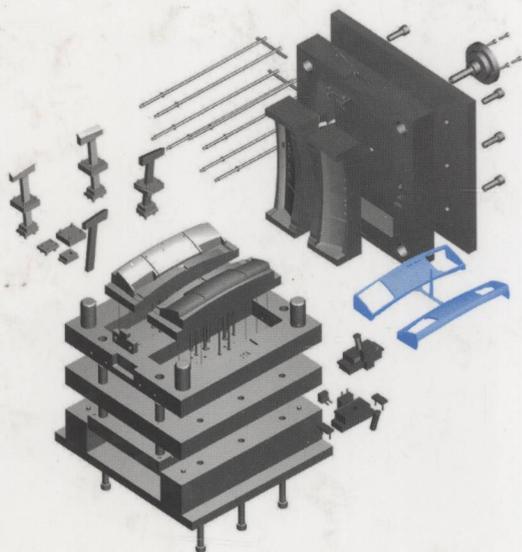


# **COMPUTER-AIDED INJECTION MOLD DESIGN AND MANUFACTURE**



**J. Y. H. Fuh  
Y. F. Zhang  
A. Y. C. Nee  
M. W. Fu**

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*To our families*

*for their kind understanding and unfailing support during  
the long hours we have spent on this book*

# Preface

Mold making is an important sector in the precision engineering industry since molded parts represent more than 70% of the consumer products, ranging from computers, home appliances, medical devices, to automobiles, etc. The high demand for shorter design and manufacturing lead-time, good dimensional accuracy, overall quality and rapid design changes have become the main bottlenecks to the mold-making industry. To maintain the competitive edge, there is an urgent need to shorten the lead-time and reduce manufacturing costs by automating the design process. Computer-aided design and computer-aided manufacturing (CAD/CAM) technologies, which emerged during the past two decades, have helped to increase engineering productivity significantly. They have provided the total integration of design, analysis and manufacturing functions and have had a large impact on the engineering practices.

While CAD/CAM has found a wide range of engineering applications, its applications to mold design and manufacturing have been relatively limited. Most of the mold-making companies now use 3-D CAD software to design tooling for increasing their productivity; however, the lack of a semi-auto- or fully auto-design system makes the design tasks manual, daunting, time-consuming and error-prone. Thus, the development of computer-aided injection mold design systems (CADIMDS) has become a must and a research focus in both industry and academia since the 1990s.

This book aims to report the latest research and development achieved in automating plastic injection mold (for plastic) and die casting mold (for metal) design and manufacture. It hopes to promote the use of CADIMDS and stimu-

late greater R&D efforts in this critical area. While most of the major CAD/CAM vendors are actively developing mold application modules, there are still many technical issues which need to be addressed. Based on the authors' past eight years of research on intelligent mold design technologies at the National University of Singapore, many important findings are summarized and concluded in this book. In particular, the development and commercialization of an Intelligent Mold Design and Assembly System (IMOLD<sup>®</sup>) are thoroughly presented. The system architectures and detailed technologies described will be very useful for the development of applicable CADIMDS in the CAD/CAM markets.

Chapter 1 introduces the historical background of CAD/CAM technology for tooling design such as fixtures and injection molds, highlighting the importance of its R&D efforts and impact on industry. The bottlenecks and technical issues are described in detail. The main concepts of plastic injection mold and molding design, based on report literature, are described in Chapter 2. The design flow from the creation of a containing box, parting generation, runner and gating design, mold base selection, ejector design, cooling layout, etc., is presented. The issues of slider and lifter design for undercut features are also highlighted. The approaches to intelligent mold design and assembly that can lead to future fully automated systems are presented in Chapter 3. The algorithms for optimal parting directions, parting lines, and parting surfaces are given with illustrative examples. The undercut features recognition for sliders and lifters design and core and cavity generation are also covered. Several examples are used to illustrate the methodology. Chapter 4 describes a semi-automated die casting die (mold) design methodology that is similar to the plastic injection mold design approach but is applied to the injection of metals, e.g., aluminum, magnesium, etc. A unique method for a parametric and feature-based design approach is presented.

