The Empirically Comparative Analysis of Advanced Manufacturing Paradigm of Chinese, Japanese and South Korean Enterprises

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Abstract - **Just-in-time Production (JIT) and Agile Manufacturing (AM) are both production paradigms that are widely used all over the world. JIT and AM are utilized to compare and analyze the manufacturing industry in China, Japan and South Korea. The application conditions and the development of JIT and AM in manufacturing industry in China, Japan and South Korea are analyzed separately, and then comparison is made by providing some useful and important comparison items of JIT and AM. The primary stage of JIT / AM mixed production paradigm of manufacturing enterprises in China is proposed by comparing Chinese JIT/AM production paradigm with that of Japan and South Korea. According to empirically comparative analysis, suggestions are given in popularizing and deepening JIT/AM in manufacturing industry, especially for the development of Chinese manufacturing.**

Keywords - **Agile manufacturing, Just-in-time, Manufacturing industry, Production paradigm**

I. INTRODUCTION

With the continuous improvement of living standards in China, most of people start to call for products with much better quality and performance. Diverse products with individual and personalized characteristics are demanding. All enterprises are in the unpredictable and competitive market environment. It is the pressing issue to carry out the technical innovation and structural adjustment of existing enterprises in order to guarantee their survival and self-development in the complicated and volatile economic environment. Just-in-time production and agile manufacturing are put forward under this condition.

Just-in-time production (JIT) is a production form that is applicable for multiple type and small-batch production. It was put forward by Toyota in 1950s and then was widely used by Japanese automotive and electronics industries after 1972. In 1980s, it has been applicable all over the world. Being a production form, JIT provides an effective approach for enterprises to improve productivity and reduce production cost consistently [1].

JIT is a type of production paradigm that is used in production organizations at all levels. To utilize machines and equipments with high universality and high automation, and to utilize human, equipments, materials and other elements efficiently in the production process, so as to eliminate a variety of invalid labor and waste, and to ensure to produce the necessary products with necessary quantity and quality at the necessary time and places. The objective of JIT is to continue to reduce costs, and make sure no waste and zero inventory in production. In short, it is a paradigm to help enterprises to produce with the cost as low as possible and then provide customers with products and services with required quantity and perfect quality, so as to maximize customer satisfaction in the ever-changing market [2].

Agile manufacturing (AM) is a new manufacturing paradigm catering for the 21st century manufacturing and it was put forward by America in order to revitalize its leadership in the manufacturing sector. It is market-based manufacturing system, which is characterized by flexible production technology and dynamic organization, utilizes inter-enterprise network technology with the support of high-quality and well-coordinated staff in order to adapt to the market quickly [3].

AM combines the advantages of other advanced production management paradigms like JIT, MRP Ⅱ and so on. It can rapidly and timely meet the requirements of high-performance, low-cost, high-quality, multiple types, dynamic flexibility, etc, which now seems impossible and difficult to produce by a unified system to achieve the objectives and requirements of production management . The fundamental of agile manufacturing is to fully integrate the high-quality staff, dynamic and flexible organizations, or dynamic unions, and advanced flexible production technology so that enterprises can response quickly to the changing and unpredictable market and get long-term economic benefits [4].

As advanced manufacturing paradigms, Just-in-time production (JIT) and Agile manufacturing (AM) has been rapidly developed all over the world, and achieve some benefits to a certain extent. The 21st century technology development and the competitive world market make enterprises to deal with even more severe challenges. Therefore, JIT and AM will be applied at a higher level and broader field.

II. JIT/AM PRODUCTION PARADIGM of CHINESE, JAPANESE and SOUTH KOREA ENTERPRISES

As we all know, Japan and South Korea occupy important places in East Asia and even on the world economy stage. Large enterprises that make major

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contributions to the economic development of Japan and South Korea are mainly manufacturing enterprises. It is an advanced mode of production and manufacturing technology that support their rapid development. JIT and AM are widely used in manufacturing enterprises of Japan and South Korea [5].

Just-in-time production emphasizes on timely and demanding production, which is to produce according to the requirement of customers. It requires guaranteeing the convergence on time at all aspects of the production processes, and eliminating unnecessary inventory, and starting productions in accordance with those quality, quantity and delivery requirements of customers.

