双语教学教材

高等院校教材

先进制造技术（英文版）

Advanced Manufacturing Technology

（第二版）

唐一平 主编

科学出版社
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内 容 简 介

本英文版教材是从近年来国外出版的20多本英文原版专著教材中摘录、筛选后编辑而成。

全书共分三部分：第一部分介绍了计算机在制造业中的作用，并对因特网的诞生、历史沿革和结构作了初步介绍；第二部分主要介绍CAD/CAM、数控加工、柔性制造系统、计算机集成制造系统和智能制造技术；第三部分是全书的重点，系统介绍了近年来先进制造技术的几个主要内容：包括敏捷制造、快速原型制造、基于环境意识的设计与制造、纳米技术和微纳制造等。为便于读者学习，在本书的每一章对一些疑难句子作了详细注释并附有全书总词汇表。

本书可作为机械制造及自动化、现代设计、仪器仪表、工业工程与管理、环境工程以及半导体器件制造等专业的高年级本科生的双语教材，也可用作其他有关专业人员现代制造技术的英文培训教材。

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第二版前言

《先进制造技术》（英文版）自从2000年秋问世以来，先后已有西安交通大学、重庆大学、吉林大学、陕西科技大学、江苏大学等10多所高校采用该书作为面向21世纪双语教学用书。大家普遍反映良好，认为该教材内容涵盖面广，信息集成度高，反映了制造业先进技术发展趋势和近年来的部分尖端成果，对拓宽机电类工科学生的眼界，帮助他们阅读本专业英文科技文献有很大的促进作用。当然，也有不少专家学者对该书提出了一些宝贵的修改意见。

目前，制造技术已从自动化、集成化走向数字化、信息化、全球化，从传统工业领域进一步渗透到新兴产业如IT、生物制造和微纳制造。特别是我国正在成为世界的制造工厂，各行业对从事制造科学的技术人才需求越来越迫切。考虑到5年来制造科学与技术的发展，为进一步拓展机电类工科学生的知识领域，用最新的制造技术培养新世纪优秀人才，根据有关专家学者对该书的修改意见并参考了近5年内国外新出版的英文原版优秀教材，编者对本书进行了重新修订。原书中某些陈旧的内容已删除；数控技术全部重新编写，快速成型技术部分作了重大修改，智能制造技术修改后并入了第二部分；原书的纳米技术和微机械一节中扩充了微纳器件制造的内容，其他有关章节也作了相应调整。另外，根据部分使用本书的授课教师的意见对原书少数句子作了改写，学生较难理解的个别生僻单词，已作了代换。全书共新增单词80个，缩略语20条。

为使本教材日臻完善，在新版书的使用过程中，欢迎各有关专家学者继续提出宝贵的批评与建议，并可直接同编者联系（029-82665575）。

编　者

2006年5月

第一版前言

先进制造技术（advanced manufacturing technology，AMT）这一概念是美国根据本国制造业面临来自世界各国，特别是亚洲国家的挑战，为增强制造业的竞争力，夺回美国制造工业的优势，促进国家经济的发展，于20世纪80年代末提出来的。它是以提高制造企业综合效益为目的，以人为主体，以计算机技术为支柱，综合利用信息、材料、能源、环保等高新技术以及现代系统管理技术，对传统制造过程中与产品在整个寿命周期中的使用、维护、回收利用等有关环节进行研究并改造的所有适用技术的总称。AMT这一全新概念一经提出，立即受到世界各国政府、企业界和学术界的高度重视并将其称为面向21世纪的技术。因为先进制造技术的主要特征是强调实用性，它以提高企业综合经济效益为目的，所以被认为是提高制造业竞争能力的主要手段，对促进整个国民经济的发展有着不可估量的影响。

同先进工业国家相比，我国制造业技术水平还很低，面对世界市场的激烈竞争，我们只有认真实施“科教兴国”战略，采用以高新技术为支撑的先进制造技术，开展“知识创新”，才能在竞争中站稳脚跟，迎接21世纪制造业的严峻挑战。

