ANALYSIS ON THE APPLICATION OF MODERN MANUFACTURING-ORIENTED CAD/CAM

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ABSTRACT

In recent years, CAD/CAM has been extensively applied in global machinery with the rapid development of computer technologies. Due to the technical application of CAD/CAM in manufacturing industry, enterprises have gradually changed their traditional approaches to design and manufacture products. Meanwhile, qualitative changes begin to occur to the production process and control pattern. Hence, CAD/CAM slowly becomes fundamental for the development of modern manufacturing enterprises. In fact, modern CAD/CAM refers to a design technique and theory which effectively support the automatic design of products with the impacts of a complicated system. CAD/CAM needs to be constantly improved and developed from various perspectives pertinent to technological advancement such as design tools and environment, etc, in order that the design can become intelligent, network-based and integrated rapidly, to promptly meet the requirements for product design, reduce production costs, shorten the product design period as far as possible and improve the efficiency of product design in modern manufacturing. This paper focuses on demonstrating the concept of CAD/CAM, formation of modern manufacturing-oriented CAD/CAM, corresponding research contents, the application of CAD/CAM in modern manufacturing industry and development of modern CAD/CAM and so on.

Keywords: *Modern Manufacturing, CAD/CAM, Application*

1. INTRODUCTION

CAD/CAM, mainly deriving from military and aviation industries, has been widely utilized in global manufacturing industry with the fast development of computer technologies in the past few years. After CAD/CAM was adopted in modern manufacturing, the product design has been improved to a large extent, the period of which was greatly shortened as well. The research on and development of CAD/CAM are of great significance since it is one of the tools of higher market competitiveness in Chinese machinery.

At present, CAD/CAM technology system has gradually developed to the third-generation system, named CAD/CAM system. In terms of modern CAD/CAM system, great improvement has been made in modeling techniques. Its variable, parameterized and feature-based modeling techniques have been widely adopted, many of which are still being studied for further development. Since the late 20th Century, revolutionary changes have begun to occur to manufacturing technologies in China and previous traditional manufacturing technologies could hardly adapt to social changes. After the human society entered a brand new economic era, traditional manufacturing technologies began to be constantly developed steadily in manufacturing industry. In particular, information and computer technologies have been extensively applied in manufacturing industry. CAD/CAM has been effectively improved, creating certain economic benefits for the development of modern manufacturing. In traditional manufacturing, relevant information was primarily exchanged by technical personnel with the aid of surrounding environment. Machines were operated by man, while the production quality, efficiency and machining accuracy were mainly dependent upon the quality and skills of operators, namely restricted by human factors. Compared with traditional manufacturing technology, advanced CAD/CAM has remarkable advantages. Once traditional manufacturing technology is integrated with modern management technology, automation technology and information technology, advanced manufacturing technology will be effective in controlling all systematic production processes. Traditional manufacturing technology, in a general sense, refers to the techniques used for machining and manufacturing, whereas advanced manufacturing technology involves the whole process including product design, manufacturing,

selling, use and maintenance. As regards advanced CAD/CAM, related disciplines are integrated and intersected with other specialties, the boundary of which becomes vague and even disappears. Advanced CAD/CAM focuses on applying technology in combination with management, particularly placing emphasis on scientific and reasonable management and coordination of the whole manufacturing process[1-6].

Confronted with fierce market competition, all large enterprises begin to take product design as the most fundamental part for corporate development. It would be impossible for an enterprise to find any suitable marketing channels if its products are not innovative. In this case, it is rather hard for the enterprise to survive through the competitive market even if it is fairly advanced in technologies and equipment. With the constant development of society, advanced technologies for product design gradually become fundamental for the development of advanced manufacturing, which plays a very important role in corporate development. Furthermore, CAD begins to be expanded from traditional technologies, the expanded part of which is called modern CAD/CAM which in essence refers to a design technique and theory which effectively support automatic product design with the impacts of a complex system. From the perspectives of all related technological advancement in design tools and environment, etc., CAD/CAM is continuously perfected and developed, so that the design can become intelligent, network-based and integrated swiftly in manufacturing industry, in order to rapidly satisfy the requirements for product design, reduce production costs, shorten the period of product design as much as possible and improve the efficiency of product design.

