INDUSTRIAL PILOT PROJECT

Deoxidation of stainless steel during high temperature vacuum brazing, studied with PEEM at MAX IV

THE INDUSTRIAL CHALLENGE

Every year Alfa Laval produces millions of compact plate heat exchangers in stainless steel by high temperature vacuum brazing. The products are used in variety of applications such as tap water heating and air conditioning. During the brazing process one of the challenges is to “break” the thin oxide film that always form on stainless steel, so that the braze material can wet the steel surface and create a sound joint. The exact mechanism behind the important de-oxidation and how it varies with different steel alloys is not understood and to optimize the high volume brazing requires complex and time-consuming R&D work.

WHY USING A LARGE SCALE FACILITY

Since the oxide is only a few nanometres thick, both imaging and chemical analysis requires a microscope with very good surface sensitivity combined with state-of-the-art methods. To understand how the oxide is influenced by elevated temperature, the microscope also needs to be equipped with heating capabilities. The Swedish synchrotron MAX IV is one of few facilities in the world equipped with such setup.

HOW THE WORK WAS DONE

The project was initiated with a detailed *ex-situ* analysis with traditional characterization methods such as x-ray diffraction, scanning electron microscopy and different spectroscopy methods. The pre-analysis established a chemical and microstructural understanding and the start conditions to execute the more complex *in-situ* synchrotron radiation experiment. The MAXPEEM beamline at MAX IV is equipped with a Spectroscopic PhotoElectron and Low Energy Electron Microscope (SPELEEM). This allows for surface imaging techniques with structural, chemical, electronic, and magnetic contrasts at spatial resolutions in the nanometer range. The equipment enables characterization of the oxide both at room temperature and at elevated temperatures, similar to Alfa Laval’s brazing temperature (>1000 °C). The experiment was performed by Alfa Laval and Lund university in strong collaboration with the beamline personnel.

THE RESULTS AND EXPECTED IMPACT

The results gave new and detailed insights in how the chemical composition of the oxide is influenced by the base alloy configuration. In addition, the *in-situ* imaging and characterization during heating have the potential to throw light on how the Alfa Laval’s brazing processes can be optimized and altered for higher efficiency.

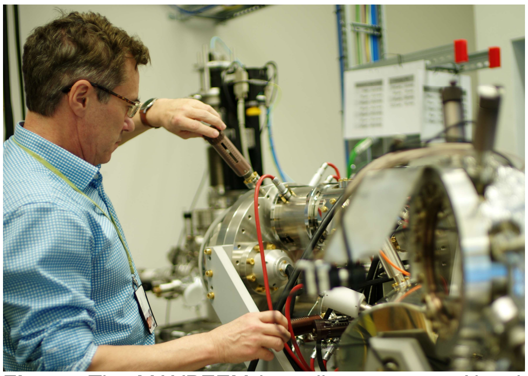

Figure. The MAXPEEM beamline manager Alexei Zackarov mounting Alfa Laval steel samples

Out of extensive understanding of the capabilities of the MAXPEEM beamline, Alfa Laval is now considering it as potential tool to solve both R&D and other production challenges.

“The experiment is a black box opener which generates knowledge about what occurs during industrial scale brazing.”
/Jenny Rehn Velut, Manager Alfa Laval R&D Materials Technology & Chemistry, Lund

ALFA LAVAL

LUND UNIVERSITY

Contacts: Axel Knutsson – Alfa Laval Lund AB, axel.knutsson@alfalaval.com
Filip Lenrick – Industrial production technology, Lund University, filip.lenrick@iprod.lth.se
Anders Mikkelsen – Synchrotron radiation research, anders.mikkelsen@sljus.lu.se

Vinnova’s project No: 2018-04404 **Duration:** November 2018 -- March 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.