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Influence of the surface roughness on the fatigue properties in ausferritic ductile irons (ADI)

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Abstract. Heat treatment of cast ductile iron (DI) to ausferritic ductile iron (ADI) is known to increase fatigue properties. However, the surface roughness of the cast material is also of significant importance. In this investigation, test rods with seven different surface qualities were cast from the same melt i.e. with same chemical composition. The surfaces of the test rods were varied by a number of parameters; grain size of the moulding sand, coated or non-coated mould surfaces, as-cast or machined and polished, shot peened or not. In addition, a reference material in conventional DI was cast and tested. All eight series were subjected to high-cycle fatigue bending tests. The results show that surface defects, such as micro porosity and minor inclusions drastically decrease the fatigue properties. For some ADI materials the stress amplitude limit was actually lower compared to the non-heat treated DI. The machined, polished and shot-peened material demonstrated the best fatigue properties, which is as expected.

1. Introduction

The surface roughness, as well as defects and other irregularities, affect the fatigue properties. Present investigation was performed in attempt to clarify the influence of casting surface and other production parameters on the fatigue limit.

2. Experimental

Rectangular ADI test rods, with similar chemical composition (see Table 1), were cast and treated to different surface roughness. In addition to the seven ADI materials, a conventional DI material was also tested as a reference. All test rods were subjected to high cycle fatigue bending, with a minimum of 17 rod per series.

3. Results

Mechanical data from tensile tests are shown in Table 2. The experimental set-up for achieving different surface conditions is described in Table 3, including the acquired results from fatigue tests.

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Table 1. Chemical composition in weight-% for the fatigue test rods.

C	Si	Mn	P	S	Mg	Cu	Cr	Ni	Mo	Ti	Sn	N
3,65	2,97	0,18	0,044	0,026	0,049	0,79	0,03	1,58	0,15	0,010	0,008	0,045

Table 2. Mechanical properties before and after heat treatment. Results from separately cast samples.

Material	$R_{p0,2}$ [MPa]	R_m [MPa]	A_5 [%]	HBW
DI before heat treatment	573	845	5,1	287
ADI after heat treatment	786	1072	5,9	342

Table 3. The obtained fatigue limit values, i.e. the flat line from the Wöhler curves.

Series	Sand	Coated	Shot peening	Machined	Polished	Mean Fatigue limit [MPa]
1	0,14	Yes	Yes	No	No	214
2	0,14	Yes	No	No	No	205
3	0,14	No	No	No	No	183
4	0,25	No	Yes	No	No	186
5	0,25	No	No	No	No	178
6	0,25	Yes	No	Yes	Yes	195
7	0,25	Yes	Yes	Yes	Yes	239
8*	0,25	Yes	No	Yes	Yes	204

* Reference material in DI (not ADI).

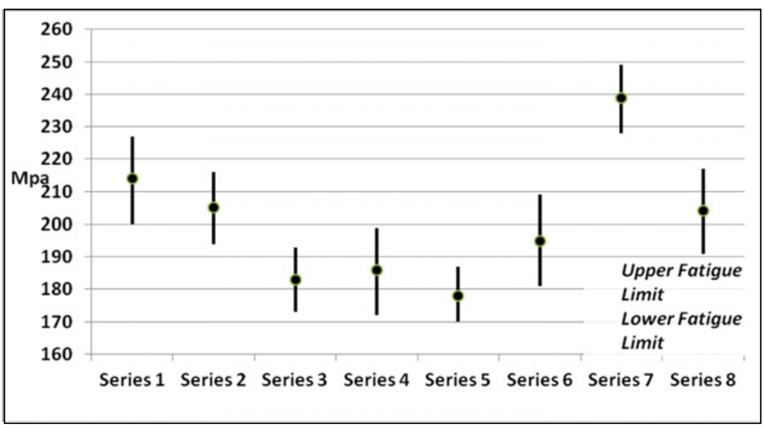

Figure 1. Stress amplitude results from the High Cycle Fatigue bending. The Limit Life was set to 106 cycles, R = −1 and runout was defined as a survivor at 3M cycles (with the exception of series 7 where runout was defined at 7M cycles). Upper and lower fatigue limit encloses the true mean with a probability of 80%.

Figure 1 shows the upper and lower fatigue limit and encloses the mean limit with 80 % probability. The results show enhanced fatigue properties for a polished surface and post-treated shot peening (series 7). Coating of the sand moulds resulted in a finer surface of the castings and thereby better fatigue properties (series 3-5 have the lowest values). Surface defects, such as micro porosities, affect the fatigue properties negatively.

4. Conclusions

Castings with machined and polished surface with post-treated shot peening gave the best fatigue properties. Coating of the sand moulds before casting results in better surface quality and thereby better fatigue properties.