

# Sand Casting Rapid Tooling Guidelines

Full download: <http://manualplace.com/>

Wanlong Wang  
Henry W. Stoll  
James G. Conley

## Rapid Tooling Guidelines For Sand Casting

 Springer

This is the cut pages sample. Download

# Mechanical Engineering Series

**Frederick F. Ling**

*Editor-in-Chief*

For further volumes:

<http://www.springer.com/series/1161>

# Mechanical Engineering Series

Frederick F. Ling  
*Editor-in-Chief*

The Mechanical Engineering Series features graduate texts and research monographs to address the need for information in contemporary mechanical engineering, including areas of concentration of applied mechanics, biomechanics, computational mechanics, dynamical systems and control, energetics, mechanics of materials, processing, production systems, thermal science, and tribology.

## *Advisory Board/Series Editors*

---

<b>Applied Mechanics</b>	F.A. Leckie University of California, Santa Barbara
	D. Gross Technical University of Darmstadt
<b>Biomechanics</b>	V.C. Mow Columbia University
<b>Computational Mechanics</b>	H.T. Yang University of California, Santa Barbara
<b>Dynamic Systems and Control/ Mechatronics</b>	D. Bryant University of Texas at Austin
<b>Energetics</b>	J.R. Welty University of Oregon, Eugene
<b>Mechanics of Materials</b>	I. Finnie University of California, Berkeley
<b>Processing</b>	K.K. Wang Cornell University
<b>Production Systems</b>	G.-A. Klutke Texas A&M University
<b>Thermal Science</b>	A.E. Bergles Rensselaer Polytechnic Institute
<b>Tribology</b>	W.O. Winer Georgia Institute of Technology

Wanlong Wang • Henry W. Stoll  
James G. Conley

# Rapid Tooling Guidelines For Sand Casting

 Springer

Wanlong Wang  
Wang Consulting International  
1415 Bellevue Avenue  
Unit 6  
Burlingame, CA 94010  
USA  
wangwl@hotmail.com

Henry W. Stoll  
Department of Mechanical Engineering  
Northwestern University  
2145 Sheridan Road  
Evanston, IL 60208-3111  
USA

James G. Conley  
Kellogg School of Management and  
McCormick School of Engineering  
Northwestern University  
2001 Sheridan Road  
Evanston, IL 60208  
USA

ISSN 0941-5122  
ISBN 978-1-4419-5730-6 e-ISBN 978-1-4419-5731-3  
DOI 10.1007/978-1-4419-5731-3  
Springer New York Dordrecht Heidelberg London

Library of Congress Control Number: 2010920244

© Springer Science+Business Media, LLC 2010

All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer Science+Business Media, LLC, 233 Spring Street, New York, NY 10013, USA), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden.

The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

Printed on acid-free paper

Springer is part of Springer Science+Business Media ([www.springer.com](http://www.springer.com))

## Series Preface

Mechanical engineering, an engineering discipline forged and shaped by the needs of the industrial revolution, is once again asked to do its substantial share in the call for industrial renewal. The general call is urgent as we face profound issues of productivity and competitiveness that require engineering solutions among others. The Mechanical Engineering Series features graduate texts and research monographs intended to address the need for information in contemporary areas of mechanical engineering.

The series is conceived as a comprehensive one that covers a broad range of concentrations important to mechanical engineering graduate education and research. We are fortunate to have a distinguished roster of consulting editors on the advisory board, each an expert in one of the areas of concentration. The names of the consulting editors are listed on the facing page of this volume. The areas of concentration are applied mechanics, biomechanics, computational mechanics, dynamic systems and control, energetics, mechanics of materials, processing, production systems, thermal science, and tribology.

Austin, Texas

Frederick F. Ling

## Preface

Sand casting is a versatile manufacturing process with a history that dates back thousands of years. As automation and production technologies have evolved with time, sand casting methods have advanced to realize improved adaptability and efficiency. The process is now used for both large and small dimensioned products in both high volume and small batch production lot sizes. Many metals and alloys that can be poured in a foundry can use the sand casting process.