到目前为止，全面系统地介绍先进制造技术的书籍尚不多见，这同当前正在形成的先进制造技术的研究和推广应用热潮很不相适应。为此，我们组织力量，花了两年多时间参考了20世纪90年代以后出版的20余本有关先进制造技术的英文原版专著与教材，并经过仔细筛选后编写出了这本英文版教材。我们直接采用英文原著，目的是为了使工科高年级学生和研究生能尽快熟悉本专业的技术词汇，尤其是在知识更新越来越快的信息时代能及时了解当前最新科研成果，鼓励他们广泛阅读反映本专业领域最新发展状况的外文原著（包括论文和专著）。香港和台湾高校用原版书教学对提高学生的外语水平有极大好处，故值得借鉴。

为了提高本教材的教学效果，我们特意在每章后面附有一些疑难句子的注释，并在书后附有总词汇表（按章节和出现先后次序编排）。从书后的总词汇表可以看出，该书几乎包括了最近几年内涌现的涉及计算机、自动控制、制造技术和信息产业等方面的大部分最新词汇（有少数词汇甚至在较大的英汉科技词典中都未来得及收录）。

本书作为选修课已经在高年级本科生中讲授了两遍，在听取有关专家的意见和建议的基础上对书中内容又作了一些删节与修改。

本书在编写过程中得到西安交通大学户秉恒教授、吴序堂教授和重庆大学张根保教授以及西北轻工业学院曹巨江教授的指导与帮助；在第二次修改定稿送出版社之前承蒙西安交通大学管理学院资深教授汪应洛先生审看了样稿，并向出版社郑重推荐出版该书；在原稿录入和编辑、配图过程中还得到了江云女士和胡德洲、张顺德两位博士的协助，在此一并致以衷心的感谢。

由于先进制造技术的概念提出的时间不长，还未形成完整的理论体系，尤其是编写这样一本以英文原著作为素材的面向中国学生的教材还仅仅是一种尝试，加之编者水平有限，缺点错误在所难免，敬请各位专家学者批评指教。

编　者

2000 年 7 月于西安交通大学

CONTENTS

CHAPTER 1

Computers in Manufacturing

1 Computer-Aided Production and Control Systems

Manufacturing technology has been around for many years.[1] Over these years, it has gone through many changes, ranging from the simple to the complex. The driving forces behind the changes were people's desires to improve basic needs such as food, clothing, shelter, and recreation. To meet these desires, methods have been developed from producing simple devices such as weapons for obtaining food to today's modern manufacturing systems, which use computers to produce such items as televisions, mobile phones and space vehicles.

Computers are being given an increasingly important role in manufacturing systems. A computer's ability to receive and handle large amounts of data, coupled with their fast processing time, makes a system more powerful and versatile. The use of computers in manufacturing is now coming of age. Computer application in manufacturing production controls the physical process and is typically referred to as computer-aided manufacturing (CAM). It is built on the foundation of such systems as NC, AC, robotics, automated guided vehicle system (AGVS), automated storage/retrieval system (AS/RS), and flexible manufacturing system (FMS). Some of the new uses are briefly discussed below. More detailed discussion is presented in subsequent chapters.

Many interrelated manufacturing activities are grouped together to form a special application system that may be referred to as a production and control system (PACS). The grouping of manufacturing activities into PACS varies from one manufacturing environment to another. A

PACS is defined as a subsystem in a global manufacturing environment. It may be a single subsystem, or it may be a complex set of subsystems. An illustration of PACS working in a global manufacturing system is shown in Fig. 1. 1. For PACS to meet their designed functional requirements, they should be designed to function independently of other PACS. Also, PACS should be able to work collectively with other PACS in a total integrated manufacturing environment. Each PACS in the total system can have an effect on the other PACS in the total system, and a systems planning approach must be taken for the following reasons:

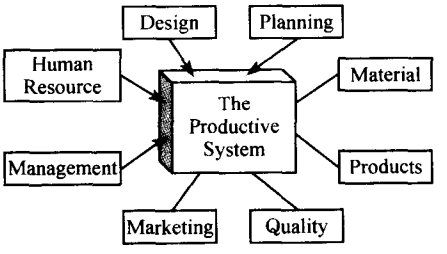

Fig. 1. 1 Interaction of PACS in aManufacturing System

- To prevent duplication of effort.
- To enable vital information to pass efficiently through the system.
- To allow each PACS to know its relation to the others and how it affects the others.
- To make the whole manufacturing system function more efficiently and productively.

