INDUSTRIAL PILOT PROJECTS

# Residual stress measurements in Hardox™ high strength steel using neutron diffraction

## THE INDUSTRIAL CHALLENGE

High strength steels can be sensitive to hydrogen embrittlement (HE) which can limit the application of the steel in certain environments. A prerequisite for HE is the presence of residual stresses built up in the product during production and in service. Residual stresses can be reduced by applying thermal treatments, i.e. tempering, during the production process. However, a limitation is that the time and temperature profile used must not alter the strength of the steel from acceptable values. To optimize the process, there is a need to map the stress distributions. This is the quest for an effective production route that will allow for the full potential of these high strength steel products.

## WHY USING A LARGE SCALE FACILITY

It is desirable to map residual stresses throughout the whole of the thickness of steel plates. Non-destructive analysis of the bulk is impossible to perform with conventional laboratory methods (e.g. X-ray diffraction) due to the limited penetration depth. Since neutrons penetrates deep into a material, neutron diffraction is an ideal tool for this.

## HOW THE WORK WAS DONE

The neutron diffraction data used to analyse residual stress were recorded from the Engine-X diffractometer at ISIS Neutron & Muon Source, UK.

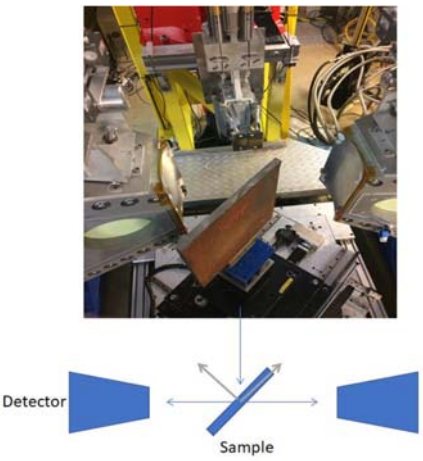


Figure 1. The experimental set-up of Engine-X.

Measurements were performed on samples after quenching, tempering and levelling of the steel plate. The residual strain and stress at each measurement depth was calculated using the bcc cubic cell parameters obtained from the corresponding neutron time of flight data.

## THE RESULTS AND EXPECTED IMPACT

Examples of macro stress profiles are shown in Figure 2, where the quenched state is compared to the 600°C tempered sample.

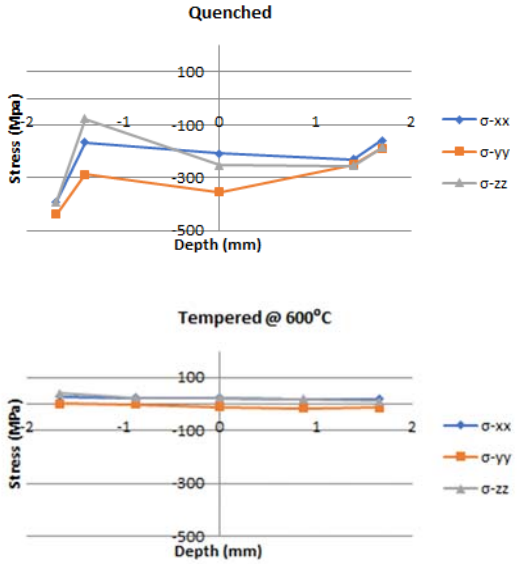


**Figure 2**. Stress diagrams with stress in MPa vs sampling depth.

The residual stress levels and the through plate stress profile changed between the different process steps and both levelling and tempering reduced the stresses in the plate. The results need to be further analyzed since the stresses differ between the top and bottom side of the plate and the reason for this needs to be clarified.

***"For SSAB it is important to see the evolution of the residual stresses in the production route and further to develop steel with higher resistance to hydrogen embrittlement. Also important is the aspect of sharing the possibilities with neutron diffraction within the R&D function throughout the company." /Torbjörn Narström, SSAB Special Steels***

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**Vinnova's project No:** 2018-04427 **Duration:** November 2018—November 2019

Funded by Sweden's Innovation Agency, Vinnova, in order to build competence and capacity regarding industrial utilisation of large-scale research infrastructures such as MAX IV and ESS.