

CADCAM: Principles, Practice and Manufacturing Management (2nd Edition)

By Chris McMahon, Jimmie Browne

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The most balanced coverage of Computer Aided Design and Manufacture available!

Providing a balanced coverage of both aspects of CADCAM, this book explores the processes of defining a product design with the aid of computers, of developing manufacturing plans and instructions for the product, and of managing the manufacturing system itself. The book has been thoroughly updated and expanded for this second edition and the mix of theory, practice and analysis makes it suitable for both analytical and overview courses.

This book provides an ideal core text for CADCAM courses at undergraduate degree level in Industrial, Mechanical, Manufacturing and Production Engineering.

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Editorial Review

From the Inside Flap
Introduction

Throughout the life cycle of engineering products, computers have a prominent, often central role. In the process of product design and manufacture, this role is becoming increasingly important as competitive pressures call for improvements in product performance and quality, and for reductions in development time-scales. Computers assist design engineers to improve the productivity with which they carry out their work. Through simulation or analysis they allow the performance of a product to be evaluated before a prototype is made. They aid the organization of complex systems, and the communication of data within the engineering team. These applications may collectively be termed CADCAM: computer-aided design and computer-aided manufacture.

The purpose of this book is to provide a tutorial and a reference source for student and professional engineers who have an interest in the application of computers in product design and manufacture. Through sixteen chapters that provide a comprehensive overview of the application of computers in the product introduction process, the reader is guided through the process of defining a product design with the aid of computers, then developing manufacturing plans and instructions for the product from the design, and finally planning and managing the operation of the manufacturing system itself. Throughout, we seek both to explain underlying principles and to provide insights from applications, and we also seek to provide extensive references to books, research papers and on-line material to assist the reader in finding more information about the topics we present. In some cases we have omitted a detailed discussion of wide-ranging topics such as robotics and techniques for design analysis, because the subjects are in our view properly covered in dedicated textbooks. In these cases we again provide pointers to sources that we have found useful.

The material we present is intended to be suitable for senior or final year undergraduates and graduate students, principally in mechanical engineering (hence a particular emphasis on design), but also in manufacturing systems and industrial engineering. We hope that the material will also be of value to practising engineers in similar disciplines. It has been organized such that the text may be followed without the necessity to pursue theoretical detail, much of which has been placed in boxed sections or appendices. The chapter content has also been organized such that different routes may be taken through the material (identified at the end of this Preface), depending on whether the reader wishes to have an overview of the topics, to explore the theoretical foundations of the material, or to understand current research issues and developments. Exercises are provided so that the reader may check his or her progress with the material, and projects allow the concepts that have been introduced to be explored through practical applications.

New in this edition

Since the first edition of this book was published, a number of important developments have taken place in CADCAM, in the standards that apply to the topic, and in the engineering environment in which CADCAM is applied. The primary purpose of this second edition is therefore to update the text to describe these developments. At the same time, the opportunity has been taken to make a general revision of the contents of

the book, to expand the number of case-study type applications examples and exercises, and to introduce project material.

In the first edition, concurrent engineering was introduced as an important driver for improved product quality and reduced development time-scales. In this edition it receives further emphasis, as does the modelling and management of product data. Opportunity has also been taken to generally update and expand material, especially on geometric modelling, database management systems, communications, graphics and product data exchange standards, parametric and variational approaches to geometric modelling, interfaces between CAD and design analysis, and process planning. In particular, the section on standards emphasizes recent developments in international standards, and extends description of de facto standards in CADCAM. New material has been incorporated on mesh generation for finite element analysis, the application of artificial intelligence in design, Taguchi methods for the design of experiments, robotics, the extended enterprise and distribution planning and control. As in the first edition, the material is divided into a number of parts that are each designed to be able to be read as stand-alone sections covering key areas in the subject. A development for this edition is the addition of a new final section to discuss emerging issues in CADCAM, including product data management, assembly and tolerance modelling, the impact of the global networks, and design for the environment.

