

TSINGHUA UNIVERSITY

Tsinghua University Academic Treatise

CAST IRONS CONTAINING RARE EARTHS

Sheng Da Liu Jincheng

Tsinghua University Press

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清华大学学术专著

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含稀土的铸铁

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内 容 简 介

本书是一本关于含稀土铸铁的专著,书中综述了该领域国内外的进展和作者近年来的研究和工业实践成果。内容包括稀土在铸铁中应用的理论基础和对铸铁组织与性能的影响;制取含稀土的铸铁的方法;含稀土的球化剂、蠕化剂和孕育剂、熔炼技术;稀土在球墨铸铁、蠕墨铸铁、灰口铸铁、白口铸铁和可锻铸铁中的应用实例和经济成果。此外,还附有各国的各种铸铁标准和所用的含稀土的球化剂、蠕化剂和孕育剂的规格与成分

本书可供从事铸造和稀土专业的大学生、研究生和工程技术人员参考。

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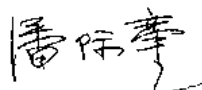
ABSTRACT

This book is based on national and international developments, together with the author's fifteen years' experience of teaching, research and industrial practice concerning the effects and application of rare earths in cast iron. It describes the fundamental principles and experience of the application of rare earths in cast irons ; the effects of rare earths on microstructure and properties of cast iron; the production methods of different types of cast irons containing rare earths; spheroidisers, vermicularisers and inoculants containing rare earths; melting practice; application examples and the economical effects of rare earths in grey cast irons, spheroidal graphite cast irons, vermicular graphite cast irons, white cast irons and malleable cast irons. In addition, different countries' standards and specifications for different types of cast iron, and standards and specifications concerning the composition of different types of inoculants, spheroidisers and vermicularisers are given.

This volume can be used as a reference book for university lectures and research students, engineers and technicians in the foundry and rare earth industries.

FOREWORD

China has the richest Rare Earths (REs) resources over the world. The recoverable REs reserve amounts to 36 millions tons taking up more than 80 % of reserves of REs in the world. Cast iron is the largest field of application of REs and the quantity of utilized REs in this area is the biggest among all industrial departments. Authors have devoted themselves to study of mechanism about effects of REs on microstructure and properties of cast irons and industrial applications more than twenty years. This book covers extensive topics dealing with both fundamental theories and technological problems for application of REs in cast irons. Especially it contains the development of application of REs in cast irons in China. I believe that this book is a valuable materials for expert concerned, it would certainly promote international exchange in the fields of both fundamental theory and technological problems about application of REs in cast irons. Great progressing in this field can be expected in future.



(Jiluan Pan)

Professor of Tsinghua University

President of Nanchang University

Member of the Chinese Academy of Sciences

在我的案头摆着盛达教授编著的《稀土铸铁》一书，读后给我增加不少这方面的专业知识。欣闻此书将出英文版，便于传世。为此，想谈几点看法。

半个世纪以来，稀土在中国得到特殊的重视，三代国家领导人都曾为发展中国稀土工业给予过指导。近十年来，我国稀土产量和出口量都跃居世界第一位。原因除了我国有世界上最丰富、最齐全的稀土资源外，更由于稀土具有的优异性能和广泛用途，无论在国民经济上，还是高新技术发展上都是重要的战略物资。在我国稀土发展史上还有个特殊情况，就是 20 世纪 50 年代建设包头钢铁公司时，将世界最大的稀土资源——白云鄂博复杂矿当作铁矿来开采利用。这样每年就有几十万吨稀土随着铁矿被开采出来，等待利用。这个任务迫切摆在国家领导面前，当时，除积极组织成立包头白云鄂博资源综合利用研究机构外，60 年代接连召开两次包头资源综合利用会议。明确了白云鄂博资源综合利用方针，特别提出在我国要大力推广稀土的应用。根据当时世界稀土利用趋势，要多用稀土，必须附在如冶金、石油化工、玻璃陶瓷等大的行业上。为此，中国还致力于将稀土用于农业的增产上，并获得成功。

