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时代教育·国外高校优秀教材精选

计算机集成制造

（英文版·原书第2版）

Computer-Integrated Manufacturing

(美) 詹姆斯 A.雷(James A.Regh)
亨利 W.克雷贝尔(Henry W.Kraebber) 著

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出版说明

随着我国加入 WTO，国际间的竞争越来越激烈，而国际间的竞争实际上也就是人才的竞争、教育的竞争。为了加快培养具有国际竞争力的高水平技术人才，加快我国教育改革的步伐，国家教育部近来出台了一系列倡导高校开展双语教学、引进原版教材的政策。以此为契机，机械工业出版社拟于近期推出一系列国外影印版教材，其内容涉及高等学校公共基础课，以及机、电、信息领域的专业基础课和专业课。

引进国外优秀原版教材，在有条件的学校推动开展英语授课或双语教学，自然也引进了先进的教学思想和教学方法，这对提高我国自编教材的水平，加强学生的英语实际应用能力，使我国的高等教育尽快与国际接轨，必将起到积极的推动作用。

为了做好教材的引进工作，机械工业出版社特别成立了由著名专家组成的国外高校优秀教材审定委员会。这些专家对实施双语教学做了深入细致的调查研究，对引进原版教材提出许多建设性意见，并慎重地对每一本将要引进的原版教材一审再审，精选再精选，确认教材本身的质量水平，以及权威性和先进性，以期所引进的原版教材能适应我国学生的外语水平和学习特点。在引进工作中，审定委员会还结合我国高校教学课程体系的设置和要求，对原版教材的教学思想和方法的先进性、科学性严格把关，同时尽量考虑原版教材的系统性和经济性。

这套教材出版后，我们将根据各高校的双语教学计划，举办原版教材的教师培训，及时地将其推荐给各高校选用。希望高校师生在使用教材后及时反馈意见和建议，使我们更好地为教学改革服务。

机械工业出版社

2002 年 3 月

序

本书简练地介绍了CIMS的基本概念，其涉及的范围较广，包括下列几个部分：第一部分为制造业及CIM的概述，包括制造业及制造系统；第二部分为设计原理及生产工程，包括产品设计和生产工程、计算机辅助工程；第三部分为企业资源管理，包括生产运行规划及制造规划和控制简介、材料计划、生产高度及运作系统等；第四部分为现代制造系统及其实施过程，包括生产加工机械和系统、生产支持机械和系统、机械和系统控制以及在制造过程中的质量等。这4部分共13章，内容涵盖了CIMS所涉及的相关单元技术，是机械工程类学生必备的知识，也是21世纪机械制造业先进生产模式的技术人才必备的知识。本书对相关技术内容的基本概念的介绍非常清晰，其专业英语词汇也能很好地满足机械工程类学生的需要。本书在每章后都有一个小结，并附有问题及作业供学生讨论和练习，能加深学生对所介绍的内容的理解，在此过程中，如果能用英语进行讨论和用英语完成习题的写作，则更能有效地提高学生的英语表达能力。

本书可以作为机械工程及自动化专业高年级学生的教材，亦是相关专业技术人员的学习材料。

赵汝嘉
西安交通大学机械工程学院
2002年8月

About the Authors

James A. Rehg, CMfgE, is an Assistant Professor of Engineering at The Pennsylvania State University–Altoona College, where he teaches automation controls courses in the B.S. program in Electromechanical Engineering Technology. He earned both a B.S. and M.S. in Electrical Engineering from St. Louis University and has completed additional graduate study at Wentworth Institute, University of Missouri, South Dakota School of Mines and Technology, and Clemson University. Before coming to Penn State–Altoona, he was the CIM coordinator and department head of CAD/CAM/Machine Tool Technology at Tri-County Technical College. Prior to that, he was the Dean of Engineering Technology and Director of Academic Computing at Trident Technical College in Charleston, South Carolina. He held the position of Director of the Robotics Resource Center at Piedmont Technical College in Greenwood, South Carolina, and was department head of Electronic Engineering Technology of Forest Park Community College in St. Louis, Missouri. In addition, he was a Senior Instrumentation Engineer for Boeing in St. Louis. Professor Rehg has authored five texts on robotics and automation, and has presented numerous papers on subjects related directly to training in automation and robotics. He has also been a consultant to nationally-recognized corporations and many educational institutions. He has led numerous seminars and workshops in the areas of robotics and microprocessors and has developed extensive seminar training material. In addition, he has received numerous state awards for excellence in teaching and was named the outstanding instructor in the nation by the Association of Community College Trustees.