Nowadays, industrial products shall go through an increasingly complicated process from design, molding to mass production which need to be fulfilled with the collaboration of product designers, machining process planners, production operators and managerial personnel of production lines, etc. This is a process for constant optimization and repetitive alternation, integrating design, modification and product redesign. Slowly, it is rather difficult for enterprises to meet the demands of competitive market by traditional manufacturing and manmade design. As CAD/CAM constantly develops and advances, enterprises have achieved brand new development in manufacturing from different aspects. For the application of CAD/CAM, enterprises gain much more social and economic benefits. CAD/CAM is highly comprehensive, knowledge-intensive and efficient, updated rapidly, playing an increasingly important role in supporting the whole manufacturing industry. With the development of CAD/CAM and its application in corporate production, it will necessarily become an irresistible trend in modern industrial production in China. CAD/CAM is neither the basic mapping of traditional product design and manufacturing techniques, nor uses computer as a main tool in certain part or step of production, but brings its major merits into full play in the entire process of product design and manufacturing in combination with professional technicians' help and management concepts by adopting engineering and computer technologies for manufacturing modern products to the largest extent, for the purpose of fulfilling all tasks which can hardly be completed purely by men due to computational complexity, heavy workload and high repetitiveness. It assists technical personnel in completing all tasks in the entire manufacturing process, but doesn't replace them[7-10].

2. CONCEPT OF CAD/CAM TECHNOLOGY

In manufacturing industry, one of the major outcomes is product. Products, in the traditional sense, refers to the products finally manufactured by enterprises for users after firstly analyzing the production from market demands and production processes, and then going through the processes of designing and machining (shown in Figure 1).

CAD/CAM technology fulfills relevant tasks with the aid of computer technologies which are CAM, CAPP and CAD respectively. Traditionally, the manufacturing actually refers to the processing and transformation of materials. In recent years, scholars have begun to bring forth the concept of Computer-integrated Manufacturing, because of which the manufacturing has been gradually expanded to a larger extent (shown in Figure 2).

CAD and CAM are respectively the abbreviation of Computer Aided Design and Computer Aided Manufacturing. As regards CAD/CAM, different data and graphic information are constantly generated and utilized by special technical means including computer software and hardware, so as to continuously assist people in product design and manufacturing. By CAD/CAM, people are supported by computer technologies to complete product design and manufacturing. CAD/CAM is a brand new breakthrough regarding the technical application of computer technologies in

manufacturing. CAD principally covers automatic drawing, dynamic simulation, product analysis, engineering analysis and building geometrical models, etc. CAM mainly involves plant management, flexible manufacturing system, robots, process design and numerical control, etc, which is extended and developed from CAD in the field of production and machining. Numerical control plays a fundamental role in CAM, by which lathes are operated, being helpful for improving the machining and production of parts. As industrial production is aided by computer, CAD and CAM gradually becomes two dispensable parts, which are mutually constrained and associated, becoming a systematic operating procedure for manufacturing. CAD/CAM, emerged in late 1050s and early 1960s, flourished in 1980s and 1990s. Over the past few years, CAD/CAM has been gradually applied in the entire process of corporate manufacturing management with more and more extensive application of computer technologies, the development of which has greatly facilitated the design and manufacturing of products, becoming the fundamental approach for manufacturing enterprises to enhance their competitiveness[11-15].
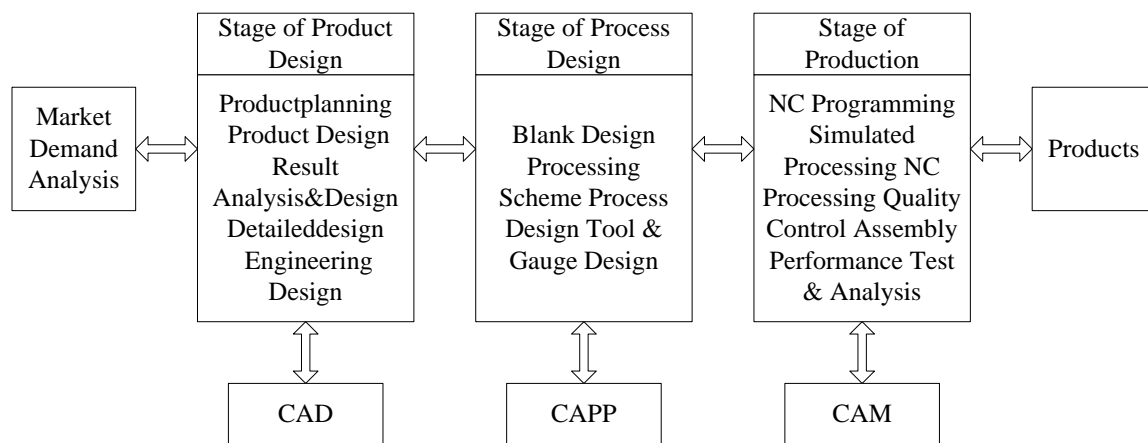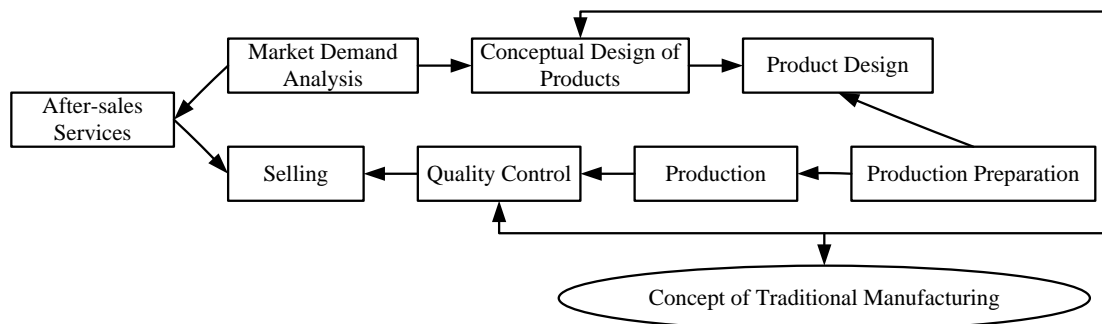

