INDUSTRIAL PILOT PROJECT

Quantitative characterization of chemically complex low alloyed high strength tempered martensitic steels using ASAXS

THE INDUSTRIAL CHALLENGE

The strength of low-alloyed steels is improved by the nano sized secondary carbides rich on molybdenum (Mo) and vanadium (V). To set the properties of these SSAB steels, they are quenched from high temperature and then tempered at 500-600ºC for some hours. It is important for SSAB to better understand the precipitation sequence in order to optimise alloying and heat treatments processes.

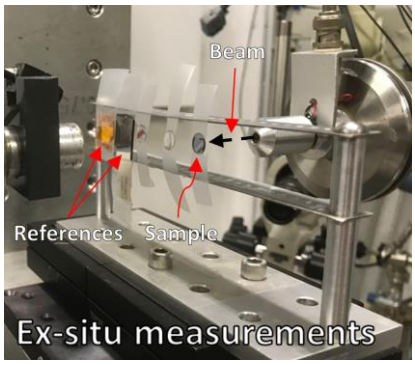
WHY USING A LARGE SCALE FACILITY

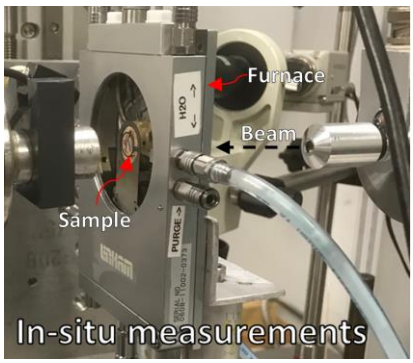
The precipitation sequence of nano-sized particles has previously been analysed with electron microscopy (SEM/TEM) and atom probe tomography (APT). However, quantifying particles with these lab-based techniques is limited by the small probe volume. By using scattering techniques at large scale facilities, a greater sample volume can be analysed which is useful for determining size distributions and phase fractions of carbides. In previous work small angle neutron scattering (SANS) has been used to detect these small carbides, but due to the complexity of the steel with many different but similar carbides, it was difficult to isolate the scattering contribution from different sorts of carbides. Carbides with similar size range can be iron carbides or Mo/V secondary carbides. With anomalous small angle x-ray scattering (ASAXS) at a synchrotron facility it is however possible to distinguish the anomalous effect (AE) which is selectively related to Mo-rich carbides. ASAXS was therefore chosen as suitable supplement to previous characterisations.

HOW THE WORK WAS DONE

ASAXS experiments were performed at the Advanced Photon Source (APS) in USA, by representatives from SSAB, Kungliga Tekniska Högskolan and Swerim. A monochromatic x-ray beam with energies close to the absorption edge of Mo was used to study differences in the Mo-content at different q-ranges. X-ray energies were close to 20 keV.

In total 20 different energies were measured for each sample to study the anomalous effect (AE) related to Mo-rich carbides with ASAXS. The measurements were performed both ex-situ and in-situ at 550 °C.





THE RESULTS AND EXPECTED IMPACT

From the data analysis it is evident that the AE is observed only at high q-values, i.e. the small particles. This indicates that the smallest carbides can be separated through the AE-effect at ASAXS experiments, which gives additional information compared to previous SANS experiments. This effect becomes even more pronounced with longer tempering times, which is reasonable since Mo portioning in the secondary carbides requires time for diffusion. The improved understanding of the precipitation sequence obtained within this project can aid the further optimization of heat treatment and alloying of these commercial materials.

Contacts: Diana Orrling – SSAB EMEA AB, diana.orrling@ssab.com
Erik Claesson, Fredrik Lindberg – Swerim AB, erik.claessonl@swerim.se,
Peter Hedström – Kungliga Tekniska Högskolan, pheds@kth.se

Vinnova's project No: 2018-04413 **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.