As noted, this edition has a greatly increased emphasis on practical examples and on projects. A number of applications examples have been drawn from current manufacturing practice, to illustrate how the principles that are presented are being applied in a manufacturing context. The reader will also have the opportunity to explore applications through two projects that are developed through the first two parts of the book. The first project involves the development, from computer-aided design through to analysis and manufacture, of a single part. The second project explores the same process for a small electro-mechanical assembly. The projects are first explained in some detail in Chapter 1, and then at the end of each chapter the next stage in the development of the project is introduced, to allow the reader to explore concepts introduced in that chapter.

This edition also introduces some changes in the presentation and organization of material. In the treatment of geometric transformations the use of column vectors for coordinate data has been adopted in order to bring the book in line with engineering practice. The first edition used row vectors for coordinate data, as is common practice in computer graphics texts. The alternative approaches are described when the topic is first introduced. The main change in organization is the moving of the discussion of parametric and variational modelling from Chapter 6 to Chapter 8, where it has been extended and is now linked to feature-based approaches. Some of the material on engineering data management has also been moved from Chapter 5 to Chapter 16, where it is incorporated into a much wider discussion of product data management. Finally, some material has been removed or reduced, in particular the discussion of vector display devices and some aspects of the GKS graphics standard.

PART CONTENTS

Part One: Computer-aided design

This first part is concerned with the fundamentals of the modelling process by which designs are defined using computers, and with exploration of applications of the CAD model within the design process.

Chapter 1 The design process and the role of CAD: This chapter introduces CAD and places it in the context of the design process.

Chapter 2 Defining the model: This chapter provides an overview of the techniques for representing the design using drawings, diagrams and threedimensional computer models, including wire-frame, surface and solid modelling approaches.

Chapter 3 Techniques for geometric modelling: This chapter provides details of the fundamentals of the representations used in geometric modelling, including parametric curves and surfaces and techniques for solid modelling.

Chapter 4 Elements of interactive computer graphics: This chapter provides an overview of the display and user interaction techniques used in CADCAM, from two-dimensional graphics to techniques for visual realism. The chapter includes an overview of computer graphics hardware.

Chapter 5 Entity manipulation and data storage: The manipulation of elements of the CAD model and techniques for its storage are described in this chapter, including an overview of database management systems and details of the relational database approach.

Chapter 6 Applying the CAD model in design: This chapter describes applications aspects of CAD, and also presents details of methods for system custornization and links to analysis, including geometric analysis and mesh preparation for finite element analysis.

Chapter 7 Standards for CAD: This chapter provides an overview of the standards that apply to computer graphics, to networks, and to the exchange of product data.

Chapter 8 Expanding the capability of CAD: This reviews developments aimed at improving the utility of CAD through incorporation of techniques from artificial intelligence, and through improved representational techniques such as parametric, variational and feature-based modelling approaches.

Part Two: The design/manufacture interface

This part is concerned with activities at the design/manufacture interface, such as the organization of the product development activity, and preparation of process plans and manufacturing instructions from the design data.

Chapter 9 The design/manufacture interface: This chapter introduces the subjects at the interface between design and manufacture, and in particular describes design for manufacture and assembly, and process planning.

Chapter 10 The total approach to product development: This chapter reviews techniques and strategies for a systems approach to product development and quality in manufacture at the design/manufacture interface. In particular, organizational approaches to concurrent engineering, and Taguchi methods for off-line quality

control, are described.

Chapter 11 The link to machine control: The operation and programming of numerical control machine tools and robotic devices, and techniques for rapid prototyping, are reviewed in this chapter.

Part Three: Production planning and control

This part is concerned with the planning and control of the flow of work through a factory floor. It considers production planning and control issues at all levels in the factory and indeed back to suppliers and forward to distributors.

Chapter 12 Introduction to production planning and control: This chapter introduces a typology of manufacturing systems and presents an overview of the production management system in terms of a hierarchy of production planning and control systems. It seeks to present planning and control in the context of the extended enterprise model of manufacturing systems.

Chapter 13 Requirements planning systems: This chapter presents an overview of business planning and master scheduling systems and a detailed review of the operations of a requirements planning system. Reference is also made to the operation of material requirements planning systems and distribution requirements planning in practice.