Henry W. Kraebber, P.E., CPIM, is an Associate Professor of Mechanical Engineering Technology at Purdue University in West Lafayette, Indiana. He has fifteen years of experience and leadership in manufacturing operations, engineering, quality, and management. He has worked at the Collins Avionics and Missiles group of Rockwell International, the Plough Products Division of Schering-Plough Corporation, and Flavorite Laboratories. His work has supported the production of industrial, consumer, and military products in the food, consumer products, and electronics areas. Career highlights include developing and implementing manufacturing control systems (MRP2, including MAPICS and AMAPS)

and implementing the concepts of total quality. He earned a B.S. degree in Industrial Engineering from Purdue University, and a M.E. degree in Industrial Engineering from Iowa State University. He is a senior member of the Institute of Industrial Engineers (IIE). As an active member of professional organizations, he is now Past President and the VP of Education for the Wabash Valley Chapter of APICS. In August 1989, Mr. Kraebber returned to Purdue University to become a faculty member in the School of Technology program in Computer Integrated Manufacturing Technology. He currently teaches courses in manufacturing operations, manufacturing quality control, and integrated systems. He is President of the CIM in Higher Education Alliance, a nonprofit corporation that supports CIM and manufacturing education.

This text is dedicated to two very special young men, Jim and Richard, and to our families, students and friends that have helped make this possible.

Preface

The new millennium brings many new issues and twists to the subject of computer-integrated manufacturing (CIM). It remains as broad as the complex manufacturing enterprises it attempts to model. Many would suggest that CIM is too broad for a single course or textbook. However, the essence of CIM is in the integration of the enterprise elements: physical integration through the linking of hardware and software systems, logical integration through shared common enterprise information and data, and philosophical integration based on a new sense of purpose and direction in every entity in the enterprise. Therefore, the integration so critical to a CIM implementation is best introduced in a single course so that links between the enterprise elements can be explored. This book was written to support such an introductory course.

To understand the operation of a comprehensive CIM solution requires some study of manufacturing as it was in the early 1990s, as it was at the end of the decade, and as we think it might look in the twenty-first century. The integration of basic product design techniques and manufacturing fundamentals and principles, along with a look at the changing operations and information systems that support CIM in the enterprise, make this book unique. In the book we:

- Describe the different types of manufacturing systems or production strategies used by industries worldwide. This description is important because no two CIM solutions are the same.
- Go beyond the description of automated machines and software solutions because a successful CIM implementation demands more than technology. In practice, ordering hardware and software is the last step in a CIM implementation; the preliminary work is what guarantees a successful CIM project.
- Include the impact of CIM on all the major elements in an enterprise: product design, shop floor technology, and manufacturing production and operational control systems.
- Provide a convincing argument for implementing CIM so that the enterprise will be competitive in the global market. In practice, the technologies available to manufacturers around the globe open every market to worldwide competition.

In addition, the second edition has the following significant changes: numerical problem examples have been added to Chapter 1; the introductory material presented in the old Chapter 3 has been incorporated into other chapters in the

text; web addresses (universal resource locators, URLs) for companies offering CIM-related technology are listed at the end of many of the chapters; and a new chapter on enterprise resource planning (EPS) has been added.

To provide a complete overview of the computer-integrated enterprise, the book is divided into four parts. In the first part, Chapters 1 and 2, we provide an overview of global competition, describe an internal manufacturing strategy, discuss in detail the problem facing manufacturing and the development of an effective solution, and characterize the operation of different types of enterprises. In the characterization, we finish a classification and description of the manufacturing systems and production strategies used by manufacturing, an explanation of the product development and engineering change cycle, and an overview of the enterprise organization. At the end of Part 1, the need for change in manufacturing is made clear and a basic strategy for change in the organization is established. In addition, the description of the enterprise organization in Part 1 provides a framework for the CIM concepts introduced in the rest of the text. Part 1 provides the critical introduction of manufacturing and the enterprise that is necessary for a course designed to teach computer-integrated manufacturing.

In Part 2, which includes three chapters, we examine the three major design and engineering process segments that take a product from concept to production. Chapter 3 provides an introduction to design and production engineering concepts and issues. The use of CIM technology to design and produce world-class products with enhanced enterprise productivity is emphasized. The old design model is compared to a recommended new process that incorporates a concurrent engineering focus to product design. This part of the text concludes with an in-depth description of the functions in production engineering and the opportunities for productivity gains through CIM. Computer-aided design (CAD) is the focus of Chapter 4. A full chapter is devoted to CAD because it is one of the major building blocks in a CIM implementation. The topic includes a comprehensive definition and brief history of CAD, description of CAD systems and operation, classification of CAD hardware platforms and software systems from 2-D to solid modelers, and applications for CAD technology in the manufacturing systems described in Part 1. In Chapter 5, we explore the relationships between the concurrent engineering product design model and the computer-aided engineering (CAE) technology available to support every step of the design process and production engineering. We include a complete definition of CAE, design for manufacturing and assembly, finite-element and mass property analysis, rapid prototyping, group technology, computer-aided process planning, computer-aided manufacturing, production and process modeling and simulation, maintenance, automation, and product cost analysis. In the final section of Chapter 5, we describe the computer network used to tie the design and production engineering functions to the common enterprise database and other business functions.