Computers are by far the most powerful single approach used in integrating and manipulating the series of interrelated manufacturing PACS and activities.

They have brought manufacturing technology into the era of

"smart" machines. The advances in technical production have brought about a computer technology and manufacturing technology that has enhanced manufacturing technology development. This marriage is the basis for computer-aided production and control systems (CAPACS), which are computer-driven CAPACS. Thus, CAPACS have increased the roles of smart machines in production and control functions. The increased roles of smart machines have demanded a more intimate communication and interaction between such functions as design, financial accounting, production, personnel, and marketing. The ways in which production operations are conceptualized, formulized, discharged, and performed are being changed by CAPACS.

Typical CAPACS in manufacturing are as follows:

- CAD Computer-aided design
- CAIN Computer-aided inspection
- CAM Computer-aided manufacturing
- CAPP Computer-aided process planning
- CAQC Computer-aided quality control
- CIPM Computer-integrated production management
- DNC Direct numerical control
- GT Group technology

Fig. 1.2 gives an overview of interrelated functions of CAPACS working from an integrated database system. The design data, generated by the interaction between CAPACS, is a single collection of all the information that describes the product and related operations. It is the hub of the manufacturing wheel. The CAD system is the principal tool used by engineering in carrying out its responsibility.

The spokes of the wheel are made from various kinds of CAPACS involved in the activity. Each CAPACS has a communication link to the controlled database so that it will capture the data to form its own

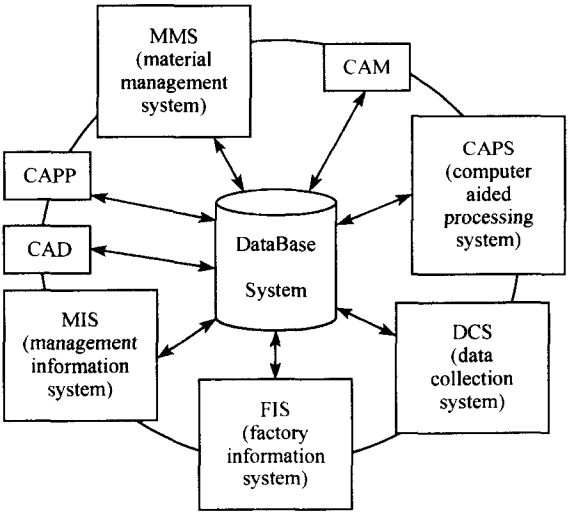

Fig. 1.2 Interaction of CAPACS in a Manufacturing System

distributed database. Values are added to the distributed database to meet the needs and requirements of its expected users. The application of CAPACS to the manufacturing process enables the total system to increase productivity, reduce waste, and produce things it would not otherwise be able to make. As a result, new technologies, demands for products of higher quality and lower production costs, and the need for improved technology in a competitive society have caused extensive use of CAPACS.

1.1 Automation Concepts

Automation may be defined as a system that is relatively self-operating. Such a system includes complex mechanical and electronic devices and computer-based system that take the place of observation, effort, and decision by a human operator. It is a system that exhibits properties of human beings by following predetermined operations or responding to encoded instructions.

1.2 Computer Process Control

Process control involves the control of variables in a manufacturing process, where one or any combination of materials and equipment produces or modifies a product to make it more useful and hence more valuable. In process control systems, the computer serves as the control mechanism that automatically controls continuous operations. Two kinds of control systems are the *open loop* and the *closed loop*. In an open-loop control system, the computer does not itself automate the process. That is, there is no self-correction. The process remains under the direct control of human operators, who read from various sources of information such as instruments, set calibrated dials for process regulation, and change the controlling medium.

Closed-loop control systems use computers to automate the process. The computer is directly in charge of the process. It adjusts all controls from the information provided by sensing devices in the system to keep the process to the desired specifications, a technique that uses a feedback mechanism. Feedback is the action of measuring the difference between the actual result and the desired result and using that difference to drive the actual result toward the desired result. The term feedback comes from a measured sample of the output of the process (production) function that becomes the input of the control function. That is, the output of the control function, meeting special designed requirements is the input to the control system. Thus, the signal begins at the output of the controlled production function and ends at the input to the production.

Typical functions of process control systems are monitoring, data