

普通高等教育“十三五”规划教材



CAD/CAM 原理与应用

(英文版)

CAD/CAM Principles and Applications

康兰 编著



 机械工业出版社
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蒋 丹 主审

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本书共分5章。第1章阐述了机械CAD/CAM的基本概念、方法、原理和应用以及未来的发展趋势。第2章阐述了常用的实体建模方法及理论,重点探讨了表面模型及其数学原理,以及CAD技术领域的另一建模技术——反求工程。第3章介绍了参数化特征建模技术,并对目前最新的直接建模、同步建模及集成建模方法从应用的角度进行了介绍。第4章探讨了CAD/CAM技术的集成问题,内容涉及IGES、STEP、STEP-NC、特征识别及成组技术。第5章从应用的角度介绍了CIM系统,重点介绍了CIM系统中的柔性制造系统。

本书可作为高等工科院校机械工程及相关专业本科生及研究生的双语或全英文教学用书,也可作为从事CAD/CAM技术应用的工程技术人员的参考书。本书还可作为希望提高在机械专业领域内进行跨国交流能力的各类人士的参考读物。

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Preface

CAD/CAM course is one of compulsory courses in mechanical engineering. In Chinese universities, courses related to CAD/CAM technology are open for undergraduate and graduate students majoring in Mechanical Engineering. Currently, one major trend in many universities is to promote internationalization of higher education. Education departments at all levels encourage and support universities to give lessons to students in bilingual way even in full English, and many universities recruit foreign students world widely. Therefore, textbooks in English, which act as the cornerstone in the process of internationalization of higher education, are urgently needed.

The main features of this book are as follows:

- (1) Organizing teaching contents concisely and practicably, so that readers are able to master the basic concepts, principles and methods of CAD/CAM, which will build a good foundation for them to do more further research in CAD/CAM;
- (2) In order to help readers test the effect of learning, a number of assignments are provided at the end of each chapter;
- (3) Written in English with Chinese annotation of related words at the end of each chapter, the book may be used as a textbook for undergraduates and graduate students in bilingual or full English teaching practice, or used as a reference book for engineers engaged in the application of CAD/CAM.

For teaching undergraduates, it is suggested that the teaching focus should be on the first three chapters. In Chapter 2, the mathematical principles behind the curves/surfaces should be introduced in detail, then give an assignment to students, for example, to construct complex surface model, such as human faces, shells of cars and planes etc. by using software involving NURBS function. In Chapter 3, it is suggested that a comprehensive assignment should be given to students, for example, to build 3D parametric models of a complicated product by using one of 3D design software, so that students could combine theory with practice.

For teaching graduate students, it is suggested that programming assignments should be given to students in Chapter 2. For example, to write computer programs based on the algorithms mentioned in the book to create 3 degree Bézier/NURBS curves using programming language like C++ or Matlab, and students' solutions are expected to have interactive user interfaces. Chapter 5 can be fin-



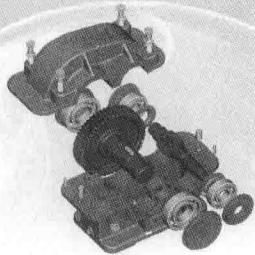
ished in the form of seminars. Four or five students form a collaborative learning group at the beginning of the class and an assignment is given to each group. Each group chooses a topic related to advanced manufacturing technology and does research work on it, then makes a presentation about their research, and presents it in the class during seminars.

I would like to extend my hearty thanks to College of Mechanical and Electrical Engineering, Hohai University, which provides a lot of support for publishing the book at many levels. I would also like to thank Jiang Dan of Shanghai Jiao Tong University, who reviewed the book carefully and made valuable suggestions.

Finally, I welcome and appreciate all comments and suggestions from readers so as to make further improvements to the book.

Kang Lan





CAD/CAM 课程是机械工程专业开设的一门学位课程,国内有机械工程专业的高等院校在本科生和研究生教育中都设有与 CAD/CAM 技术相关的课程。当前国内许多高校都在朝着教育面向国际化的方向发展,各级教育部门大力鼓励和支持有条件的高校在本科生及研究生教学中开展双语乃至全英文教学,许多高校面向全球招收留学生,因此急需全英文教材,全英文教材是高校向国际化教育发展的基石。

本书正是基于以上的现实需求而编写的,其内容以讲义的形式已在留学研究生(全英文教学)及国内研究生(双语和全英文教学)中进行了几轮的教学试用,并经过了多次的修改与完善。本书的主要特点如下:

