Physical Metallurgy of Cast Irons

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This book is dedicated to the memory of José Antonio Pero-Sanz Elorz.

Endorsement

"The second half of the twentieth century was seeing casting processes gradually lifted from the art of crafts status to that of a science-engineers are complementing and supplementing the craftsman, and for the first time books are being published treating casting processes on the level of an advanced engineering or scientific subject; for contrary to the opinions of many, no other branch of industrial engineering will lend itself more responsively or rewardingly to scientific treatment and control, although the road will not be easy because the start has been slow and the numbers of scientist and engineers engaged in the process were relatively few … ."

"Cast iron is second only to steel in total tonnage produced. Cast iron has certain metallurgical and economic characteristic to the engineer; perhaps the most important is its cheapness".

H. F. Taylor, M. C. Flemings and J. Wulff
(*Department of Metallurgy,*
Massachusetts Institute of Technology (MIT), 1959).

Preface

The possibility of obtaining metallic parts by simply solidification, without the subsequent processes of forging, justifies the interest of cast irons as structural materials. The economic advantages derived from this kind of manufacture, as well as some of their intrinsic properties, explain the strong demand of this product. Cast irons, with an annual production of 73.2 million tonnes in 2015, are, after steels, the metallic material most used worldwide. Cast irons are followed (regarding the production) in weight importance by aluminum and alloys (58.3 million tonnes in 2015).

The relation among the world production of cast irons and the total production of steel has decreased in the last years, being this relation 4.58% in 2015 (Fig. 1).

The industry of cast irons generates more employments than the steel industry, even when the investment for each position is only the seventh part of the equivalent in the steel industry. Nowadays, it is estimated that around 4.5 million people work (worldwide) in the steel industry, while around 3.5 million people work in the cast irons industry. However, one position in the cast irons industry generates, at

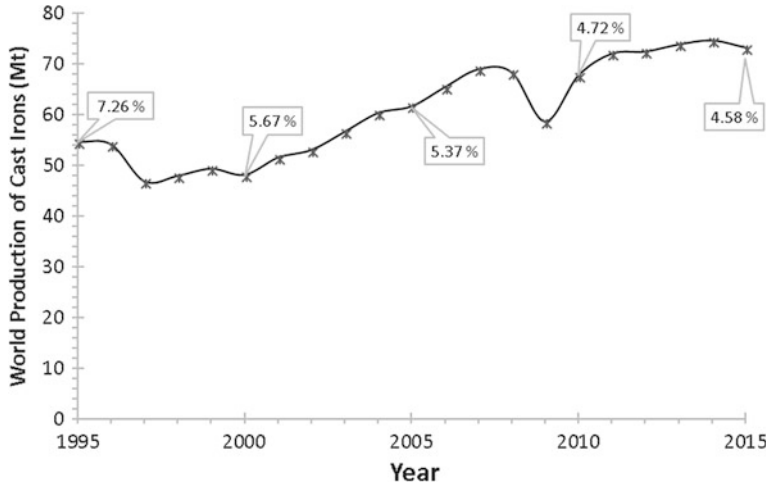

Fig. 1 World production of cast irons and their percentage in relation to steel production

least, other two or three in the metal mechanic industry. In short, the industry of cast irons has a strong impact in the horizontal integration of goods production.

The study of cast irons offers several facets: melting elaboration, physical chemistry of the equilibriums in liquid state, appropriate geometrical design of the parts, moulding technology, etc. Throughout the pages that compose this book, the physical metallurgy of cast irons is preferably studied with the objective of providing a criterion for the rational election of cast irons. That is, the relation between composition, metallographic structure derived from the composition and properties is studied, as well as the possibility of modifying the structure and properties by heat treatment.

It is assumed that the reader is familiarized with the constituents of the alloys, simples (solid solutions, intermetallic compounds, etc.) or compounds (eutectics, eutectoids); and that the reader knows and interprets the equilibrium diagrams. To study the previous fundamentals, as well as to know the fundamentals of solidification and transformations in solid state, the book of José Antonio Pero-Sanz Elorz, María José Quintana Hernández and Luis Felipe Verdeja González entitled *Solidification and Solid-state Transformation of Metals and Alloys* (Elsevier, 2017, first edition) is available for the readers.

From Chaps. 1 to 5, the metallographic structures of cast irons are studied. These chapters concern low and medium-alloyed cast irons, although the notions developed in these chapters will reach other types of cast irons. Chapter 5 is dedicated to the general properties resulted from the structure of grey cast irons.

Chapters 6 and 7 are devoted to malleable and ductile irons, while Chaps. 8 and 9 deal with the high-alloy cast irons. Chapter 8 is dedicated to the diagram Fe–C–Cr with the purpose of justifying several types of cast irons with corrosion resistance. White cast irons are first studied in Chap. 9 as an introduction to the alloyed cast irons used in applications where abrasion resistance is required. Chapter 9 continues with the explanation of high-alloy cast irons characterized by abrasion, corrosion or heat resistances.

Chapter 10 comprises exercises, problems and case-studies. This chapter could be of special interest for the readers after studying the book. Different situations, some of them real case-studies, will help the reader in the full understanding of the cast irons applications, with problems of moulding practice as well as exercises for studying the mechanical properties of cast iron parts. Finally, Chap. 11 is dedicated to the manufacture of cast irons in cupola furnace.

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Acknowledgements

Nearly 30 years after the first edition in Spanish (new revised edition in 2018) of the book of Prof. José Antonio Pero-Sanz Elorz, that was entitled *Materiales para la Ingeniería. Fundiciones Férreas*, the new edition of the book, this time in English, is published as a small tribute to him. With the idea of reaching a larger public, the original book was translated into English, and more than 50 solved exercises were included with the purpose of facilitating the understanding of the document. The book, now entitled *Physical Metallurgy of Cast Irons*, will be a support for professors in the fields of metallurgy and materials science, but also will be interesting for industrial professionals and researchers.

In this new edition of the book, several people have collaborated, and we want to express our sincere gratitude for their support. We thank José Ignacio Verdeja González of the University of Oviedo (Oviedo, Asturias, Spain), and María José Quintana Hernández and Roberto González Ojeda of the Panamerican University (México City, Mexico) for their advices and support. We cannot forget the invaluable help of José Ovidio García García, we thank him for the micrographs and good attitude towards work. Moreover, we express our gratitude for the valuable collaboration, help and support to the companies Arcelor Mittal Spain and Fundyser (www.fundyser.com/, Gijón, Asturias, Spain).

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