60 年代初，就在这种时代背景下，中国科学院上海冶金研究所的邹元曦教授首先研究成功用硅铁还原包钢的高炉渣，制得稀土硅铁合金。为我国以后开展稀土在冶金中的应用，开一个好头。因为包钢在 60 年代初还未建选矿厂，炼铁是原矿入炉，高炉渣含稀土（氧化物）高达 9% 左右，用硅铁还原得稀土硅铁合金，开辟了

稀土在冶金中应用的途径。最初用于生产稀土铁锅、铧犁，逐步从稀土铸铁到稀土钢，在我国稀土应用史上起到带头羊作用。不仅如此，其消费稀土量始终居第一位，近年来我国消费的稀土有 1/4 是用于生产稀土铸铁，而全部用于冶金的稀土量约占总消费量的 1/3。虽然如此，稀土在冶金中的应用还远远没有达到饱和程度，只是稀土铸铁一项，仍有庞大的市场有待去开发。例如，我们不时看到这样的新闻：由于大直径铸铁上水管爆裂，造成灾害。假如用的是稀土铸铁管就不会发生这类事故。

盛达教授长年从事稀土铸铁研究和应用推广工作，成绩卓著，是这方面工作的带头人。所著《稀土铸铁》一书是积其多年心血和经验而写成。从稀土在铸铁中的作用机理到稀土铸铁的制备方法，包括稀土球化剂、稀土蠕化剂、稀土孕育剂以及稀土球墨铸铁、蠕墨铸铁等的实用价值及经济效果。该书既具有稀土铸铁研究的指导作用，又有组织生产和应用推广实用价值，是本难得的好书，愿给予推荐。

李东英

中国工程院院士教授
国家发展技术委员会
稀土办专家组组长

2000 年 1 月 17 日

FOREWORD

I am very glad to learn that the English version of *Cast Iron Containing Rare Earths* by Prof. Sheng Da is being brought out. I have read the Chinese version of the book and find myself having gained a greater insight into this field. The book is indeed a quintessence of the development of the rare earths (REs) industry in China.

The REs industry has been attached great importance to in China for the past five decades. All the three generations of the Chinese national leaders since 1949 have given personal guidance to the development of the industry. China has the richest and the greatest variety of REs resources, and her output and export of REs have both ranked the first in the world for the past ten years. Owing to their excellent properties and their wide range of application, REs have become an important strategic material in the development of both the national economy and the high tech industries.

There was a special occasion which facilitated the development of the REs industry in China. The Baiyunebo multiple mineral deposit, which was the biggest REs mine of the world, was exploited as an iron mine in the 1950s to supply raw materials to the then newly-built Baotou Iron & Steel Plant (BISP). Thus simultaneously hundreds of thousands of tons of REs were mined as a by-product. How to use the REs became an urgent concern to the national leaders. Consequently, the Institute for Comprehensive Utilization of Baiyunebo Resources was set up in Baotou City. In the 1960s at the two successive

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conferences on comprehensive utilization of Baotou resources, it pointed policy complete utilization of Baiyunebo resources and made clear that the application of REs should be vigorously promoted. REs then tended to be applied in metallurgical, petrochemical and glass-ceramic industries in other countries. Besides those conventional uses, China has also successfully found ways to use them in raising agricultural production.

Among the efforts to study the application of REs, Prof. Zhou Yuanxi from Shanghai Metallurgical Institute of the Chinese Academy of Sciences made a distinguished contribution. In the early 1960s, he discovered how to use ferrosilicon to reduce blast furnace slag to get REs ferrosilicon alloy. There was no ore dressing process in BISP at the time and the ores from the mine were put directly into the furnace. As a result, the slag contained as high as around 9 % REs.

