Engineering Knowledge Management for Product Design

（面向产品设计的工程知识管理）

Jing Shikai　Zhou Jingtao　Zeng Yunbo

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内 容 简 介

书系统的阐述了产品设计中知识管理的相关理论与关键技术，主要内容有：工程知识管理的定义和重点研究内容；复杂产品总体设计面临的问题以及对工程知识的管理需求；工程知识驱动的复杂产品总体设计方法的核心思想；连续、一致、可追溯的工程知识形式化描述方法；设计状态要素实例提取算法和基于流形算法的产品演化映射关系提取算法；工程知识驱动的设计状态要素推理的总体思路；云环境下的知识融合；面向任务的知识主动推送技术；原型系统以及工程知识驱动的产品设计方法、关键技术的有效性验证。

全书重点突出了工程知识管理思想与产品设计过程的融合，可以作为高校设计学科在创新设计方面本科生、硕士生的参考书或教材，也可以作为研究机构在知识管理工程实践的参考书。

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Preface

After decades of development, a set of practice and experience for overall designofcomplex product has been basically formed in military industry (aviation, aerospace, electronics industry etc.) in China. These practice and experience plays very important role in product development. However, with the continuous increase of the complexity of product and new technology, the development cycle is further shorten and coupled, with strengthened cooperativity and parallelism. Due to the dependency on experience, lack of innovative capacity, discrete design pattern result in deficiency and the fact that much effort has been put into the design result instead of the design process during the overall design of traditional complex product, the expected objective of "fast" "good" "economical" overall design is difficult to achieve.

The overall design of complex product is a process of decision-making conducted by the designer based on specific user case. Its essence is to use large number of existing knowledge to continuously generate new knowledge to solve the problem during design process. This kind of knowledge has very strong engineering background. Therefore how to reuse existing knowledge to improve efficiency has become crucial problem in the process of the overall design worth research and exploration. This bookfocuses on knowledge-based approach in overall design of complex product, namely, the basic theory and related key technologies of knowledge extraction, organization, transformation, evolution and reuse in the overall design process. The purpose of this bookis to provide a theoretical reference and technical guidance for improving the capacity of the overall design in complex product development, and transform the design model from "know-what" into "know-why" and from"experience-and-judgment" into "process-and-method". The book is divided into seven chapters. The first chapter starts with concept and categorization of knowledge management, then analyse the evolution of knowledge management development lead to the research theme of engineering knowledge management. In this chapter, the significance and characteristics of

engineering knowledge areintroduced, the definition and the key research contents of engineering knowledge management are given. In the meanwhile, the engineering knowledge management and knowledge management are also compared. The second chapter first introduces the basic design process of overall design of complex product and summarizes the key technologies of system design model construction, correlation mining, and knowledge reasoning etc., then extracts current issues in overall design of complex products and engineering knowledge management needs. Aiming at the new demands of the overall design of complex product, the third chapter puts forward the core idea of the engineering-knowledge-driven overall design method for complex product. The basic principle of this method is then elaborated, that is, with the drive of the transformation and evolution of engineering knowledge in different stages, establish unified, hierarchical and refined design ability to achieve efficient reuse of existing knowledge. The fourth chapter studies the definition of engineering knowledge model and explores the formation of descriptive method to characterize continuous, consistent and retrospective engineering knowledge in overall design process. In the fifth chapter, two algorithms to obtain the implicit evolutional mapping relationship are proposed based on characteristics of the overall design process and the analysis of the evolutional mapping relation of the engineering knowledge. One algorithm focuses on instance extraction of design state element, and the other adapts manifold learning algorithm to extract evolutional mapping relation of a product. In the sixth chapter, a general idea of engineering-knowledge-drive design state element reasoning is proposed. It uses reasoning-intention-oriented design state element reasoning method to simulate design process of human brain, then, constructs the information of reasoning intention, reasoning evidence, decision criterion, etc. to achieve design state element reasoning. Meanwhile, it proposes the use of analytic hierarchy process (AHP) for qualitative and quantitative analysis to resolve the existence of multiple resoning options. Additionally, AHP optimizes the election of reasoning options by combining weighted parameters and subjective measures together. In the last chapter, prototype system is introduced, and the engineering-knowledge-driven overall product design method is verified through an application example.