Detailed discussions on computer-aided engineering (CAE) and analyses for mold design are given in Chapter 5. This chapter fills the gap between the design and manufacturing of injection molds and thus brings up the possibility of future integrated CAD/CAE/CAM systems for mold design applications. In Chapter 6, mold manufacturing and machining (cavity and core, in particular) are discussed. The key topics of cutter selection to ensure gouge-free 3-axis machining as well as automated EDM electrode design are comprehensively described. These issues are useful for CAM users in programming and planning the NC tool paths for the machining of complex injection molds. Chapter 7 reports on a computer-aided process planning (CAPP) approach specially developed for the manufacture of mold components. The approach, implementation, and prototype system are reported. Early cost estimation of mold making, a critical activity in mold manufacture, is presented in Chapter 8. One of the promising cost estimation approaches based on neural-network modeling is introduced. The case studies on both Unix-based and Windows-based intelligent mold design systems (i.e., IMOLD<sup>®</sup> and IMOLDWorks) are given in Chapter 9.

The prototypes of Windows-based mold design system and parametric die casting die design system are used to demonstrate the previously presented methodologies. The implementation details are shown together with many industrial example parts.

The mold design and molding technologies are important to the material processing of metals and plastics that constitute most of the engineering materials used today. This book is intended to give the most comprehensive descriptions and thorough study on CAD/CAM and CAE of injection molds for researchers and developers in the industry, R&D organizations and universities, with particular focuses on the algorithms, implementations and system architecture that can eventually lead to a fully automated or semi-automated CADIMDS. It also provides valuable information to the designers and developers in this challenging research field and can be used as either a design handbook or a reference/text for a graduate course in understanding intelligent mold design technologies. We sincerely hope that through this publication, greater R&D efforts can be generated from both academia and the industry in critical CAD/CAM and CAE technologies that eventually will benefit the precision engineering industry as a whole.

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*J. Y. H. Fuh*  
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*A. Y. C. Nee*  
*M. W. Fu*

# Contents

<i>Preface</i>	v
<i>Acknowledgments</i>	ix
<b>1. Introduction</b>	<b>1</b>
1.1 CAD/CAM Technology in Tooling Applications	1
1.1.1 Fixture Design	2
1.1.2 Die and Mold Design	4
1.2 CAD/CAM of Injection Molds	6
1.2.1 Plastic Injection Molds	8
1.2.2 Die Casting Molds	9
1.3 Summary	9
References	10
<b>2. Plastic Injection Mold Design and Assembly</b>	<b>13</b>
2.1 Introduction	13
2.2 Plastic Injection Mold Design	15
2.2.1 Injection Molding and Mold	15
2.2.2 Injection Mold Design Process	16
2.2.3 Detailed Mold Design	20
2.2.4 Mold Assembly	32
2.3 Mold Design Methodology	33
2.3.1 The Mold Development Process	33
2.3.2 Top-Down vs. Bottom-Up Approach	35
	<b>xi</b>

2.4	Computer-Aided Injection Mold Design and Assembly	35
2.4.1	Assembly Modeling of Injection Molds	36
2.5	Summary	41
	References	42
<b>3.</b>	<b>Intelligent Mold Design and Assembly</b>	<b>45</b>
3.1	Introduction	45
3.2	Feature and Associativity-Based Injection Mold Design	46
3.2.1	Feature Modeling	47
3.2.2	Associativity Within Injection Molds	50
3.3	Representation of Injection Mold Assemblies	54
3.3.1	Concepts and Notations for Object-Oriented Modeling	54
3.3.2	Object-Oriented Representation of Mold Assembly	55
3.4	Optimal Parting Design for Core and Cavity Creation	58
3.4.1	Optimal Parting Direction	59
3.4.2	Generation of Parting Lines	64
3.4.3	Determination of Parting Surfaces	75
3.4.4	Automatic Generation of Core and Cavity	78
3.5	Automatic Cavity Layout Design	82
3.5.1	Cavity Layout and Number	82
3.5.2	Automatic Layout of Multi-Cavity	87
3.6	Recognition and Extraction of Undercut Features	91
3.6.1	Definitions and Classifications of Undercut Features	91
3.6.2	Undercut Features Recognition	92
3.6.3	Draw Range and Direction of Undercut Features	94
3.6.4	Graph Representation of Solid Models	97
3.6.5	Recognition Algorithms	106
3.7	Generation of Side-Cores for Sliders and Lifters	110
3.7.1	Slider and Lifter Mechanism	110
3.7.2	Designing Side-Cores	112
3.7.3	Recognition of Undercuts from Core and Cavity	113
3.7.4	Automatic Generation of Side-Cores	117
3.8	System Implementations and Case Studies	120
3.8.1	System Architecture	120
3.8.2	Development Platforms and Programming Languages	120
3.8.3	Functional Modules and Graphical User Interfaces	121
3.8.4	Case Study	128
3.9	Summary	133
	References	133
<b>4.</b>	<b>Semi-Automated Die Casting Die Design</b>	<b>137</b>
4.1	Introduction	137
4.2	Principles of Die Casting Die Design	139
4.2.1	Die Casting Die Design	139

