INDUSTRIAL PILOT PROJECT

Understanding heat-treatment of Hybrid Steel® using in-situ and ex-situ synchrotron X-ray diffraction

THE INDUSTRIAL CHALLENGE

The newly developed Hybrid Steel® of Ovako obtains its high strength by combining precipitation of intermetallic NiAl precipitates and carbides. This makes the precipitation process rather complex and a detailed understanding is needed to tailor heat treatments for each application.

WHY USING A LARGE SCALE FACILITY

The precipitates in Hybrid steel are generally very small, below 10 nm. This means that time-consuming techniques like transmission electron microscopy (TEM) or atom probe tomography (APT) are needed. By using synchrotron X-ray diffraction and scattering, valuable information can be obtained quickly. The fast acquisition also allows the precipitation process to be studied in-situ.

HOW THE WORK WAS DONE

Simultaneous Wide-Angle X-ray Scattering (WAXS) and Small-Angle X-ray Scattering (SAXS) was performed at the Swedish Materials Science Beamline P21 at Petra III in Hamburg, with an energy of 60 keV. The experiments were carried out during two visits by researchers from Ovako and Chalmers University of Technology, with assistance from the beamline scientist Dr Timo Müller. The in-situ measurements were carried out using a Linkam furnace with heat treatment times ranging from 1 to 20 hours.

Figure 1. Experimental set-up at P21 with the water-cooled and Ar-protected furnace in the foreground.

During the first visit sheet samples were used, but it was observed that the expected max temperature of 600˚C could not be reached. After modifications of the furnace to allow for match-stick shaped samples, the furnace worked well and reached 600˚C during the second visit.

THE RESULTS AND EXPECTED IMPACT

The experiments generated a large amount of data. Heat-treated samples could quickly be measured ex-situ, giving information on the precipitate structure (WAXS) and size (SAXS). The in-situ tests provided information about the temporal development of the precipitates, and also changes in the phase fraction of retained austenite. Also, changes in the lattice parameters of the austenite and the martensite could be followed during heating, holding and cooling. This type of knowledge cannot be obtained by carrying out only ex-situ measurements.

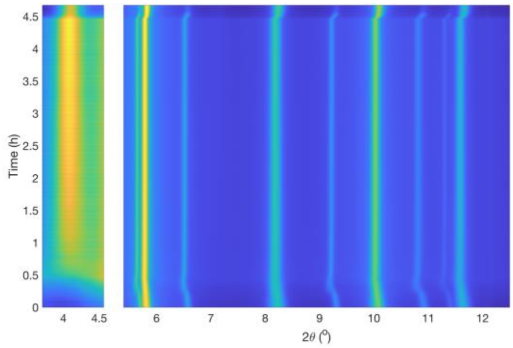

Figure 2. Development of X-ray peaks as a function of time during in-situ measurements. The left peak shows the formation of NiAl. At the top, the drop in the amount of austenite during cooling can be seen.

The results are expected to influence heat-treatment schemes and possibly as guidance when developing new grades of the hybrid steel family.

OVAKO

CHALMERS

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