signs of wear at the corners.

Result of industrial tests

As a final step in the project, a number of industrial tests are planned in both countries. The aim is to put the laboratory experience into practice. Sirris has meanwhile started three industrial tests at three Flemish companies: at Haemers, active in punched steel parts such as washers, at Stow, active in heavy steel stacking racks, and at Dejond, active in special stainless steel rivets. The tests were carried out on uncoated K110 steel, uncoated CPM4V (American PM steel), covered with a duplex coating, and uncoated ASP23, respectively.



The first two samples were hardened, followed by deep-cryogenc treatment and finally tempered at a high temperature to obtain a nominal hardness of approx. 60 HRC. Since the last steel was already hardened, it was only cryogenic treated and low-tempered (post-DCT).

The three tests are currently still in production and will soon be assessed for wear analysis.

In the coming months, industrial tests will also be started in Germany, among others at KOKI Technik and Bond Laminates, using fibre-reinforced plastic as punching material. High-speed impact cutting tests (abbreviated as ‘HSIC’) are also still on the agenda. Past experience has shown that HSIC stamps in high-quality cold work steels have a limited service life time due to the heavy wear during punching. The aim is to find out whether DCT-treated punches can increase this tool life.

Want to find out more? The complete presentations of the user meeting can be requested by sending us an e-mail.

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Authors



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