INDUSTRIAL PILOT PROJECT

Study of precipitates in an additively manufactured maraging steel using small angle neutron scattering

THE INDUSTRIAL CHALLENGE

With a good combination of high strength and adequate toughness, maraging steels have been adapted to many engineering applications. Due to their excellent welding behaviour, maraging steels are also among the most promising candidates for additive manufacturing (AM). For those reasons, maraging steels are of great interest to Uddeholms AB as candidate materials for AM products in tooling applications. Understanding the characteristics of the precipitation behaviour of the AM maraging steel would considerably assist Uddeholms AB in tailoring heat treatments to achieve optimized properties with respect to targeted applications.

WHY USING A LAR7GE SCALE FACILITY

Laboratory-based techniques such as scanning electron microscope (SEM) and transmission electron microscope (TEM) can reveal the morphology of precipitates at selected cross-sections. However, analysis of the nano-scale precipitates' volume and size distribution with statistical significance requires small angle neutron scattering (SANS) experiments.

HOW THE WORK WAS DONE

Specimens of 12mm x 12mm x 0.8mm (nominal dimensions) were manufactured by laser powder bed fusion (LPBF) and hot isostatic pressing (HIP) and subjected to various heat treatment condition. SANS experiments were conducted at the SANS-1 station of Heinz Maier-Leibnitz Zentrum (MLZ) at the German neutron facility FRM II. In order to measure precipitates in a large size range, four scattering geometries from combining four detector-sample distances and two neutron wavelengths were used to cover a wide range of scattering vector (q-range: 0.004 Å-1 to 0.4 Å-1).

We sincerely thank Dr. Sebastian Mühlbauer and Dr. Apostolos Vagias from MLZ for their contribution.

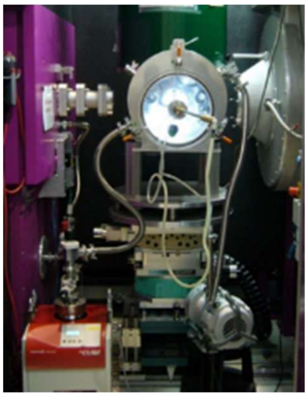

Figure 1. A typical set-up of SANS-1.

THE RESULTS AND EXPECTED IMPACT

An initial analysis of the SANS results was performed, and it was found that there was strong multiple scattering, due to specimens were too thick. Current thickness of around 0.8 mm was used in a nickel-based super alloy to analyse precipitates with SANS-1, and it worked well. However, it did not work for the current maraging steel. A speculation is that the amount of precipitates are too large, which highly increased the chance that a neutron got scattered more than once before reaching the detector. Hence, thinner specimens are required for a successful measurement. Based on the outcome, a specimen thickness of 0.2 mm was then suggested by one beamline scientist at FRM II. The consortium of this project plans to send a new proposal on this very subject to SANS-1 at FRM II.

"There is a great potential in addressing alloy design related topics for complex manufacturing processes with large scale facilities. Meanwhile, also new challenges need to be overcome in order to exploit its maximum potential."

/Christos Oikonomou, Uddeholms AB

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