Chapter 14 Shop floor control systems: This chapter presents the structure of a shop floor control system in terms of a factory coordination system and a production activity control system. The chapter also includes a review of widely used scheduling techniques.

Chapter 15 just in time: This chapter offers an overview of the just in time (JIT) approach to manufacturing systems design and operation which requires a holistic approach to manufacturing with a strong focus on product and process design as well as production planning and control.

Part Four: Future directions for CADCAM

In this part the way in which CADCAM is developing in response to the pressures for global manufacturing and reduced environmental impact are considered.

Chapter 16 Emerging challenges in CADCAM: This chapter reviews current developments in CADCAM including new approaches to product modelling, multimedia, the global networks and computer-supported cooperative work, and design for the environment.

Routes through the material

The first three parts of the book are designed to be largely self-contained introductions to computer-aided design, to computer-aided manufacture and to production planning and control respectively. The material may also be subdivided in different ways according to the requirements of the reader, as follows:

A general introduction to CADCAM, giving an overview of techniques and applications, but largely omitting detailed theoretical discussions, is given in Chapters 1 (introduction to CAD), 2 (introduction to geometric modelling), part of 6 (CAD applications), 9 (the design/manufacture interface), part of 10 (techniques for a systems approach to product development), 12 (introduction to production planning and control) and 15 (introduction to JIT).

A detailed treatment of analytical and computing principles is given in Chapters 3 (geometric modelling), 4 (computer graphics), 5 (model manipulation and data storage), parts of 6 (geometric analysis and FE mesh generation), part of 10 (Taguchi methods), 11 (techniques of computer-aided manufacture), 13 (requirements planning systems) and 14 (shop floor control systems).

Discussions of current developments that would be useful to a reader who is generally familiar with CADCAM techniques are given in Chapters 7 (networks and standards), 8 (artificial intelligence in design plus developments in modelling) and 16 (emerging challenges in CADCAM). Parts of chapters 10 (systems approaches) and 15 (JIT) would also be useful in this context.

Acknowledgements

In the first edition of this book we acknowledged the inspiration and support of students and colleagues over many years that had led to the book being written. In this second edition we acknowledge our continued indebtedness in this regard, in particular to our research students and research assistants, the results of whose studies have led to much of the new material incorporated here. We are also for this edition grateful to the users and reviewers of the first edition of the book whose thoughtful comments and feedback were of great assistance in planning and developing the revisions to the text.

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Finally, we must express our continued gratitude to our wives and families, without whose patience and forbearance over many months the work would never have been completed. The book is dedicated to them.

From the Back Cover

((shelf classification)) CAD/CAM
CADCAM
Principles, Practice and Manufacturing Management
Second Edition

Chris McMahon
and
Jimmie Brown

The application of computers to the product design and manufacturing process (known as CADCAM) is a successful and important technology which integrates the traditionally separate disciplines of Design and Manufacture.

Chris McMahon and Jimmie Browne¿s text will guide you carefully through the processes of defining a product design with the aid of computers, developing manufacturing plans and instructions for the product, and managing the manufacturing system itself. Their accessible writing style is supplemented by examples throughout and end-of-chapter problems are included to test your knowledge.

Your understanding of CADCAM will be improved by:

· industrial examples, placing the theory in context
· project-style exercises, illustrating each of the steps involved in the development of a finished product
· a new chapter on the emerging challenges in the subject, examining current developments and future directions for CADCAM
· extensive references to books and websites, pointing to more in-depth material where appropriate

The most balanced coverage of Computer Aided Design and Manufacture available, this comprehensive and accessible text is ideal for students of Industrial, Mechanical, Manufacturing and Production Engineering. The mix of theory, practice and analysis makes the book suitable for both analytical and overview courses.

Chris McMahon worked in design and CAD for an engineering consultancy for a number of years before joining the Department of Mechanical Engineering at the University of Bristol, where he leads teaching and research in design. Jimmie Browne is Dean of Engineering and Head of the Computer Integrated Manufacturing Research Unit at the National University of Ireland, Galway.

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Jennifer Case:

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