

The impact of charge materials on the metallurgical quality of ductile iron in large-size castings

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SUMMARY

The dissertation entitled "The impact of charge materials on the metallurgical quality of ductile iron in large-size castings," was carried out as part of an implementation doctorate in collaboration with the Department of Foundry Engineering at the Silesian University of Technology in Gliwice and RAFAMET Fondy. The primary aim was the implementation of solution strengthened ferritic grades: EN-GJS 450-18, EN-GJS 500-14, and EN-GJS 600-10, into the foundry's production area, following preliminary research performed to determine the effects of charge materials on metallurgical aspects of castings.

The first chapter is a literature review on the prospects of the ductile iron casting industry, explaining the motivation for exploring SSFDI irons as modern engineering materials with broad application potential, in the context of current market trends, due to the rare combination of high mechanical and plastic properties at the same time. Traditional and new-generation ductile irons are characterized, highlighting the differences between them. Special attention is given to silicon, one of the main alloying elements in cast irons, describing its influence on structure and properties, as well as the mechanism of solid solution strengthening. Subsequently, the characterization of the other essential chemical elements of ductile iron was presented. In accordance with the foundry's production profile, the issue of cast iron crystallization is discussed, focusing on thick-walled, large-scale castings, emphasizing possible production challenges—most notably, graphite degeneration into a chunky form—and identifying potential applications for SSFDI irons.

Theoretical considerations made it possible to establish a thesis and define objectives to confirm it.. An experimental plan was developed and divided into two stages. The first was aimed to achieve the properties for three normatively defined grades, accomplished by determining charge material dispositions based on previously used primary and auxiliary materials in production, assuming the invariability of materials and the modification and spheroidization processes throughout the experiment. Induction furnace dispositions were varied and selected to obtain the developed chemical compositions determining the performance properties of the castings, represented by test specimens with improved geometries in relation to the standardized ones. Tests of static tensile test, Brinell hardness, chemical

composition analysis, microscopic observations of metallographic specimens and fractures, as well as thermal analysis were carried out. The impact of pig iron content, Mn concentration, and Si quantity on the structure and properties of the resulting irons was assessed, along with the analysis of material costs for the selected melts characterized by the highest compliance. In the second part, in order to determine the relationship between the wall thickness of the casting and the obtained properties and structure, while maintaining identical metallurgical conditions, a 4Y test was developed. This provided an opportunity to determine the tendency of individual properties in the face of equal chemical composition of the casting for each grade, which made it possible to predict the behavior of cast iron under production conditions during the manufacture of large-size castings with varying geometries.

Finally, based on the experimental results, the EN-GJS 450-18 and EN-GJS 500-14 grades were implemented at RAFAMET Foundry. in response to customer demand, with necessary tests conducted to confirm the castings' compliance with requirements. Satisfactory results led to gaining experience in the production of these grades and obtaining a competitive advantage over many iron foundries.