Figure 1: Basic Concept of CAD/CAM

Figure 2: Concept of Modern Manufacturing

3. THE FORMATION OF AND RESEARCH CONTENTS ON MODERN MANUFACTURING-ORIENTED CAD/CAM

3.1 Core Technologies in Advanced Manufacturing Enterprises

With the constant advancement of science and technology, manufacturing enterprises face more and more intense market competition, taking product design as the most fundamental part for corporate development. It is of great difficulties to manufacture products that can adapt to social demands if no products are innovative. Under this situation, enterprises can hardly gain advantageous positions through fierce market competition even if they are quite advanced in production and management technologies. Effective market competition boosts the progress and development of manufacturing enterprises in China. Advanced CAD/CAM is constantly developing as well, the

widespread application of which in manufacturing enterprises has effectively improved corporate product design, greatly reduced their production costs and created new opportunities for their development.

3.2 Main Research Contents on Modern CAD/CAM

Driven by present advanced design theories and manufacturing techniques, modern CAD/CAM seeks to realize design automation based on the development of traditional technologies with the impacts of a complex system. Scientifically, the research contents on modern CAD/CAM include design techniques and theories. Compared with previous studies, great breakthrough has been made to a large extent. The information and resources of different areas are collaboratively designed by the network technology which is one of the key technologies among modern CAD/CAM as well. Modern CAD/CAM is primarily characterized by intelligence, network-based and integration. Integration actually refers to the integration of enterprises, production process and information. Network-based means the design techniques and environment required by the dynamic alliance center in support of its collaborative design. Intelligence represents the intelligent technologies needed for being network-based and integrated, such as expert system and artificial intelligence. Researchers study modern CAD/CAM for the purpose of maximizing the use of automatic design technologies by manufacturing enterprises, to satisfy the requirements for short production period, low production costs and high product quality, in order that they can obtain favorable positions through intense market competition.

