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Austempered Ductile Iron (ADI) for Hydraulic Components

Motivation

Austempered ductile iron (ADI) represents an rewarding construction material due to its steel like mechanical properties and good castability. For manufacturing and design of defined properties, a sound knowledge of the phase transition processes during heat treatment is essential. The alloying of Ni, Cu and Mo allows an ausferritic microstructure even for thick parts, e.g. 70mm diameter, by shifting the pearlitic transformation to later times. The level of the isothermal annealing defines the fineness of the ausferrite and has a substantial impact on the fatigue properties. The influence of the alloying element Mo on the phase transition kinetics is main subject of the first project phase whereas the focus is switching subsequently to the process window optimization of a technical alloy (Ni + Cu + Mo).

The retained austenite undergoes a martensitic transformation when exposed to plastic deformation. Investigation is undertaken if the phase transition at the crack propagation tip leads to a well-natured failure behavior.

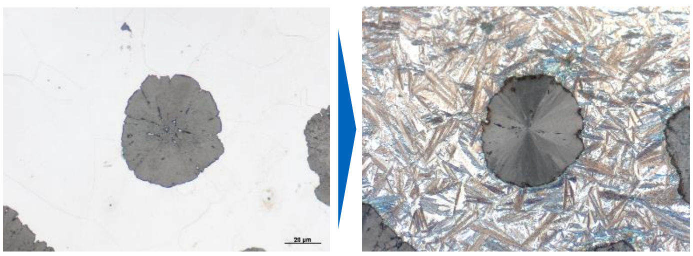

Figure 1: Initial microstructure and ausferrite after heat treatment at 350 °C

Solution Approach

The evolution of the phase volume contents in dependency of temperature and alloying composition is monitored by in-situ neutron diffraction experiments. Atom Probe Tomography (APT) measurements give insight in carbon content distribution in retained austenite, which is fundamental for its stability at room temperature. Static and dynamic properties are characterized by hardness, tensile, charpy energy and rotation bending tests.

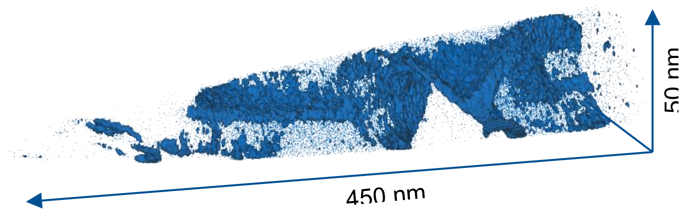

Figure 2: APT at Karlsruhe Institute of Technology (KIT) – Carbon distribution

The applicability for hydraulic components is proven by dynamic hydraulic pressure testing, carried out at a pulsedummy specimen.

Results and Outlook

Figure 3 shows the development of the phase transition at 400 °C austempering temperature in respect of different Mo contents. The results derived from the characterization of the mechanical properties at different annealing times allow the choice of appropriate time and temperature combinations.

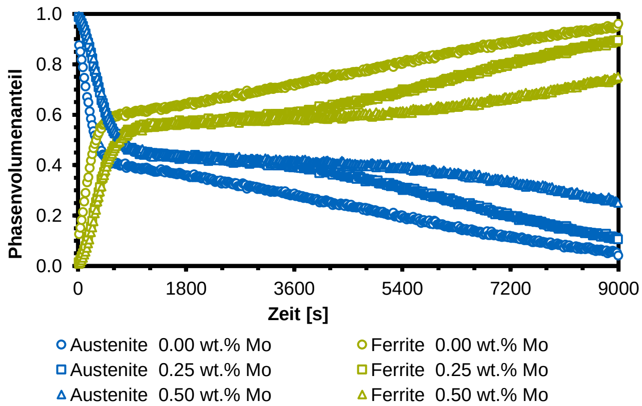

Figure 3: Austenite and ferrite phase volume fractions measured by in-situ neutron diffraction

Previous results depict an improvement for component life time by the use of ADI. Therefore the correct choice of time and temperature is critical. The experience based process boundaries have been investigated in detail using neutron diffraction and are now more accurately defined allowing an energetic optimization of the heat treatment process.

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