4.2.2	Gating and Runner System Design	140
4.2.3	Die-Base Design	142
4.3	Computer-Aided Die Casting Die Design	143
4.3.1	Automated Design of Die Casting Die	143
4.3.2	Computer-Aided Design of Gating System	144
4.4	Design of Cavity Layout and Gating System	145
4.4.1	Determination of Cavity Number	145
4.4.2	Automatic Creation of Cavity Layout	147
4.4.3	Determining the Parameters of Gating System	148
4.4.4	Design of Gating Features	154
4.4.5	Conforming the Gate Geometry to the Die-Casting Part	159
4.4.6	Design of Shot Sleeve, Sprue, and Spreader	159
4.5	Die-Base Design	161
4.5.1	Design of Die-Base	161
4.5.2	Die-Base Structure and Variables	162
4.5.3	Creating the Parametric Assembly Models of Die-Base	162
4.5.4	Building the Die-Base Database	165
4.5.5	Automatic Generation of Die-Base	165
4.6	Generation of Core and Cavity	166
4.7	Automatic Subtraction of Die Component	167
4.8	System Implementation and Examples	169
4.8.1	Development Platforms and Languages	169
4.8.2	System Architecture— <i>DieWizard</i>	170
4.8.3	Examples	175
4.9	Summary	184
	References	184
<b>5.</b>	<b>CAE Applications in Mold Design</b>	<b>187</b>
5.1	Introduction	187
5.2	CAE Analysis Procedures and Functionalities	189
5.2.1	Analysis Procedures	190
5.2.2	CAE Functionalities	190
5.3	CAE in the Mold Development Life Cycle	192
5.4	CAE Details in Mold Development	193
5.4.1	What CAE Reveals	195
5.4.2	CAE in Part Design	198
5.4.3	CAE in Mold Design	199
5.4.4	CAE in Process Design	202
5.4.5	CAE in Product Quality Assurance	202
5.5	Application Examples	204
5.5.1	Injection Mold Cooling Analysis	205
5.5.2	Simulation of the Casting Process	210
5.6	CAE Challenges in Mold Design	214
5.7	Summary	217

References	218
<b>6. Computer-Aided Die and Mold Manufacture</b>	<b>221</b>
6.1 Introduction	221
6.2 Interference-Detection in Mold Machining	223
6.2.1 Machining Interference	223
6.2.2 Methods of Interference Detection	224
6.3 3-Axis End-Mill Interference Detection	230
6.3.1 Local and Global Interference	232
6.3.2 Illustrative Example	245
6.4 Optimal Cutter Selection	246
6.4.1 Previous Work	246
6.4.2 Criteria of Selection	248
6.4.3 Machining Time and Machining Area	250
6.4.4 Step-Over and Machining Time Estimation	252
6.4.5 Cutter Selection Algorithms	253
6.5 Computer-Aided Electrode Design and Machining	254
6.5.1 Introduction	254
6.5.2 Principles of EDM Electrode Design	257
6.5.3 Electrode Tool Design	258
6.5.4 Electrode Holder Design	265
6.5.5 Sharp Corner Interference Detection	265
6.5.6 Illustrative Examples	270
6.6 Modification of Mold Design and Tool Path Regeneration	275
6.6.1 Introduction	275
6.6.2 Basic Concepts and Notations	275
6.6.3 Proposed Algorithm	276
6.6.4 Illustrative Examples	281
6.7 Summary	282
References	283
<b>7. Computer-Aided Process Planning in Mold Making</b>	<b>287</b>
7.1 Introduction	287
7.2 An Optimization Modeling Approach to CAPP	290
7.3 CAPP for Sliders and Lifters	292
7.3.1 Design of Sliders and Lifters	292
7.3.2 A Hybrid CAPP Approach	293
7.3.3 Process Planning Problem Formulation	296
7.3.4 Optimization Techniques for Process Planning	298
7.3.5 Discussions	304
7.4 System Implementation and an Example	305
7.4.1 The IMOLD_CAPP System	305
7.4.2 An Example	309
7.5 Summary	311