Preface

The globalisation of business and industry and the worldwide competitive economy are forcing one-of-a-kind production (OKP) enterprises to fully utilise the best available equipment and techniques. The objective is to have efficient control of the organisational structure in order to produce high quality products at lower prices within a shorter period of time. With the development of modern technologies and theories, a new generation of OKP systems is urgently required for rapid product development (RPD) by OKP enterprises to meet today's increasingly global competition.

RPD has been recognised as playing a key role in improving the competitiveness of OKP companies in the global market. With rapid development of information technology, network technology, modern management technology and other related advanced technologies, tremendous efforts have been made in developing new systems, algorithms and tools for the purpose of RPD through collaboration over the Internet, e.g. Internet-based systems for product design and manufacturing, Internet-based design for X (DFX) and Internet-based integrated systems. These Internet-based systems can be used to rapidly produce high quality products with low costs, bringing tremendous profit for manufacturing companies and allowing them to stay competitive in the global market. Such systems are urgently required in industry. However, the research and development of Internet-based RPD (IRPD) systems for producing OKP products are still at an early stage and further research and development in this area are becoming more and more urgent.

This book systematically reviews the historical background of the innovative technologies for OKP product development (PD). Through systematic overview of the existing systems and recent approaches of computer aided design and manufacturing systems, the problems that emerged from recent approaches have been identified. They include distributed system structure, cost optimisation algorithm, product data modelling, production information flow modelling, DFX, computer aided design (CAD)/computer aided process planning (CAPP)/computer aided manufacturing (CAM) integration technology and process modelling and distributed knowledge management. To overcome these problems and to develop a new generation of OKP systems, research and development of a PD platform has been carried out.

The main findings from this research work are outlined. These include the introduction of rapid OKP PD, a comprehensive review of recent research developments in OKP, new product modelling technologies, definition of the new PD platform, an integrated information framework for rapid development of sheet metal parts, the global data structure for global manufacturing, a CAD/CAPP/CAM integration system, a WWW-based information management system, case studies using the platform for rapid sheet metal and mould PD, and the definition and application of an Internet-based cost estimation and optimisation framework. These research topics and findings constitute the main contents of the book.

The aim of the book is to provide a snapshot of our recent research outcomes and implementation studies in the field of OKP PD. The 16 chapters are divided into four parts. The first part introduces state-of-the-art OKP PD; the second part presents the system and framework developed; the third part introduces new methods for modelling OKP products; and the final part presents our case studies showing the new algorithms, methods and tools developed for rapid development of high value-added OKP products.

As the title suggests, the first chapter gives an overview of OKP. It briefly introduces the history and objectives of the OKP PD process. This is followed by discussions on the current issues involved in OKP PD process.

The second chapter presents the historical background of Internet-based product design and manufacturing systems for the rapid development of OKP products. By reviewing existing OKP systems and recent approaches of Internet-based design and manufacturing systems, the requirements for the next generation of OKP systems and the current techniques that can be used to implement Internet-based product design and manufacturing systems are discussed. The problems that emerged from recent developments are reviewed and solutions are proposed. The future trends of Internet-based collaborative design, decision support, manufacturing support, supply chain management, workflow management, Internet techniques for product design and manufacturing, product modelling, STEP-based data environment, concurrent engineering, etc., are also discussed. The reviewed state-of-the-art approaches are used directly or indirectly as references for the development of new generation OKP systems. A reference system structure for building an Internet-based integrated PD system is then proposed to facilitate rapid development of OKP products.

Targeting product modelling, Chapter 3 presents a comprehensive review of recent developments in product modelling technology. Four types of product modelling methodology are discussed in detail. Two object-oriented product modelling methods, including STEP-based product modelling and UML-based product modelling are reviewed and compared. The research gaps and issues are identified. To implement the product modelling in the current integrated manufacturing environment, a generic product modelling framework is proposed. Future research trends in product modelling are also discussed.

To further develop the reference system structure of the Internet-based integrated PD system into a working PD system, Chapter 4 proposes an integrated PD system for rapid development of OKP products. The structure of the system is discussed and case studies are carried out to test the idea of an Internet-based integrated system.

In sheet metal processing and manufacturing there are many small- or medium-sized enterprises (SMEs). These shops have to make every effort to shorten PD lead time, improve production efficiency, approach high quality standards, while cutting down costs at the same time. Chapter 5 presents a compound cutting and punching production method supported by an integrated CAD/CAPP/CAM system. The solutions include an integrated data integration platform based on Pro/INTRALINK and STEP, and a knowledge-based real-time CAPP (RTCAPP) system for compound sheet metal cutting and punching.

The requirements for CAPP systems have changed in the current integrated manufacturing environment. Requirements have increased in terms of integration, openness, real time and distribution of process planning. Systems must now be open and dynamic with the ability to adapt and accept radical unpredictable changes in structures and industrial practices. Chapter 6 proposes an agent-based process planning system (ABPPS) for optimal OKP PD. Agents defined to carry out tasks include an unfolding agent, a feature recognition agent, a task agent, a nesting agent, a path planning agent, a bending agent, a machining method selection agent, a machine selection agent and a fixture/jig selection agent. This chapter provides a good example of how an Internet-based PD system using modern agent technology is developed.

