Abstract: With developing of global economy and information technology, international enterprises’ production mode is profoundly various. At present, because the concepts of production mode are complicated, so we researched some production modes which were summarized in Japan and America in the last century, utilized this extensive application and successful effect, and summarized these advanced manufacturing production modes. We can sum up five modes: Cell Production, Lean Production, Computer-Integrated Manufacturing System, Agile Manufacturing, and Business Process Reengineering. In point of international manufacturing, they are top-drawer. This paper analyses these modes in order to enlighten Chinese manufacturing.

Key words: Manufacturing; Advanced production modes; Comparison

In the past 20th century, some significant changes have taken place in international manufacturing, and become the driving force behind the vigorous development of the global economy. With developing of global economy and information technology, international enterprises’ production mode is profoundly various. According to the

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papers’ statistics that were published by International Manufacturing Engineering Society, the number of advanced manufacturing systems and modes is 33[1]. Some countries, such as America, Japan, Germany, have designed advanced manufacturing technologies and method: NC, CNC, CAM, CIMS, MRP, TMC, FMS, robot, CAD/CAM, LP, CE and AM. With spreading and applying these methods, not only can we confirm the competitiveness of domestic enterprises but also develop world advanced manufacturing rapidly.

At present, because the concepts of production mode are complicated, so we researched some production modes which were summarized in Japan and America in the last century, utilized this extensive application and successful effect, and summarized these advanced manufacturing production modes. We can sum up five modes, they are top-drawer. This paper analyses these modes in order to enlighten Chinese manufacturing.

1 Introduction

In the latest 10 years, every country in the world strengthened the advanced manufacturing technology and strategy study of industry development with tremendous financial and material resources. The production mode embodies a kind of philosophy of manufacture, and exists in the form of the integration of the production system and management method. That is to say, the way of production supports the development strategy of the manufacturing enterprises; it contains the company system that is fit for the level of social productivity development, management, production and the conformation and operation ways of technology system. Through several hundreds year’s development, manufacturing experiences three stages: ex-industry
Comparatively, different ways of production are matched with different stage. The first stage: from handwork production to batch production; the second stage: mechanization production, automatic production, mass manufacturing; the third stage: digital and net aptitude production.

At the beginning of the last century, the mass pipelining manufacturing of Ford Company in America initiated a new time of modern production. The production system of Ford Company has the standardization theory of production and locomotive assembly line method theory and it became the advanced manufacturing method rapidly for its low cost and high productivity features. The core point of the mass manufacturing is to increase the productivity in order to form a rigidity system configuring company internal and social recourses. However, this system was challenged in the late of 20 century, because it is difficult to reconfigure and adjust it to fit for the changeful market.

In the early 1950s, the manufacturing technology developed rapidly: such as NC, robot, PLC, automatic material moving system, LAN, the flexible manufacturing system based on group technology etc. But the above-mentioned only value the view to increase the production efficiency, reduce the prepare time of production, but ignore the increased cost with the possible increased inventory. The basic elements of JIT were developed by Toyota in the 1970's, and became known as the Toyota Production System (TPS). It also has been described as an approach with the objective of producing the right part in the right place at the right time. It attempts to eliminate waste and improve the goal by executing the zero inventories and limitation. JIT concept affected the production systems of every country in the world. So many new
production systems were born based on the JIT.

In the 1990s, the big automatization production system of Japanese manufacturing field was not popular; so many companies replaced these old systems by another more flexible system—cell production in the situation of not withdrawing the investment on the this systems for the purpose of increase the flexibility of management system[3].

In 1985, Massachusetts Institute of Technology generalized the JIT to lean production. It stands out the insistence on the non-cost idea of business management, waste elimination idea of process management and the people-oriented idea of human resource management.