4. THE APPLICATION OF CAD/CAM IN MODERN MANUFACTURING

Based on system software, peripheral equipment and computer software, CAD/CAM is an application technology aiming at engineering application and incorporating 2D drawing, engineering calculation and 3D geometric modeling in combination with the knowledge of different disciplines such as Information Technology, Electronic Technology, Control Theory, Ergonomics, Mechanical Design & Manufacturing, Computational Geometry and Computer Engineering, etc.
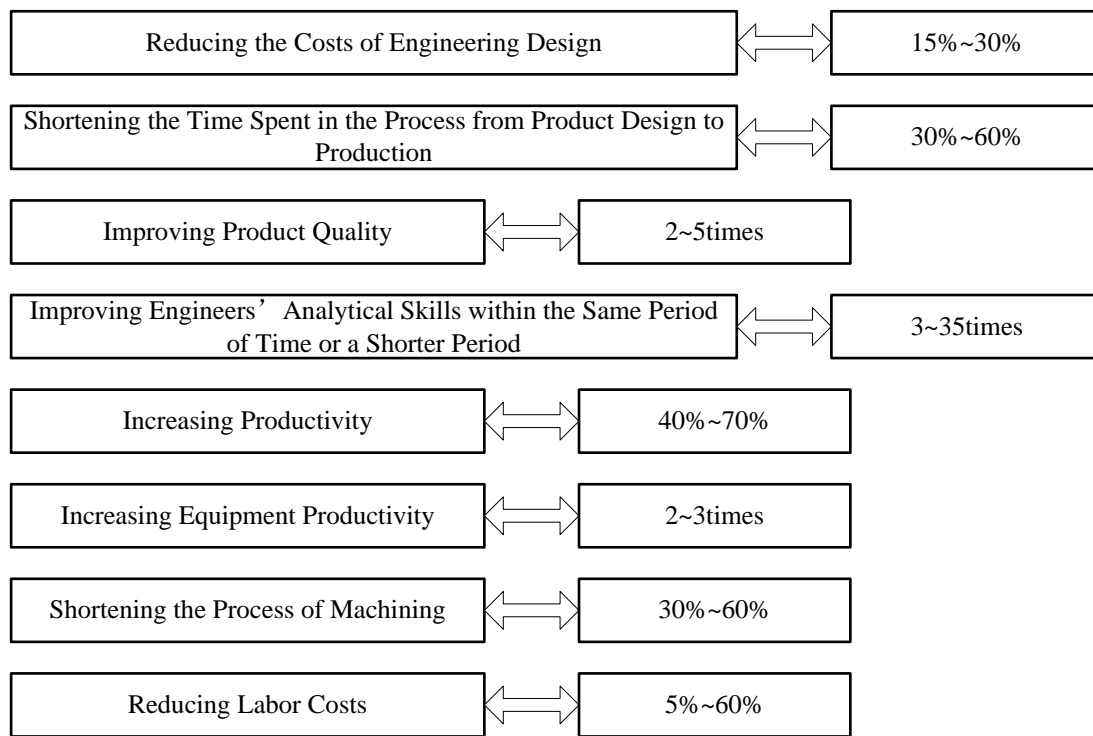
Reducing the Costs of Engineering Design	15%~30%
Shortening the Time Spent in the Process from Product Design to Production	30%~60%
Improving Product Quality	2~5times
Improving Engineers' Analytical Skills within the Same Period of Time or a Shorter Period	3~35times
Increasing Productivity	40%~70%
Increasing Equipment Productivity	2~3times
Shortening the Process of Machining	30%~60%
Reducing Labor Costs	5%~60%

Figure 3: Measurement of the Benefits Created by CAD/CAM

With the application of CAD/CAM in manufacturing industry, enterprises have begun to change their traditional design and manufacturing techniques gradually. Moreover, there are qualitative changes in the production process and control mode. Thus, CAD/CAM slowly becomes essential for modern manufacturing enterprises to improve their production. In traditional manufacturing enterprises, the entire production process is mainly controlled by technicians, while the whole machining process for products and spare parts (covering the equipment, manufacturing, process, design and state) is fed back and detected by men. All information is gathered by managerial and technical personnel. Then, technical personnel will take measures to handle corresponding information. Due to the limitations imposed on people themselves, there would be a decrease in the information during transmission. No matter in product design, manufacturing, assembly or else, it is people-centered. In this case, if any problems happen in any part, technicians are needed to solve these problems subjectively by the experience and knowledge they've accumulated. Different from traditional designing and manufacturing techniques, modern CAD/CAM has changed previous people-centered operation mode and becomes computer-centered. Computer runs at high speed, has a good memory, and can store a large amount of information. It can unceasingly take advantage of existed information and repetitively utilize it, as a result of which much time is saved from product design, manufacturing and machining, in order that its space can somewhat be expanded. By effectively controlling each part by a computer, technical personnel can realize concurrent operation in the entire process. An American academy of engineering science and technology ever measured the benefits that could possibly be created by CAD/CAM for an enterprise (shown in Figure 3).

