INDUSTRIAL PILOT PROJECT

Using neutron diffraction to study deformation hardening in cemented carbides

THE INDUSTRIAL CHALLENGE

For the mining industry and in rock tools applications cemented carbide, a composite material consisting of tungsten carbide (WC) grains and a binder phase mainly based on cobalt (Co), is used. The high performing properties of this material can be enhanced by a post-process where the material undergoes deformation hardening. This results in a component that better can withstand the abrasive nature of rock drilling and increase the lifetime of the tool. From an industrial point of view this is desired since it means enhanced safety, reduced costs, and better sustainability in mining operations. To be able to further optimize the cemented carbide material it is crucial to understand the deformation hardening mechanism in the tool component.

WHY USING A LARGE SCALE FACILITY

Unlike other methods based on X-ray technology, neutron techniques stand out due to their capability to perform bulk characterization on materials that are both dense and thick, even when composed of high atomic number elements. This unique advantage positions neutron diffraction as an unparalleled method for analysing strain and residual stress, makes it the sole non-destructive alternative available.

HOW THE WORK WAS DONE

Neutron diffraction was used to study the strains in the lattice as a function of position inside the sample, which allowed for the hole component. The test matrix consisted of two cemented carbide grades at three different levels of deformation. We tested two different diffraction methods, where time-of-flight diffraction was performed at the instrument TAKUMI at J-PARC, Japan, and monochromatic diffraction at the instrument SALSA at Institut Laue Langevin (ILL), France. Further, neutron tomography of the binder was of interest and a test run at the instrument IMAT at ISIS, England, was performed.

THE RESULTS AND EXPECTED IMPACT

The two diffraction methods showed differences in the variation of the WC lattice parameter as a function of depth. However, it was possible to monitor how the lattice parameter shifts inside the component and therefore see the effect of deformation hardening on the WC phase. Three levels of deformation were analysed in the TAKUMI diffraction analysis and the results can be seen in the illustration below. This shows the residual stresses as a function of distance from the component surface. The surface is expected to expose the highest level of deformation, which was shown, and the different levels of deformation hardening will, as expected, result in different residual stress profiles.

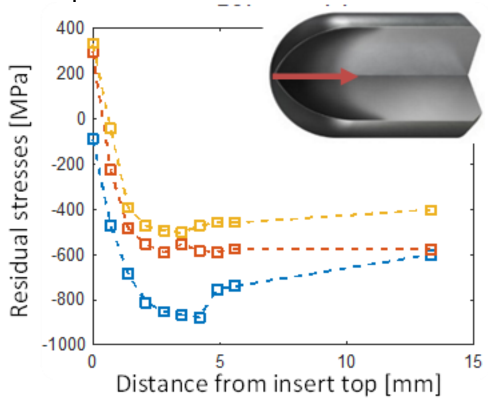

Figure. Axial analysis of residual stresses in a cemented carbide component as a function of distance from the surface for three levels of deformation hardening analysed at TAKUMI.

Monitoring the Co-rich binder phase was found to be more difficult. Our experiment at SALSA revealed that the binder phase grain sizes were too large relative to the sampled volume to give good statistical data. A new approach involving sample rotation was developed and tested. The results showed better statistics for the binder phase. The tomography test run at IMAT showed difficulties in separating the WC and Co peaks for the composite. Continued method development of both neutron diffraction and tomography is of interest.

"Neutron scattering show a new world of possibilities and at the same time a new dimension of complexity of cemented carbide materials" ***/Ida Borgh, Sandvik Mining and Rock Solutions***

Contacts: Ida Borgh – Sandvik Mining and Rock Solution, ida.borgh@sandvik.com
Johan Hektor – Malmö University, johan.hektor@mau.se

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