CIMS is produced with the widely use of computer technology. It combines the advanced manufacturing technology, automatic technology, computer and information technology, system engineering and management science etc and formed an integrative modern manufacturing system. CIM is a kind of concept and philosophy, CIMS means to form a computerized integrative system of whole process in company gradually in the guidance of CIM thinking. Intelligent Manufacturing highlighted the value of knowledge in the manufacturing activity, and knowledge-based economy is the main form of economic following the industrial economy. Intelligent Manufacturing had become the important manufacturing production in the future development of economy.

Agile manufacturing technology as an advanced manufacturing technology emerged in the early 1990s. It put forward a new competitive strategy after summing up the development course of manufacturing enterprises and the competitive positioning of United States. In 1991 the United States Congress commissioned the Iacocca Institute of Leigh University to prepare a report of “The manufacturing Enterprise Strategy in
21st Century, put forward the strategic concept of agile manufacturing implementation.

Business Process Reengineering (BPR) which was firstly proposed by the Professor Hammer in America in 1990 is a kind of rethinking and a thorough transformation of the enterprise operational process. It can improve the cost, quality, service and speed. BRP had become the important competitive strategy of some famous companies, such as IBM, Kodak, Ford Motor, and GE.

2 The comparison of production mode

Through our analyzing and researching lots of literature, despite the complexity of advanced production modes of manufacturing, we generalize the substance of them: Cell Production, Lean Production, Computer-Integrated Manufacturing System, Agile Manufacturing, and Business Process Reengineering. They are utilized synthetically advanced technology and management in the world. Some of them are not only using of production mode, but also advanced manufacturing concept, and are used widely by manufacturing, service industry and so on.

2.1 The common feature of five advanced production modes

Cell Production, Lean Production, Computer-Integrated Manufacturing System, Agile Manufacturing, and Business Process Reengineering have some common features because they were brought forward under the ground that was economic globalization and in the course of transforming of traditional manufacturing production method.

2.1.1 The uniform objective of operation of business

The means of competition of modern enterprises are not quality and price, but
orientation by customers. The objectives of enterprises are TOCS: Time, Quality, Cost, and Service.

2.1.2 The excellent adaptability of production system

The production system of modern manufacturing enterprises is based on the flexible administration, many varieties and short run production in order to increase variety of product and enhance the degree of satisfying the need of customers. Its adoptability is better, more flexible and economical and can be applied generally in modern society.

2.1.3 The same organization structure

The organization structure of modern enterprises is flat. Through decreasing the unnecessary tache, it can cut the distance of governing body and production line and establish the efficient and quick information transmission and decision-making system in order that enterprises can reflect rapidly in the race of market.

2.1.4 The stress on personnel

The harmonization is emphasized in modern manufacturing enterprises because the competitive edge begins to depend more and more on human resource under the circumstance when economy is based on information and network. The modern enterprises manage the personnel based on the proposition that man is basically faith and respect, utilize them creatively, and exert their conscious dynamic role. The modern manufacturing enterprises have been improved rapidly and continually based on the idea of man-oriented.

2.2 The differences of five modes

Cell Production, Lean Production, Computer-Integrated Manufacturing System, Agile Manufacturing, and Business Process Reengineering, they were summarized at the same period, however they had different field and circumstance.
2.2.1 Cell Production

Cell Production is an organization unit. One Cell Production is equipped a complete equipment of one kind of goods, and one or some omnipotent worker who can acquire skills and use equipment expertly. Every Cell Production can do all the work by itself. A workshop or factory has some Cell Production. The specialty is as follows:

Firstly, adjust the quantity of Cell Production and the speed of them in order to change the output. Secondly, depend on the flexibility of personnel to fill the polytrope of market based on the all-powerful worker. At the time of changing the kind of goods, we need adjust few tools and devices. We can enhance the unitary convertibility of production system and decrease the cost and time of changing the kind or batch. Thirdly, it doesn’t rely on large-scale computer control system in it, the tools and devices are simple, and can be designed and made by factory, so that the price of them is less than large-scale automatic system. Fourthly, because of each working independently on a job, the speed of every unit being absolute, eliminating the overstock of the half-finished goods, we can cut down the cost of production remarkably. Fifthly, the enterprises may appoint some Cell Production for the target customers or major products. Some Cell Production face different customers, as a result, they can work at the same time in one factory. In this way, the customers can enter the field of production and negotiate with the given Cell Production about the details of producing and delivering, the enterprises can match the demand of customers furthest and enhance the ability of enterprises which is to respond to the change of demand.