Part 3 of the text shifts the focus to managing the enterprise resources. The concepts of material and manufacturing planning and the control systems used within the enterprise are addressed in Chapters 6 and 9. The function of manufacturing planning and the automation technology available for CIM implementa-

tions is recounted. The first chapter in the sequence, Chapter 6, provides an overview of the critical concepts that are explored in the following three chapters. In Chapter 7, we introduce the concept of manufacturing planning and control (MPC) with a model of a typical MPC system. In addition, three key elements in the MPC model—production planning, material requirements planning (MRP), and master production scheduling (MPS)—are covered. Finally, automation software used to implement CIM in this critical part of the enterprise is introduced and explained. Additional elements in the MPC model are defined in Chapter 8. The topics presented include inventory and data management, capacity management, production activity control, just-in-time manufacturing, and synchronous manufacturing. Software solutions for the manual MPC functions are included at the end of each section. At the conclusion of Chapters 6 through 8, the reader will understand the operation of an MPC system and will be able to perform the manual calculations for each function in MPC and describe application software capable of automating the MPC functions. Chapter 9, "Enterprise Resource Planning and Beyond," contains material completely new to the second edition. The chapter develops the links between the concepts from MRP and MRP II systems that are essential parts of the new ERP systems. The pace of change in technology and new systems at the end of the 1990s has been extraordinary. There is no way to predict the future, but it is clear that new systems will continue to be created. Technologies for design, processing and control, information systems, and communication are rapidly converging. The coming technologies will offer substantial new opportunities and risks for manufacturing enterprises.

Part 4 concentrates on the processes and systems that lay the foundation for modern manufacturing and enterprise-wide concepts critical to a successful CIM implementation. Chapter 10 covers the commonly used production process machines used in manufacturing. In addition, manufacturing systems composed for one or more machines, called flexible manufacturing cells and flexible manufacturing systems, are addressed in the chapter. Chapter 11 covers machines and systems that support production, including coverage of industrial robots, material-handling systems, automatic guided vehicles, and automatic storage and retrieval systems. The techniques used for the control of production systems is the focus of Chapter 12. The control systems discussed include cell control hardware and software, device control hardware and software, programmable logic controllers, and computer numerical controllers. The programming techniques used for CNC machines have been significantly expanded in this chapter. The operation and management of enterprise networks and common databases are also discussed. A successful implementation of any high technology requires a change in the management viewpoint on manufacturing management and human resource development. As a result, a discussion of a broad range of quality issues and the effective use of human resources is included in Chapter 13.

In summary, the chapter sequence starts in Part 1 with a global view of manufacturing. In the second and third parts, we focus on the activities required to convert raw material into finished goods and introduce technology to aid in the conversion and management of the enterprise. The last part of the text shifts back

to systems that enable the enterprise to manufacture products competitively, with the discussion centered on the services and support functions required for successful CIM implementation. Common products (hardware, software and systems) are included throughout the book to demonstrate the technology and to stress the integration issues.

The logical order of topics and chapter content was tested in a series of workshops at Trident Technical College offered to college faculty and industrial employees. The insight gained through discussions with these workshop groups and the CIM team at the college was critical to the development of his book. We would especially like to thank Jerry Bell and Alan Kalameja for their help in the first edition with the design automation and control elements. Special thanks to Marci Rehg for her help in developing the CIM workshop material, where many of the presentation ideas were tested. And thanks to all the students who have helped us develop and test instructional materials related to CIM over the years.

Finally, thanks to the IBM Corporation, founders of the initial CIM in Higher Education Alliance program, for support in developing the CIM workshops and the CIM capability at two- and four-year colleges. The CIM in Higher Education Alliance is now an independent, nonprofit corporation that continues to encourage and support CIM and education for manufacturing. Thanks also to the reviewers: Don Arney (Ivy Tech State College (IN)), Dr. Michael Costello (Southern Illinois University at Carbondale), Dinesh Dhamija (Ohio University), Dave Hunter (Western Illinois University), and Herbert Tuttle (Kansas University, Ewards Campus).

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