Prof. Zhou's discovery opened an epoch of applying REs in metallurgical industry in China. At first REs ferrosilicon alloys were used to produce pans and ploughshare. Then they were used to manufacture cast iron and steel containing REs. In fact, the consumption of REs in metallurgy was always the highest among their multiple uses. In recent years, one fourth of the REs consumed in China was used in producing cast iron containing REs and the total amount of REs used in metallurgy was one third of the total REs consumption. However, the application of REs in metallurgy is still far from reaching the saturating level. There is a great market yet to be explored in the single field of cast iron containing REs. From time to time we may read about news of damages due to bursts of large cast iron water pipes. If cast iron containing REs were used to build those pipes, the accidents would have been avoided.

Prof. Sheng Da has been devoted to researches into cast iron containing REs and its application for years. He has made a number of notable achievements and is a leading expert in the field. His work, *Cast Iron Containing Rare Earths*, is based on his years-long painstaking work and experiences. The book deals extensively with the acting mechanism and manufacturing methods of different types of cast iron containing REs, such as spheroidizers, vermicularizers, inoculants, ductile iron, vermicular graphite cast iron and gray cast iron containing REs. Assessment of their practical value and economic effects is also included. The book, therefore, is valuable to both researchers and manufacturers. I strongly recommend it to those who are concerned.

by Li Dongying

Member of Chinese Academy of Engineering

Director of Specialists' Group of Rare Earths Office, National
Development and Plan Commission

Jan.7, 2000

Translated by Cui Xunli

PREFACE

China has the richest rare earth resources in the world. Its proven rare earth reserves far exceed the total resources of the rest of the world. In addition the production and consumption of rare earths in China are at the forefront of the world.

The effects and application of rare earths in cast iron have been key research projects sponsored by the National Science and Technology Commission during the 5th, 6th and 7th National five-year plans. Currently the largest use of rare earths is in the cast iron industry, and forecasts from China, USA and Japan suggest that this situation is likely to remain well into the twenty first century.

We are writing this book to promote the use of rare earths in cast iron production and would like to acknowledge the information and support which we have received from the following sources during the writing process: the Rare Earth Office of the National Plan Committee, The Rare Earth Office of the Ministry of Metallurgy, the Chinese Society of Rare Earth, the National Application and Technology Service Centre of Rare Earth in Cast Iron, Baotou Iron & Steel and Rare Earth Company, Cang Zhou City Fuda Metallurgical Products Limited in Hebei Province, Jing Cheng GLD Rare Earths Metal Co. Ltd in Shanxi Province. In addition a wealth of data has been accumulated through our long-standing partnership with Foundry Works of Shou Du Iron and Steel Company, Roll Works of Benxi Iron and Steel Company, the First Rare Earth Alloy Plant of Baotou Iron and Steel and Rare Earth Company, Hebei Ji Zhou City Radiator Works and others, all of whom have helped to lay the foundation for

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writing this book.

We would like to thank Dr. Jia Zhijie and Dr. Li Shuangsoo for their assistance in the writing and editing of this volume. Especially to thank professor Eilliot R. (Menchster Material Science Centre, University of Menchster & UMIST, U. K) who checks this book in both content and English carefully and presents many good suggestions to make the book better. We would also appreciate further critical feedback from whom concerning this book. This work was supported by publishing fund of Tsinghua University.



Sheng Da Professor of Dept. of Mechanical Engineering, Tsinghua University, Metallurgical Science Educator, A member of Council, Chinese Society of Rare Earth. The date of birth: July 26, 1935, graduated from Tsinghua University, China 1960. Author: Rare Earth Cast Iron, 1994. Vice general editorial director: Application of Rare Earth in Iron and Steel, 1987 Co-author: Vermicular Graphite Cast Iron, 1982. A member of Editorial Commission: Rare Earths (The second edition) 1995, holder 6 patents in field. Recipient: 3d National Science Technical Progress award, 1985; National Sparking award, 1988; 2d Science-Technical award of Beijing 1985; 2d Science-Technical Progress award of National Education Commission, 1987, 1988; 3d Science - Technical work award of Shanxi Province, 1999.

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