Chapter 1, 2, and 3 are written by Shikai Jing, Chapter 4, 5, and 6 are written by Jingtao Zhou, Mingwei Wang and Han Zhao are also involved in completion of these chapters. During the completion of this book, Yunbo Zeng, re-

searcher of china academy of space technology, provides guidance and technical support for the idea of combination of the overall design and engineering knowledge management, he is also the author of Chapter 7, The final compilation and editing is conducted by Shikai Jing.

The book can be used as reference and guidance material for innovative design of design discipline, and it also can be used as guidance textbook and reference material for managementdiscipline of colleges and universities on engineering practice of knowledge management.

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Due to limitation of time and authors, there is still deficiency exist in this book, and comment and suggestion are appreciated.

Authors
Mar 2015

Contents

Chapter 1
Summary of Engineering Knowledge Management

1.1 Conceptand categorization of knowledge management

1.1.1 Summary

With the increasing speed of development andapplication of new technology, the global integrative information environment develops rapidly, information production and diffusion continuously to accelerate, and knowledge, which is replacing the monetary capital and natural resources, becomes the primary source to core competitiveness for creating industry. The acquisition, transmission distribution, application and innovation of knowledge have become the basic means for organizations to improve theircore competitiveness and to obtain sustainable development ability. Evolution from the management of information into the management of knowledge has become the inevitable trend. Under the background of knowledge economy, a brand-new management theory and management method, knowledge management, emerges at the right moment. Currently in westernworld, research and application of knowledge management are growing rapidly. Organizations of national defense industry, such as the National Aeronautics and Space Administration (NASA) and the US Department of Homeland Security (DHS), have carried out strategic planning and project implementation of knowledge management and have achievedgood result to some extent. In domestic, as one of key elementsof national manufacturing industry development in nearfuture, knowledge engineering and knowledge management are receiving great attentions and have shown great potential, becoming a new research hotspot in the field of engineering application in our country. In order to meet the development demand of new generation of complex militaryequipment, military equipment develop units or corporations such as AVIC, CASC, CASIC, CNIGC, CSGC etc.

have gradually carried out research on knowledge-based product development. With the transition from informative intelligence to knowledgable intelligence, many intelligence institutes in the field of national defense and intelligence technology have also implemented knowledge management system respectively.

Knowledge managementhas become an important tool to stimulate development of aerospace enterprise under the new economy environment in 21st century. Foreign military enterprises have embarked and lead on knowledge management, remarkable achievements have been achieved. For example, British Aerospace Corporation, which has received remarkable benefits in implementing knowledge management, recognizes knowledge management as "the best way to practice". As industrial leader in national high-tech strategy in our country as well as typical knowledge-based enterprises, knowledge resources of aerospace enterprise widely exist in the lifecycle of research, development, production, and product service of complex product. The knowledge management system achieves efficient distribution of knowledge via managing of tremendous knowledge in the process of model scientific research and production, thus greatlyshorten the model design cycle. Therefore, the implementation of knowledge management system has significant impact on development of aerospace science and technology industry.

Nowadays, theera of "knowledge economy", the foundation of expansion, core competitiveness and development strategy of enterprises are inseparably connected with "knowledge". Under this circumstance, knowledge should be recognized as the primary productive force, knowledge management should be prioritized and implemented and information system should be further advanced. Knowledge management has become a new management mode which meets the needs of knowledge economy. It is an important strategy to meet challenges of the new age.

1.1.2 Generation of knowledge management

With the arrival of knowledge economy,"intellectual capital" has become the actual driving force to create the core value. The one who can innovate and make good use of knowledge dominates. Therefore, knowledge management has become the key to improve core competitiveness, and it is also a basic requirement to develop knowledge economy. American economist and management scientist Peter F. Drucker is one of the earliest scholars to perceive and predict the coming