



SECOND EDITION

影印版

铸造手册大全：金属铸造工艺、冶金技术和设计
第6册 熔炼·造型·铸造·凝固

COMPLETE CASTING HANDBOOK

Metal Casting Processes, Metallurgy,
Techniques and Design

JOHN CAMPBELL

ELSEVIER



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John Campbell
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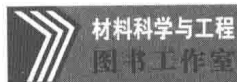
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Metal Casting Processes, Metallurgy, Techniques and Design

Second Edition

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Department of Metallurgy and Materials,
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Preface

In this first update of the *Handbook*, the major revisions are probably those relating to running system design in which the vestiges of filling defects have finally been eliminated from castings.

Thus, the powerful benefits of contact pouring (in which the universal conical trumpet decorating all traditional filling systems is now eliminated) is finally shown to have been hugely underestimated by a number of foundries. Contact pouring has probably been the most important (and the most simple and zero-cost) initiative to revolutionise quality in castings. In addition, the adoption of various forms of tangential filter designs to gates has finally eliminated the problem of the entrainment of priming bubbles. These residual bubbles have long impaired the benefits of previous filling systems.

Gravity pouring has now advanced to the point at which I find myself having to admit that it starts to threaten my cherished and favoured casting production system: countergravity.

This is seen to be especially true for those low-pressure systems which use a refractory lining for the pressurised furnace. I only recently discovered the hugely damaging emission of bubbles from these linings during depressurisation of the furnace. This problem has clearly been a major source of impaired castings in the low-pressure casting industry and has hampered this industry since its beginnings.

The use of my pneumatic pump is described for the first time. It would lower costs and solve most of the problems of this industry. Thus, I continue to stand by countergravity as the optimum casting system where it can be used. My hope is that it will be teamed up with a good melting and metal handling system. Only careful foundry design will minimise bifilm populations in metals. Only when castings can be produced substantially free from bifilms will we enjoy the full benefits of castings, and metals in general, resistant to hot tearing, cracking, blisters, corrosion pitting and attack of grain boundaries, plus the benefits of extraordinary mechanical properties, potentially eliminating future failure by fracture or fatigue.

These are heady predictions. However, early results in foundries are already indicating that beautiful defect-free castings with revolutionary metallurgical benefits appear to be routinely attainable. Despite challenges from the undoubtedly unique benefits of such new processes as additive manufacture, my hope for the future for castings is based on the adoption of simple principles which could not only secure the future of our casting industry, but improve the welfare and environment of all of us whose lives depend on it.

JC
Ledbury, Herefordshire, England
02 April 2015

Introduction

CASTINGS HANDBOOK, 2ND EDITION, 2015

When *Castings Handbook* first appeared in 2011, I had not expected to revise it so soon. However, the latest findings require publicising as quickly as possible—there is still a long way for the industry to go! The message of the book, summarised in the section “Bifilm-free Properties”, is that a quality improvement of astonishing scale is possible now. When I first started to experiment with novel filling systems for castings, there were naturally many disappointments. However, those days are long gone. The concepts of entrainment and bifilm creation laid out in the book are now proven. Some foundries are already being designed to take advantage of a unique and easily affordable quality revolution and scrap reduction. More need to follow. The risks are minimal and the rewards are great.

With regard to improved casting techniques which can reduce or even eliminate the usual vast populations of bifilms in our metals, I have always been aware of the potential benefit of contact pouring, but had completely underestimated its effects. It achieves miraculous improvements to castings by eliminating the 50% air mixing step. Contact pouring is strongly recommended in this volume as a major but low-cost step forward.

The ultimate step forward is countergravity casting which should always be targeted if possible. However, although I discuss the traditional pumping techniques, I present here for the first time my new pneumatic pump. It is another low-cost, reliable technique which enjoys uniquely low turbulence and might allow a rapid takeover of this unique technology.

Turning to the seriousness of the current position in casting, and in metallurgical engineering as a whole, the fact that most current metals can fail by cracking should alert us to the glaring inconsistency in our metallurgical thinking because many of our metals and alloys are ductile, so failure by cracking should be impossible. In a ductile metal an attempt to propagate a crack should merely result in the crack tip blunting, preventing propagation.

In the absence of any other viable alternative mechanism, that metals do crack is a strong indication that cracks pre-exist in metals in the form of bifilms formed in the liquid state during pouring of the metal to make a casting. The poor practice is almost universally associated with pouring methods which ensure that the molten metal is mixed and emulsified with at least 50 volume % of air during its journey into the mould. I defy anyone to make a respectable casting from such a disgracefully inappropriate and inept technique. This book presents the case that this need not be so; metals need not contain bifilms, and thus need not contain those Griffith cracks which can initiate failure by cracking. To achieve this, we simply have to improve our casting technology.

It remains the case that bifilms are still lamentably researched, so that this book has to resort to sifting through inconclusive and fragmentary evidence from researchers who were not looking for bifilms. Unfortunately, researchers up until now have not been aware of their presence, and certainly did not suspect their overwhelming influence on their results. Although a welcome start is being made by a few workers, I remain impatient for more definitive research to be carried out.

In the meantime, while researchers slowly get around to proving the background theory, founders need not wait for answers. Practical low bifilm casting techniques have already been developed and are described here. They promise the quality improvement and cost reduction that the casting industry so badly needs.

Acknowledgements

It is a pleasure to acknowledge the significant help and encouragement I have received from many good friends. John Grassi has been my close friend and associate at Alotech, the company promoting the new, exciting ablation castings process. Ken Harris has been an inexhaustible source of knowledge on silicate binders, aggregates and recycling. His assistance is clear in Chapter 15. Clearly, the casting industry needs more chemists like him. Bob Puhakka has been the first regular user of my casting recommendations for the production of large aluminium and steel castings, which has provided me with inspirational confirmation of the soundness of the technology described in this book. In addition, the practical feedback and warm friendship over several years from those at the UK steel foundry Furniss and White is a pleasure to record. Murat Tiryakioglu has been a loyal supporter and critic, and provides the elegantly written publications that have provided welcome scientific underpinning. He has provided generous and invaluable help with the important section *The Statistics of Failure*. Naturally, many other acknowledgements are deserved among friends and students whose research has been a privilege to supervise. I do not take these for granted. Even if not listed here, they are not forgotten.

The American Foundry Society is thanked for the use of a number of illustrations from *Transactions*.

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