A chronic challenge in managing sand casting production is the efficient (cost, time) fabrication and maintenance of the elements that form the sand molds, specifically patterns and core tooling. Traditionally, sand casting patterns and tooling are produced manually from wood or dimensionally stable synthetic materials. The advance of numerical controls and computer numerically controlled (CNC) machining dramatically improves the efficiency and reliability of this form of tooling production.

With the invention and commercialization of the stereo lithography process in 1986, a variety of new and improved layered manufacturing processes were introduced to the marketplace. The working materials of these processes evolved from laser cured epoxy to wood like layered paper, engineering plastics and other forms. With the appropriate part data, rapid prototyping processes could produce patterns and core box tooling directly, hence the dawn of rapid tooling. While CNC fabrication processes are accurate, they consume a considerable amount of working material to get to the net tooling shape. They are also time consuming, often a critical variable in a world of short supply chains.

In this environment of dynamic technological change, the use of either CNC or emergent rapid tooling techniques to produce parts that have uncertain demand curves, like military hardware, becomes an important question for procurement professionals.

In an effort to inform such decision, the authors undertook an analysis of how tools and sand castings may be produced for a variety of part geometries. With the support of the Defense Logistics Agency, Clinkenbeard, and Lufkin, the authors developed best practice guidelines for rapid tooling of sand castings. The methodology used included:

- Identification and selection of components (w/ solid model) suitable for sand casting;
- Evaluate tooling error sources for sand casting;

- Produce the rapid tooling (by either CNC, RT or a combination) and create castings;
- Express tool path selection framework for sand casting;
- Dimensional metrology investigation of rapid tooling patterns, molds and resultant castings using best practices;
- Analysis of tooling related costs and lead times.

The results of these investigations provide the research foundation for this book.



## **Acknowledgement**

The authors are grateful to Dan Gearing of the Defense Logistics Agency, Joseph Santner of the American Foundry Society and Ron Gustafson of Clinkenbeard for their support of the research that provides the foundation for this book.

James Conley would also like to acknowledge the early career support of Prof. Morris E. Fine of Northwestern University and Dr. Akio Urakami of the Ryobi Group of Companies. Both positively influenced the author's logic for addressing the practical challenges described in this manuscript.

The authors also want to express their appreciations to Alex Greene, Editorial Director, and Ciara.Vincent from Springer US for their support in realizing the publication of this work.

## **Table of Contents**

<b>Series Preface</b> .....	<b>v</b>
<b>Preface</b> .....	<b>vii</b>
<b>Acknowledgement</b> .....	<b>ix</b>
<b>Chapter 1 Sand Casting Processes</b> .....	<b>1</b>
1.1 Basic Steps in Making Sand Castings.....	1
1.1.1 Patternmaking .....	2
1.1.2 Coremaking.....	3
1.1.3 Molding.....	3
1.1.4 Melting and Pouring.....	3
1.1.5 Cleaning .....	4
1.2 Mold Making Processes.....	4
1.2.1 Green-sand molding.....	4
1.2.2 Dry-sand molding.....	7
1.2.3 Core-sand molding.....	8
1.2.4 Shell molding.....	8
<b>Chapter 2 Tool Design and Construction for Sand Casting</b> .....	<b>11</b>
2.1 Sand-Casting Tool Design and Construction.....	11
2.2 Pattern Type.....	15
2.2.1 Loose Patterns .....	16
2.2.2 Gated Patterns .....	17
2.2.3 Match-Plate Patterns .....	17
2.2.4 Cope & Drag Patterns .....	19
2.3 Pattern Design.....	20
2.3.1 Pattern and Core Box Materials .....	20
2.3.2 Pattern Allowances.....	23
2.3.3 Draft .....	27
2.3.4 Parting Line.....	28