INDUSTRIAL PILOT PROJECT

# Neutron Bragg Edge Imaging of 3rd Generation AHS-Steel.

## THE INDUSTRIAL CHALLENGE

The 3rd generation steel called Medium Manganese type is a variant of advanced high strength steels (AHSS) that shows more attractive forming properties compared to presently used steel types. The major phase constituents in this steel product are martensite and retained austenite, and a fine tuning of the ratio can result in an attractive combination of high strength and good ductility which is of interest for e.g., the automotive sector. According to the transformation induced plasticity (TRIP) mechanism, austenite transforms to "fresh" martensite upon deformation such as cold forming. The challenge is to control the stability of the austenite to make it transform at the right stress/strain in the metal forming step.

## WHY USING A LARGE-SCALE FACILITY?

The phase fraction of austenite can be analysed using laboratory methods such as X-ray diffraction (XRD) and EBSD, but these methods can only be performed on limited areas or volumes. Understanding how the austenite fraction is dependent on the deformation, requires knowledge of the phase fraction on a macroscopic scale. With XRD or EBSD, this requires many individual measurements at different locations on for example a tensile test sample. Using the imaging capabilities at a neutron scattering beamline and the technique referred to as Bragg Edge Imaging, spatially resolved images of the said phase transformation due to deformation, can be made on a macroscopic scale. The time resolution of neutron sources also opens up for in-situ studies during deformation, for example by tensile testing or forming operations.

## HOW THE WORK WAS DONE

Tensile test specimens, 90mm in length, were prepared from the investigated material and drawn to four different deformation levels. These samples went through preparatory measurements at the Conrad instrument at BERII in Germany and were further imaged using the Bragg edge technique at both the Raden instrument station at the J-Parc neutron spallation source in Japan and on the IMAT instrument at ISIS UK. Dr Takenao Shinohara and Dr Winfried Kockelmann are acknowledged for the remotely performed measurements due to the travel restrictions. As validation also quantification with XRD was performed at five different locations from the center of each sample cross-section

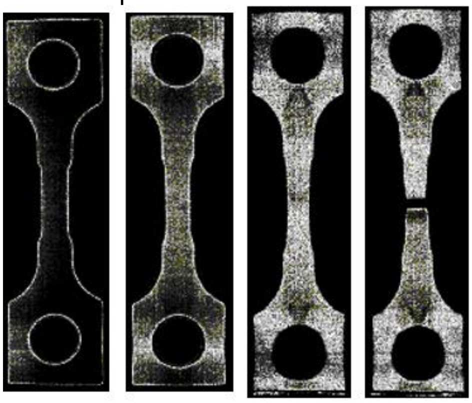

**Figure**. From left to right: an increased degree of deformation is followed by a larger amount of martensite (brighter regions).

## THE RESULTS AND EXPECTED IMPACT

The images computed from neutron Bragg edge data showed the profile of the austenite and martensite phases. At the different stages in the deformation curve an increased signal of the martensitic content could be seen, see Figure, where the brighter regions indicate a larger amount of martensite following the degree of deformation. XRD data confirmed the neutron findings. This project has introduced SSAB to a new type of characterization technique that allows for both larger sample sizes and an in-situ approach to follow phase transformations in the specimen during deformation. This allows for a better understanding of phenomenon's occurring in the material also under other types of loads than deformation.

***"This project has opened our eyes to the possibilities made available through the use of neutron sources and Bragg edge imagery in characterizing material and the present investigation of the TRIP effect can successfully be followed using this technique."*/ *Erik Nymann, SSAB EMEA AB***

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