Abstract

Increasing knowledge and suggesting new heat treatment parameters for improved very high cycle fatigue (VHCF) strength of austempered ductile iron (ADI) are the main purposes of this thesis. The work was performed within Epiroc a mining and infrastructure company. They have performed internal research on VHCF properties of ADI had previously for one set of heat treatment parameters. The scientific community in contrast have extensively studied fatigue properties of ADI in the low to high cycle regime ($\leq 10^8$ cycles) but only scarcely in the VHCF regime ($>10^8$ cycles). Therefor the thesis is built upon the hypothesis: 'Improvements in HCF strength should also mean improvements in VHCF strength'. Enabling utilization of published research on heat treatment effects on fatigue strength in the HCF regime ($\geq 10^7$ cycles).

Finding an efficient way of exploring heat treatment parameters and their effects on the given Cu-Ni-Mo ADI alloy were a main objective. Thus, finding mechanical- and material properties characteristic for high cycle fatigue strength in the HCF regime became crucial. The potential in using these properties to develop and execute an experimental plan to evaluate heat treatments, yet minimizing the amount of fatigue testing required.

The first step was identifying the heat treatment parameters (and parameter ranges) that showed high HCF strength, which are: Austempering temperature (T_{aus}), austempering time (t_{aus}) and austenitization temperature (T_{γ}). Then finding the characteristic mechanical- and material properties for said high HCF strength material, found to be: high- ductility, unnotched impact energy and volume fraction of carbon stabilized austenite (VRA). With both heat treatment parameters, mechanical- and material properties distinctive of high HCF strength material an experimental plan was developed based on a full factorial design (2^3). The factorial design was chosen for its simplicity and inherent strengths, especially as both individual and interaction effects can be estimated for all factors (heat treatment parameters). Two levels ($\mathbf{2}^3$), one high and one low, for each of the three factors (2^3) were determined necessary, giving a total of 8 heat treatment trials. The primary response variables of interest (evaluated properties) for each heat treatment trial were: ductility, unnotched impact energy and volume fraction of carbon stabilized austenite. Meaning usage of the following tests: Tensile testing, impact energy testing, and X-ray diffraction. Specimens for testing were extracted from austempered Y-block type III, initially cast by a commercial foundry with an Epiroc specified chemical composition. The main and interaction effects from the heat treatment parameters on the response variables were both calculated and visually determined. The experimental data was validated against literature found data for similar heat treatments. The evaluated experimental results showed good correlation with literature for the given chemical composition. Ultimately resulting in recommendations for a new heat treatment parameters for improved high cycle fatigue strength.