(1) 在内容编排上力求简练实用,使读者能掌握 CAD/CAM 技术领域的基本概念、原理和方法,为进一步深入学习和研究奠定基础。

(2) 每章最后有相应的课后练习,以辅助检验学习者的学习效果。

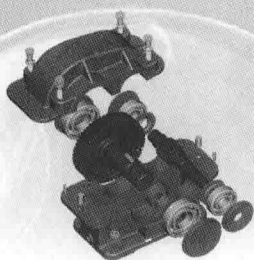
(3) 全英文编写,每章后有对相关词汇的中文注解,本书可作为高等工科院校机械工程专业及相关专业本科生及研究生的双语或全英文教学用书,也可作为从事 CAD/CAM 技术应用的工程技术人员的参考书。

在本科生教学中,建议教学的侧重点放在前 3 章,第 2 章中应详细介绍曲线曲面背后的数学原理,之后以集成了 NURBS 曲线曲面功能的工程软件为平台,给学生布置大作业,将理论与实践相结合,应用软件完成一个复杂的表面模型的构建,如人脸、汽车、飞机外壳等。第 3 章中结合教材内容,给学生布置大作业,让学生利用参数化软件完成一个复杂产品的三维参数化建模设计。

在研究生教学中,建议在曲线曲面部分给学生布置一项编程的综合作业,让学生根据教材中所讲的算法以 Matlab 或 C++ 为平台完成三次贝塞尔曲线及 NURBS 曲线的生成,有界面并有一定的交互功能。第 5 章可以以研讨课的形式来开展,课程开始之时让学生 4~5 人组成一组,每组以先进的 CAM 技术为话题,课后进行深入的研究与学习,每组制作演示文稿,并在研讨课上进行讨论与交流。

本书从撰写到出版得到了河海大学机电工程学院的大力支持,在此表示由衷的感谢!上海交通大学的蒋丹教授审阅了全部的书稿,在此表示由衷的感谢!

最后,热忱欢迎各界读者提出批评和建议,以便以后进行改进。



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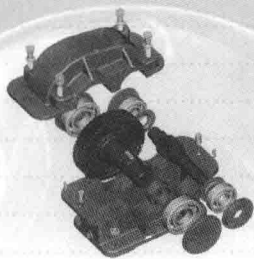
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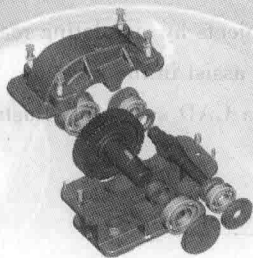


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Chapter 1

An Overview of CAD/CAM

1.1 Concept of CAD/CAM

About 25 years ago, nearly every drawing produced in the world was done with pencil or ink on paper. Minor changes meant erasing and redrawing while major changes often meant recreating the drawing from the scratch. If a change to one drawing affected other documents that engineers were dependent upon, someone manually had to make the changes to the other drawings and documents. Over the past 25 years, the landscape of science and engineering has changed in an unthinkable way due to the emergence and rapid growth of information technology. The emergence of information technology has revolutionized the way we think, work, communicate, and live.

We are now living in an information age. Use of computers has become part of our life no matter where we are, either in office or at school. It is almost unthinkable to undertake a project without the use of computer. When we use computers we apply software tools to meet our needs or to deal with technical challenges. Nowadays engineers no longer use pens, pencils, rulers and compasses to design parts and prepare drawings. Communications among engineers have been in the digital format as we communicate with each other through the Internet and the use of different kinds of design software.

Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) are a pair of often interdependent industrial computer applications that have greatly influenced the chain of processes between the initial design and the final realization of a product. CAD/CAM has fundamentally changed the way design is done, and the way products are manufactured. CAD and CAM technologies are responsible for massive gains in both productivity and quality, particularly since the 1980s. For some purposes CAD and CAM methods can be used exclusively of one another, and in general, CAD is used more commonly than CAM.

CAD involves creating computer models defined by geometrical parameters. These models typically appear on a computer monitor as a three-dimensional representation of a part or a system of



parts, which can be easily altered by changing relevant parameters. CAD systems enable designers to view objects under a wide variety of representations and to test these objects by simulating real-world conditions. Generally speaking, CAD is the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. The input and output of a CAD system is illustrated in Figure 1-1.