Agile Manufacturing was put forward firstly in the United States, and then it was introduced to Japan and South Korea. Thereafter, Agile Manufacturing started a rapid application and development both in Japan and South Korea. In 1995, Japan launched an international research project, which is called "intelligent manufacturing systems (IMS)". There were two agile manufacturing projects [6].

JIT has the following characteristics: (1) To produce in accordance with demand. To start production under the drive of customer –demand, and to utilize concurrent engineering to reduce product development time, so as to make rapid response to market demand. (2) To use pull-type production [7]. The production can speed up by promote the products of one process to go on to the next process more quickly. Human intervention is possible to improve the productions. (3) To follow lean production. To remove all superfluous and useless things in product design, manufacturing, sale and other aspects, and to take full advantage of group technology. (4) To promote group work as the main form for employee organization, and be available to staff participation in decision-making and management. (5) Full participation of staff.

The capacity of AM is reflected as follows: (1) The capability of rapid response to the market. (2) Competitiveness, which is about skills that needed for Enterprises to enjoy productivity, efficiency and effective participation. (3) Flexibility, which is the capacity of utilizing the same equipments and personnel to make different products and to achieve different goals. (4) Quick production, which is the ability to implement its mandate in shortest time. (5) The agility of day-to-day operations, which is the ability to adjust quickly a variety of changes that affect their day-to-day running of business [8].

To sum up, the basic characteristics of JIT/AM Production Paradigm of Japanese and South Korean Enterprises are as follows.

1) Clear and accordant target: It is the pursuit of efficiency, lowest cost, least waste, most varieties, simplest processes, perfect quality, and best user satisfaction.

2) Quick response: JIT and AM are embodied in the adapting and managing ability to seize fleeting opportunities in the unpredictable and constantly changing market environment.

3) High flexibility and non-inventory: It is necessary to provide customers with satisfactory and high-quality products and services with reasonable price by adopting modular reconfigurable processing modules and inter-enterprise resource reorganization [9]. Low-cost manufacturing contact between enterprises replaced the inventory in traditional manufacturing.

4) Emphasis of the integration of staff, technique and organizations: To remove the barriers of department knowledge-sharing in enterprises and the geographical boundaries among enterprises to achieve full sharing of a variety of resources by an extensive network of contacts both inside and outside the enterprises. Production processes must coordinate together to form the integrated supply chain for flexible production.

5) To fully mobilize and play the role of employees: It emphasizes to replace centralized control by decentralized decision-making, and exert initiatives and creativity of employees. Enterprises should have high-quality staff and to maximize the consistent ability innovation of staff. This is obvious in Japan and South Korea. The staff of Japan and South Korea has a strong sense of cause fighting spirit and team awareness. They emphasize the spirit of professionalism and rigorous work. Enterprises will communication with staff, to be responsible for staff, and to shape harmonious corporate atmosphere. These are the foundations of rapid development and wide application of JIT / AM in Japan and South Korea [10].

III. THE STATUS QUO OF CHINESE MANUFACTURING INDUSTRY AND PRODUCTION PARADIGM

At present, China is the world's fourth largest country of manufacturing industry. The added value of manufacturing in China is more than one-third of GDP. According to the prediction by Academy of Mechanical Sciences utilizing input-output system dynamics model (IOSD model), the growth rate of industrial added value of Chinese manufacturing industry from 2000 to 2020 will be up to 8.64% in accordance with price in 2008. In the next few years, the contributions of the overall industrial growth to GDP growth will reach 65% ~ 70%. Manufacturing sector becomes the main supporting force in the GDP growth. From an overall perspective, there are both adequate equipments and considerable human resources in China. All departments own or import the advanced production equipments, and enjoy a certain advantages in their respective fields [11]. Manufacturing industry is the concentrated reflection of scientific and technological level and the vector of high-tech industries. Besides, it is the main industry that attracts labor and employment, and expands export. Furthermore, it is the main industry that is an important guarantee for national security. Last but not least, it is a pillar industry of Chinese national economy and the engine of Chinese economic growth. To sum up, manufacturing sector, as

the drive of Chinese modernization, has an irreplaceable and important role in China.

The drive of the rapid development of manufacturing is the powerful domestic demand and international transfer of industry. Manufacturing industry is still the most attractive sector to investors. China's manufacturing develops vigorously. In 2003, large-scale industrial added value increased by 17%.The increasing speed in the first half of 2008 reached 17.7%, while increasing speed in March and April are both 19%. From May and June, there was a steady decline with growth rate of 16.2%. Manufacturing high-speed growth momentum will last for a considerable period of time.