5. DEVELOPMENT OF MODERN CAD/CAM

Product design and development are highly complicated and innovative. Up till now, people haven't acquired a comprehensive understanding of product design and no strict theoretical systems have completely formed for them to conduct relevant studies. Besides, advanced design techniques and theories are still the major contents studied by CAD/CAM technicians. For the past few years, design theories and techniques including artificial intelligence technologies, large-scale customized design, collaborative design and concurrent design have been gradually put into use,

which has greatly promoted the constant development of CAD/CAM. With the continuous development of manufacturing technologies in China, new modes of such technologies are bound to emerge and develop slowly, due to which new challenges and higher requirements will be posed to the application of CAD/CAM.

5.1. Concurrent Design

In concurrent design, the entire design period of products need to be fully considered during the design before production and development. It is necessary to consider some major factors such as market demand for products, maintenance, assembly, manufacturing and environmental protection, etc which are integrated concurrently to accelerate the production & management to the largest extent, reducing manufacturing costs and constantly improving product quality. In advanced manufacturing field, concurrent design is most commonly used for production (shown in Figure 4 in details). Besides, it is the product of communication, network and information technologies when they reach a certain stage of development. By systematically designing products, the production processes can be reorganized and optimized effectively.
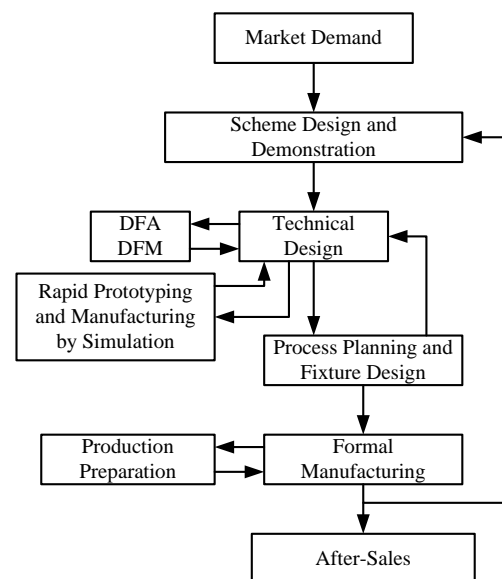

Figure 4: Working Mode for Concurrent Design

The key of concurrent design lies in its transfer of information integration to process integration according to distributed, concurrent and collaborative solutions. Information integration focuses on universally managing large amounts of

data required in different stages such as product design, machining, manufacturing and management, for the purpose of sharing and exchanging correct information with high efficiency at last. Process integration aims at product restructuring and optimization. With the major technical support of data management technology and computer network technology, collaborative working environment is created step by step, to realize concurrent design rapidly in strange lands. Compared with serial design, it is possible for concurrent design to incorporate more design activities, in order that multiple activities can be implemented concurrently to save the time in design.

5.2. Collaborative Design

To reasonably optimize product design, it is usually necessary to constantly introduce various design techniques into modern CAD/CAM to meet people's changing demand for product design. Regarding a design issue, several different data patterns and multiple design tasks are often included. The entire design process is generally involved with the specialized knowledge of different fields related to the same categories of products. It also requires comprehensively employing and handling the data, experience and knowledge of many different fields. Due to the complicacy of the whole design process, the most intuitive design requirements are also put forward for the collaborative design of products. Collaborative design means that under the support of CAD/CAM, each member assumes certain design tasks within the same project and work with each other to fulfill all design tasks, to achieve the same design objective eventually. As shown in Fig.5, collaborative design makes it possible for multiple subject specialists to jointly work with each other for effectively improving the production efficiency, effectively shortening the production period and increasingly enhancing enterprises' market competitiveness.
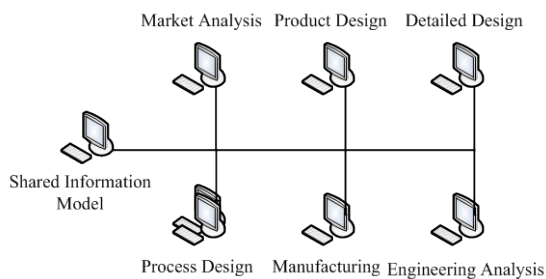

Figure 5: Collaborative Working Environment

6. CONCLUSION

With the constant development of modern manufacturing, advanced manufacturing technologies increasingly impose impacts upon modern CAD/CAM, proposing higher requirements for the research on and development of CAD/CAM. In modern manufacturing enterprises, only if engineering technicians accurately grasp the development trend of CAD/CAM and rapidly learn how to apply modern CAD/CAM can they adapt to social development trend quickly, gain more economic and social benefits from social production, and making contributions to the society.

7. ACKNOWLEDGEMENT

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