To model OKP products, Chapter 7 proposes a generic product modelling framework (GPMF) that aims to provide an infrastructure for modelling various types of product information. The outcome of the GPMF is a set of data models defined to model product information at different stages of the development process. This chapter discusses the structure of the GPMF and its main components.

Chapter 8 investigates the EXPRESS data model (EDM) that is developed based on the STEP-based modelling environment and the "five-phase" modelling method. The structure of the EDM is discussed. The elements of the EDM – schemas and the relationships between these schemas – are presented using both EXPRESS language and EXPRESS-G diagrams.

Chapter 9 further develops the product modelling methods into a GPMF for efficient information exchange and sharing. This framework consists of four functional components: the EDM, a STEP-based modelling environment, a "five-phase" modelling method, and three EDM data exchange and sharing methods. The focus of this research is on the modelling methodologies and the definition of schemas for various PD activities such as manufacturing, inspection, etc., and the integration of the schemas with other resources defined within STEP. There are 25 schemas defined to ensure that the proposed GPMF is compatible and can be used to model various types of products. To the best of our knowledge, these aspects have not been studied extensively in the literature.

Information integration is an important issue to address in supporting integrated and concurrent PD. Chapter 10 explores the definition and structure of an information framework for rapid development of sheet metal parts. This framework aims to build an information bridge to fill the gap among sheet metal part design, process planning and manufacturing systems. A tree-based step-structure information modelling methodology for sheet metal parts has been developed and a case study is described.

In the early stages of a PD process, the estimate of a developing product life cycle cost is the primary information needed to determine the profitability of the product. Chapter 11 presents a cost estimation and optimisation system, which is a part or a subsystem of an integrated PD system. The PD cost under consideration in this chapter is the sum of the costs of product design, production and logistics, which is the main cost of a product. Some other possible costs associated with a PD cycle, e.g. overhead costs, are normally proportional to this main PD cost and in practice, these are estimated by adding a fixed percentage to the PD cost. Unlike some earlier research which focused on cost estimation in a single manufacturing company, this cost estimation system aims for PD cost estimate and optimal control under the complexities of a global manufacturing environment. The proposed cost estimate and optimal control system has been implemented in a sheet metal manufacturing company.

Chapter 12 reports on research work that aims to develop an integrated data structure to support RPD in the Internet environment. The emphasis is placed on integrated data management and the reuse of past PD experience to support a company's aim to shorten its PD cycle. The integrated global data structure model was modelled using EXPRESS from STEP with the consideration of real-time data communication within the Internet environment. In terms of this data structure, a design/manufacturing knowledge base was developed as a major part of the WWW (world wide web)-based PD system. The basic principles and concepts of the knowledge base and the WWW-based knowledge management system are presented. An industrial implementation is also reported.

As efficient management of product information that covers the whole life cycle is critical to the enhancement of corporate competitiveness, Chapter 13 explores the design and development of a WWW-based PD information management system for a cross-nation manufacturing corporation in New Zealand. Since product data are often managed in a distributed computing environment, CORBA is employed to ensure interoperability among distributed information objects. This WWW- based information management system is discussed in this chapter.

Internet-based DFX systems have been recognised as efficient tools for implementing concurrent engineering and playing a key role in RPD. Internet-based DFX or IDFX systems can be applied by manufacturing companies to rapidly produce high quality products with low costs and high profits. However, the implementation of IDFX systems is not an easy task. Chapter 14 presents two typical applications of IDFX, i.e. Internet-based design for manufacture (IDFM) and Internet-based design for cost (IDFC) systems, for rapid and economic tool-/mould-making. The structure and the key models of the systems are discussed.

Process planning has become very important for the OKP industry as global competition to reduce product cost has intensified. An optimal process planner can maximise the utilisation of costly raw material resources, improve machining efficiency, and hence reduce product costs. Chapter 15 explores algorithms for solving the path planning issue. This work uses sheet metal products as examples and investigates the two issues using genetic algorithms. The proposed genetic algorithm approach uses a genetic encoding scheme and a genetic reproduction strategy to reach an

optimum solution. Case studies are carried out to test the genetic algorithms. The effectiveness of the genetic algorithm path planning approach is compared with that of the ant colony algorithm.

The future trends in PD technologies are discussed, and include such topics as Internet-based collaborative design, decision support, manufacturing support, supply chain management, Internet techniques for product design and manufacturing, system integration, product modelling, STEP-based data environment, and concurrent engineering. This may be used to guide coming research, or act as a reference for a company to deploy or develop new systems, algorithms and tools for producing OKP products.

This book also contains an Appendix that summarises some of the systems developed for RPD. It provides the source code of the tools developed including the quality function deployment (QFD) interface, CAD/CAPP/CAM system, and database interfacing program. These are excellent examples for users or developers.

I would like to also take this opportunity to express my deep appreciation to those who have contributed to this book. The authors are also grateful to Ms Bomiao Li and Ms Jenny Xu for their assistance in compiling the book. It is our sincere hope that readers will find this book useful to their study and research.

Auckland, New Zealand Shane (S.Q.) Xie
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