INDUSTRIAL PILOT PROJECT

Exploring XANES and EXAFS to access wear behaviour of cutting tools during high-speed turning

THE INDUSTRIAL CHALLENGE

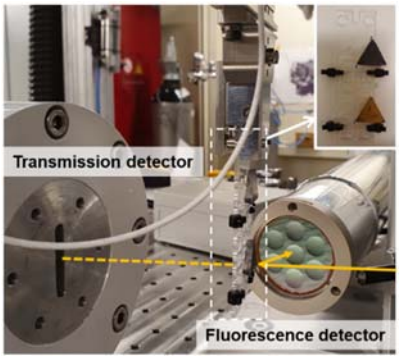
Metal machining requires high-performance cutting tools with excellent wear properties to enable high cutting speeds and thus high production rates. To design next generation high-speed cutting tools, detailed knowledge on the tool wear behaviour is required.

WHY USING A LARGE SCALE FACILITY

The part of the tool that is in contact with the chip is inhomogeneous as a result of differences in temperature and stress on the tool. Thus, characterization methods with a good spatial resolution are required to resolve local changes of the surface.

HOW THE WORK WAS DONE

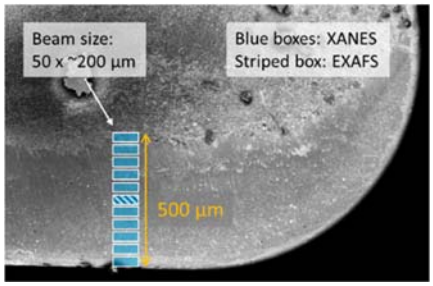
Worn cutting inserts were prepared by turning in stainless steel with TiAlN coated tools. Five samples with different Al-content in the coating were studied. EXAFS and XANES experiments were performed at the BALDER beamline of the MAX IV synchrotron, in Lund. The samples were placed so that the beam was incident at 10° to the surface normal and the fluorescence signal was detected at 80° exit angle.



The chemical changes across the surface of the tool were probed by measurements at the Ti *K* absorption edge. Additional measurements at the Cr-*K* and Fe-*K* edges were made to investigate the nature of the steel species adhered to the tool. Complementary studies of structural changes were performed by transmission electron microscopy (TEM) at Linköping Uni.

THE RESULTS AND EXPECTED IMPACT

The spectral features from XANES data on the as-deposited TiAlN coatings revealed differences in the cubic and hexagonal chemical environments and their hybridization, thus changes in the atomic arrangement as a function of Al content could be identified. The XANES line scans across the surface of the worn tools showed that there are changes in the atomic arrangements in the coating at different spatial areas of the worn cutting edge.



The EXAFS measurements on selected regions of the worn areas also showed changes in bond distances and number of neighbours between the atoms of the coatings compared to the corresponding as-deposited reference coatings. Additional TEM investigations revealed formation of nm-sized domains enriched in TiN.

To conclude, XANES and EXAFS are useful techniques as they are sensitive to very small local changes in the atomic structure of the coatings. The results reveal the possibility of accessing chemical interactions during use of the tool by x-ray based methods. This knowledge will be used for designing future experiment to further explore the material behaviour during machining and in the extent to optimize the material of the tool.

"As researchers we always want to study and understand our materials at the highest possible detail. These techniques help us explore the unknown" /Jon Andersson, Seco Tools

Contacts: Jon Andersson – Seco Tools, jon.andersson@secotools.com
Lina Rogström – Linköping University, lina.rogstrom@liu.se

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