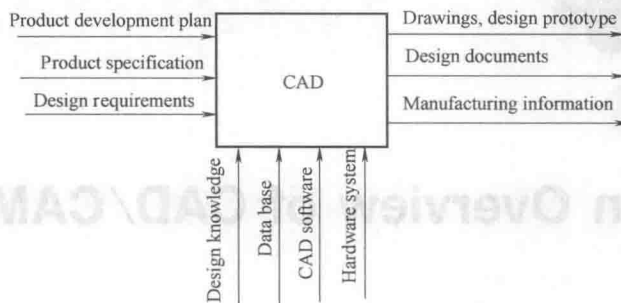


Figure 1-1 The input and output of a CAD system

CAM refers to the use of a computer to assist in all operations of a manufacturing plant, including planning, management, transportation, storage and monitoring manufacturing processes. The input and output of a CAM system is illustrated in Figure 1-2.

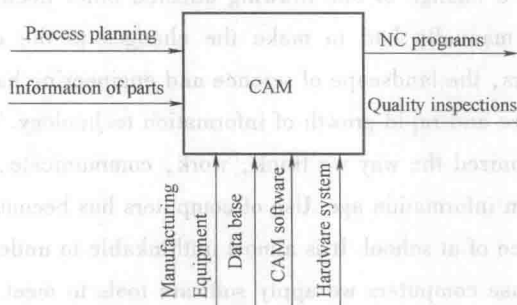


Figure 1-2 The input and output of a CAM system

1.2 Process of Computer-Aided Design

The process of designing a product is characterized as an interactive procedure, which usually consists of four major stages or phases: conceive, design, validate and manufacture, as illustrated in Figure 1-3. Each stage requires specific knowledge and skills, and often requires the use of specific software.

1. Need or idea

Usually the design process starts with a defined need. The need can be defined by market research, by the requirements of a larger body of work (for example airplane part). Sometimes, the design process is begun with a new idea or invention.

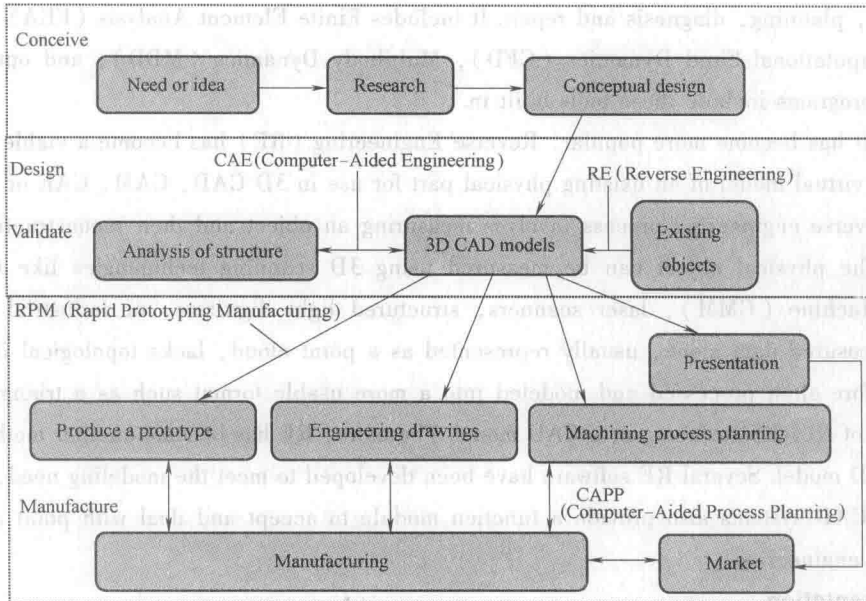


Figure 1-3 Process of designing a product

At any rate, a need analysis should precede any decision to undertake a project. This includes defining the need in a highly detailed way. This is similar to the requirements specification process in software engineering.

2. Research

Designers tend to research available solutions before beginning their work. There is no need to “reinvent the wheel”. Designers should study existing solutions and concepts, evaluating their weaknesses and strengths. Designers’ research should also cover available parts that can be used as a part of the design. It is obvious that Internet and search engines are very helpful for this task. There are also many libraries of standardized parts which can be imported into the project.

3. Conceptual design

Conceptualization is the process whereby a conceptual design satisfying the problem definition is formulated. Based on the previous research, a draft may be created to show the main principles and major parts by pens and papers, or by using simple vector graphics programs or even by starting directly in three-dimensional CAD system.

4. 3D CAD models

3D CAD models of products with details are constructed, and this is the key part of the design process, and often the most time consuming. This will be described in greater detail in further lessons. In this stage, a complete engineering description of the product is developed. Detailed design involves the specification of dimensional and geometric tolerances, the analytical evaluation of the system and components, the confirmation of the cost and quality of the manufacturing processes, and the examination of assembly and component drawings. Many software tools related to Computer-Aided