With the reform and opening-up, Chinese industrial system has changed fundamentally since 1980s. Some new management thoughts and management practices began to enter the Chinese industrial fields. With further awareness of advanced manufacturing technology and management these technologies began to be applied in the auto industry, instrument manufacturing enterprises and achieved good results. Since Chinese second auto enterprise implemented JIT, the output increased a lot, even doubled the original design capacity. Besides, flow of capital and workers reduced by 50%, and labor productivity improved one time. Shanghai Automobile Gear Factory, used JIT production methods from early 1993 to 1995, the output increased by 100%, and the production cost fell by more than 400 million Yuan. Furthermore, the cycle time dropped from the 134.81 days in 1987 to 32 days at the end of 1994. Previously, inventory period of the general products in hot pre-workshop reduced from more than 10 days to less than two days. In recent years, the cost of Santana production in Shanghai Automotive Corporation fell 5% year after year, while labor productivity raised by 5% year after year. At present, in some large and medium-sized Chinese enterprises, advanced technology and equipment throughout takes a large proportion, and automation is also relatively high [12].

Although Chinese manufacturing industry has its own foundations, there are also a lot of problems as follows. (1) Limited overall scale. Although Chinese manufacturing industry ranks 4th in the world, its overall scale only equals to 1 / 5 of the United States, or 1 / 4 of Japan. (2) Low labor productivity and industrial added value. On the whole, it is in a labor-intensive stage. (3) Irrational manufacturing structure. Equipment manufacturing industry, which is decisive in the manufacturing sector, only accounts for 26.5% of Chinese manufacturing industry. It is far below 41.9% in United States, 43.6% in Japan, 46.4% in Germany and that of some other countries. (4) Great energy consumption and serious pollution. Pollution of unit output is far higher than that of developed countries. (5) Weak technological innovation capability. Products are mainly low-end products with fewer added values. (6) Bad group advantages, excessive low production capacity, and lack of high-level production capacity. (7) Management system is pressing to be improved. Key enterprises of manufacturing industry in China are mainly state-owned enterprises. Their structural reforms lag behind, organizational structure is overstaffed, management levels are excessive, and decision-making is slow.

Though Chinese manufacturing enterprises have a certain explorations and practices on the JIT, MRP Ⅱ, AM and other advanced modes of production, most of Chinese manufacturing enterprises are still in the traditional production modes. That is to say, the traditional production paradigm and partial application of advanced manufacturing technology are concurrent in China, which is called mixed production paradigm.

With the promotion of reform and opening-up in China, its industrial system has changed fundamentally. Besides, in accordance with the further awareness of advanced manufacturing technology and management, popularization and application start in the auto industry and instrument manufacturing enterprises and have achieved good results. At present, advanced technology and equipments account for a large proportion in some of large and medium-sized enterprises in China, and their degree of automation is relatively high as well. To some extent, they have already owned the foundation of the implementation of JIT / AM.

At the same time, many Chinese manufacturers utilize the traditional modes of production, and the proportion is relatively large. On the one hand, these enterprises have slow response to the market. Most of companies used push-mode that is lagging behind, rather than pull- mode of sensitive customer traction. On the other hand, the degree of specialization of production is relatively low, core competence of enterprise is weak, and it is difficult to achieve rapid response. Besides, the control ability of enterprise production plan is weak, the level of production management information is low, and so companies tend to guarantee the continuous production on the cost of high inventory and high production costs. Therefore, China introduced JIT / AM from abroad, and relevant theoretical research is not thorough. Most introductions are about the principle JIT / AM, and its propaganda is not enough. They are lack of reference books with high practical operational guidance for enterprises. Enterprises attach importance to the introduction of production equipments, and they do not attach importance to investment in production management technology. Furthermore, they are lack of similar manufacturing foundations and supporting conditions as in Japan and South Korea. So we can call Chinese manufacturing production paradigm the primary stage of JIT / AM mixed production paradigm.

IV. COMPARISON AND ANALYSIS OF JIT/AM PRODUCTION PARADIGM OF CHINESE, JAPANESE, AND SOUTH KOREAN ENTERPRISES

As we all know, in the traditional manufacturing paradigm, the main task of enterprises is to produce products in order to meet market demand, and the

appropriate production mode is mass production. After the period of shortage economy, living standards of people improve a lot, and their demand becomes higher and more personalized. Thus, production paradigm of enterprises transforms to multiple type and small- batch mode.