2.2.2 Lean Production

Lean Production come from Toyota production system and is summed up after
theorization. Its core idea is to meet the customers’ requirement of product sorts, the
demand of price through eliminating unnecessary waste (human, material, time, space)
in every tache. The specialty of Lean Production is as follows:

Firstly, change the method of quality control, search, correct and resolve the
question. Secondly, adopt flexible production, small quantities. Thirdly, minimize the
time of designing, cut the time of launch. Fourthly, diversify the product, quicken the
product cycle, and decrease in effect of economies of scale. Fifthly, increase efficiency
and productivity, decrease waste. Sixthly, enhance the adaptation emphasize the
assembly through standard size and cooperation. Seventhly, reinforce studying, keep
improving, train and communicate with personnel, add the staffs’ sense of participation
and responsibility.

2.2.3 Computer-Integrated Manufacturing System

Computer-Integrated Manufacturing System is composed of four primary
application systems (Integrated management and decision-making system, Branch
system of engineering designing, Branch system of automatic manufacturing and
Branch system of computer-aided quality control) and two supporting systems (Branch
system of database and Branch system of computer network). The specialty of
adopting CIMS is as follows:

Firstly, emphasize unitary system optimization, not to pursue an optimal technology.
Secondly, emphasize the integration of management technology and person, avoid just
considering technology. Thirdly, pay attention to training personnel; enhance staffs’
understanding and proficiency of producing.

2.2.4 Agile Manufacturing

Agile Manufacturing is a harmonious and interrelated system through integrating
technology, management, and person. Generally, AM must be supported by AM producing, technology, personnel and public relations. The specialty of Agile Manufacturing is as follows:

Firstly, the planning and controlling of production represent the desire of synchronization and flexibility, emphasize the cooperation under the organization mode which is composed of mission-time-geographical position, the orientation by customers and their participation, the importance of building the corresponding mechanism to respond the changing of demand. Secondly, pay attention to the information of some enterprises and users in quality management, the combination keeping improving with innovation of quality, the individuation and customization of quality demand. Thirdly, stress the feature of the cooperation between enterprises and flexibility in supply chain management to enhance the responsibility overall.

2.2.5 Business Process Reengineering

The core idea of BPR is to re-consider fundamentally, redesign drastically and improve dramatically the business process. BPR is the part of business reengineering, and integrate with idea restoring, organization reconstructing in order to form the whole business process. The specialty of BPR is as follows:

Firstly, found the regimental manner, unite the jobs which are finished by different workers into one, enhance the production efficiency. Secondly, integrate the creating and processing of information, dispose the decentralized resource centrally. Thirdly, actualize decision-making and controlling by oneself, the worker at the production line is entitled to decision-making and controlling.

From above discussing, we can conclude that these production modes have some differences which are listed as follows[4]:

<table>
<thead>
<tr>
<th>Mode Item</th>
<th>Cell production</th>
<th>Lean production</th>
<th>CIMS</th>
<th>Agile Manufacturing</th>
<th>BPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>Japan</td>
<td>America</td>
<td>America</td>
<td>America</td>
<td>America</td>
</tr>
<tr>
<td>Time</td>
<td>1990’s</td>
<td>1990’s</td>
<td>1990’s</td>
<td>1990’s</td>
<td>1990’s</td>
</tr>
<tr>
<td>Background</td>
<td>The extinguishments of bubble economy</td>
<td>America International Vehicle Research Center</td>
<td>The development of information and the demand of market</td>
<td>The manufacturing strategy in the 21st century</td>
<td>Business Reengineering</td>
</tr>
<tr>
<td>Investment</td>
<td>Low cost automation</td>
<td>Less cost</td>
<td>Sizable investment</td>
<td>More investment</td>
<td>Less cost</td>
</tr>
<tr>
<td>Equipment</td>
<td>Flexible transformation</td>
<td>Flexible transformation</td>
<td>Technological transformation</td>
<td>Flexible production</td>
<td>Redesign</td>
</tr>
<tr>
<td>Process</td>
<td>The form of division, one-man and circuit</td>
<td>The product line of just in time, product unit of U and C shape</td>
<td>Controlled by large computer system</td>
<td>The intelligent cooperation of information Technology</td>
<td>The simplification of process</td>
</tr>
<tr>
<td>Staff</td>
<td>Dependence on staff, absolute operation</td>
<td>Man-oriented</td>
<td>Integration and optimization of staff and organization</td>
<td>Emphasis on human and knowledge</td>
<td>The regimental manner, decision-making and controlling by oneself</td>
</tr>
<tr>
<td>Information</td>
<td>Customer enter the field of production</td>
<td>Visual management</td>
<td>Centralized information processing</td>
<td>The information of enterprise and customer</td>
<td>The integration of creation and disposal</td>
</tr>
<tr>
<td>Application</td>
<td>Industry, service industry</td>
<td>Industry, service industry, government</td>
<td>Industry</td>
<td>Industry, service industry</td>
<td>Industry, service industry</td>
</tr>
<tr>
<td>Effect</td>
<td>The production in changing the variety and quantity, just in time, economical manpower</td>
<td>Zero of inventory and defect, JIT</td>
<td>The integration of the technology and management</td>
<td>The global cooperative production</td>
<td>The enhancement of competitiveness</td>
</tr>
</tbody>
</table>

3 Analysis
The wider application of advanced manufacturing production abroad promotes the sustainable development of the manufacturing industry in the world. Analysis of the reasons for the development of advanced production modes can largely be attributed to the development of information technology and demand changes of market.

In the 1990s, developed information technology greatly enhanced person's ability to handle information, so that transactions costs reduced and the enterprise structure went to the smaller size and diversification. However, the decline in communication costs and transaction costs lead to the high possibility of interdependence between companies through Internet. Therefore, as a consequence of rapid technological updating, and the highly developed financial system, it is difficult for the leading enterprises to retain their innovative long-term profits increasingly. The survival and development of enterprises depend on employee’s knowledge, ability or experience. Whether companies can retain high quality staff by a certain way and provide them for some appropriate incentive had been the key point of the source of enterprises value. So "humanized" was the highlighted requirement of this operating environment and business practices.

On the other hand, the market changes challenged the means of production. First, the variety and personality of demand. In many developed countries, the preferences of consumers for goods and services tend to personalize and uncertainty. This has led to increasingly difficult to grasp the changing market demands. Second, with the personalized demand of customer, competition among enterprises on product differentiation is becoming increasingly fierce. Especially in the global market, the more we recognized a promising market, the more intense competition. Third, the ever-accelerating technological innovation, the innovation of goods and production
process is in the process at an unprecedented pace; drastically shorten of the life cycle of products and processes, and intense price competition, which makes large-scale, high investment, long payback time production equipment had been to made some technical adjustments and changes to adapt to those changes.

4 Conclusion

In a word, the above five advanced production modes are only the representative of all the production methods, and they complement each other with their differences; For example, lean production can be regarded as the theoretical basis for business process reengineering. Because of the elimination of all waste is the same thinking with the business process reengineering; however, it stressed that expanding to other areas should be from the improvement in the job site gradually, so the thinking of Business Process Reengineering can be applied in the improvement of job site in order to drive the lean innovation of production system. Therefore, regardless of any changes in production methods, with the continuous update of quality concept, manufacturing industry will have a greater development in the open systems based on quality strategy.

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