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Effect of Austenitizing Temperature on Microstructure and Mechanical Properties of Low-alloyed Ausferritic Ductile Cast Iron

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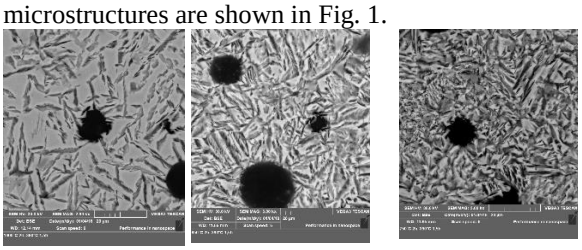
Tests have been conducted on the effect of austenitizing temperature on the microstructures and properties of ADI according to EN-GJS-800-10 grade with Cu and Ni additives. The samples were austenitized at temperatures of 1000, 950, 900, 850, 800 and 750°C for 2 hours and then austempered at 390°C for 1.5 hours. Microstructures and mechanical properties and of cast iron were assessed. The morphology of the Ausferritic Ductile Iron matrix was identified by assessing the average number of ausferrite plates per 1 mm of the metallographic specimen length. The ductile cast iron austenitizing temperature, i.e. 850°C, is a process parameter that provides the castings with optimum mechanical properties, especially in terms of strength and ductility.

1. Introduction

The excellent strength and ductile properties of Ausferritic Ductile Iron make this material widely used in the automotive, railway and agricultural industries [1,2]. The microstructure of ausferritic ductile iron (ADI) determines the values its mechanical property parameters. Heat treatment of ductile cast iron and the selection of austenitizing and ausferritizing parameters allow controlling the microstructure of cast iron [1-4]. The majority of research focus on the impact of austenitizing parameters on the properties of ADI. Austenitizing parameters, in particular temperature, are selected based on literature data [5,6], and only a few studies relate to ductile iron with high ductile properties [7]. Properties of austenite, its homogeneity, grain size and carbon content in austenite are factors determining the morphology of ausferrite and residual austenite [1, 4]. It is microstructure that is responsible for the ductile and strength properties of ausferritic ductile iron, while the morphology of graphite in ADI (number of precipitates and spheroidality) significantly improves the strength, elongation and impact strength of cast iron [2,8,9].

2. Methodology

The test material was taken from production smelts of ADI of EN-GJS-800-10 grade (2.31 %mas. Ni and 0.68 %mas. Cu). Standard sample was poured (Type "YII"- 25 mm block standard, according with EN 1564). Cut-off parts of these block were austenitized at temperatures of 1000, 950, 900, 900, 850, 800 and 750°C, each time for 2 hours. The samples were austempered in a salt bath at 390°C for 1.5 hours for each austenitizing temperature. Specimens for the evaluation of strength, impact resistance (samples without a V-notch) and microstructure were taken from the samples prepared in this way. The prepared specimens were subjected to a tensile test (Zwick 250) and impact strength test (Charpy hammer with an energy of 150 J). The microstructure was evaluated using the VEGA 3 SBH/EDS Oxford Instruments AZTec Electron Microscope. The obtained microstructures were used for estimating the average number of ferrite plates in ausferrite per 1 mm of metallographic specimen; the method of evaluation is described in [9]. Examples of microstructures are shown in Fig. 1.



a b c

Fig. 1. Microstructure of cast iron austempered from the austenitizing temperature of: a) 1000°C, b) 850°C, c) 750°C

The results of the tests of mechanical properties and the number of ferrite at 1 mm of metallographic specimen length are presented in Table 1.

Table 1. Results of the tests of mechanical properties of ausferritic ductile iron and the number of ferrite plates per 1mm

Aust. temp.	YS	UTS	El. A_5	K	HB	P(x)*
[°C]	[MPa]	[MPa]	[%]	[J/cm^2]		[1/mm]
1000	433	881	5.1	49.4	269	248
950	496	944	9.5	82.2	262	298
900	626	978	15.5	123.9	285	318
850	679	952	16.7	130.1	302	410
800	666	911	13.8	115.5	293	400
750	555	789	11.3	117.7	262	**
EN 1564	500	800	10	110	250, 310	

*P(x) – number of ferrite plates in ausferrite per 1 mm of specimen
**) – degenerated ausferrite microstructure

Conclusions

The tests concerned ADI of EN-GJS-800-10 grade for braking system castings for the railway industry. The presented test results indicate a significant effect of the cast iron austenitizing temperature on the mechanical properties of the castings. With the previously applied temperatures of castings annealing (950-900°C), the parameters of yield strength YS, elongation A_5 and impact strength K were found to be unstable and not reaching the level required as per EN 1564. The most favourable relations between strength and ductile properties were obtained by austempering of cast iron from the austenitizing temperature of 850°C (Table 1). The cast iron heat-treated in these conditions is characterized by the highest dispersion ausferrite (410 ferrite plates per 1 mm). These heat treatment process parameters were applied to production castings. Mechanical properties of ausferritic ductile iron determined on samples taken from production castings showed stability and compliance with the standard requirements for the EN-GJS-800-10 grade; a technological reserve of a several dozen percent of individual property parameters was obtained.

The research will be continued in the selection of ausferritizing parameters and improvement of ADI graphite morphology.

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