TABLE I
COMPARISON OF MASS PRODUCTION AND SMALL-BATCH

Item \ Mode	Mass production	Multiple type and small batch
Output products	Standard products	Multiple type products
Equipment usage	Special and expensive equipment	High flexible equipment
Production division	Meticulous, repetitive, standardized	Coarse, multi-skilled
Inventory level	High	Low
Production cost	Low	Lower
Production quality	High	Higher
Market demand	Supply falls short of demand	Buyers' market

TABLE II
COMPARISON OF THE PRIMARY STAGE OF JIT / AM MIXED WITH PRODUCTION PARADIGM IN CHINA AND JIT / AM OF JAPAN AND SOUTH KOREA

Item \ Country	Japan and South Korea	China
Objective	Lean	Good enough
Product design	Parallel	Serial
Organization way	Integrated General group work	Specialized division of work
Automation	Simple	Complicated
Product quality	High, TQC and automatic anti-failure-free devices	General, examination of quality inspection department
Production system	Multiple type and small-batch	Single type and mass production
Process control	Major emphasis at the group work and streamline business processes	Strict operational audition, to achieve personal job efficiency
Inventory	Zero inventory	To adjust production by inventory
Combine with IE	Closely combination	Few combination
Coordination	Close, steady, and interdependent	Unstable
Human resources	A variety of skills, sense of participation, responsibility, mutual exchanges, job enthusiasm	Single Skill, boring, lack of communication and enthusiasm
Relationship with staff	Exert personal initiative, emphasize coordination, and long-term performance-based evaluation	Strict hierarchical relationship and short-term performance-based evaluation
Enterprise culture	Influence enterprise culture	Weak influence
Production Orientation	Customer demand drive	Production drive
Optimization scale	The whole production system	Itself

The proportion of advanced manufacturing technology in mixed production paradigm of Chinese manufacturing sector is not large and thus reflects more characteristics of mass production, while JIT / AM production technology in Japan and South Korea are relatively more mature and thus reflect more characteristics of multiple type and small- batch (See TABLE I).

To summarize, there are obvious differences among the primary stage of JIT / AM mixed production paradigm in China and JIT / AM of Japan and South Korea (See TABLE II).

V. CONCLUSION

In accordance with comparison and analysis above, the five proposals are as follows,

1) JIT and AM are the essence of the market concept: All activities of enterprises depend on the development of market. The manufacturing of production system is market-oriented. It is especially critical and vital for China's manufacturing enterprises to achieve actually the changes of the market concept.

2) To strengthen win-win concept, and to enhance corporate culture: Win-win concept is the prerequisite for cooperation. To cooperate and utilize the resources is the basis for sustainable development of enterprises. Corporate culture of Japan and South Korea is worth our consideration and learning. In their corporate culture, the communication, considering the general interest, dedication, cooperation and so on are all indispensable concept supporting for implementing advanced manufacturing technology.

3) To emphasize human resource management: During the implementation of JIT / AM, decentralized decision-making is one of the principles so that each operator is able to respond promptly to relevant problems and make right decisions. This has spurred the traditional object-centered management to transform to people-centered management. Enterprises of Japan and South Korea attach great importance to the staff training and the comprehensive training system, which provide a powerful guarantee for the implementation of advanced manufacturing technology.

4) To pay attention to JIT / AM digestion, absorption and innovation: It is necessary to consider about the actual conditions of existing production systems of Chinese enterprises during the promotion and popularization of JIT / AM in China, and to improve and optimize in the process of practice with the combination of Chinese national conditions.

5) The manufacturing industry today is not the traditional sense of the machine manufacturing industry: It becomes a combination of many other industries with emerging technologies, such as financial machinery, electronics, optics, information science, materials science, management and so on. China's state-owned enterprises are in the crucial moment of transforming from the planned economy to market economy system, and from

extensive to intensive production. During this process, advanced manufacturing technology is the basis and foundation for the promotion and implementation of these two basic changes. With the rapid development of technology and the global competition, all enterprises will be in a continuous and unpredictable market environment. In order to survive and develop, it is necessary for all enterprises to make transformation and structural adjustment in the existing manufacturing production paradigm, or else it will lead to the slow development and even degradation of Chinese manufacturing sector.

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