Acta Technica *62* (2017), No. 7A, 913–926

Construction of cooperative intelligent manufacturing standard system under the premise of industry 4.0

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Abstract. The intelligent manufacturing technology introduces artificial intelligence into manufacturing theory and production process based on informationization, digitization and networking, and forms the product manufacturing technology driven by machine intelligence characterized by storage, computing, logic and reasoning. In order to realize the socialization and coordination, a socialized collaborative reference model and the working mode supported by the model are put forward under the environment of loosely coupled alliance and enterprise system autonomy. The model achieves the creation of a peer-to-peer network of manufacturing resources and manufacturing services by fabricating resources using microservices architecture encapsulation, adding interfaces for service invocation among enterprises, optimizing and expanding service buses, deploying LDAP services and UDDI regional centers, and integrating P2P protocols. Finally, some suggestions for the development of the collaborative smart manufacturing standard system are given under the premise of Industry 4.0.

Key words. Industry 4.0, Collaboration, Intelligent manufacturing, Standard system.

1. Introduction

Industry 4.0 is the future blueprint for the manufacturing industry as defined by the government and industry in Germany. After the era of human steam into the second half of the 18th century and the promotion of machinery manufacturing to promote economic development, Industrial Age 1.0 entered the late 19th century In the era of ‘ Industry 2.0” promoted by electrification and automation, the electronics and information technology were widely used in the 1970s. The world industry entered an era of “industry 3.0” marked by informatization. In 2011, Germany first proposed “Industry 4.0” Concept that the world’s industry entered the “industrial 4.0” era of transition from manufacturing to intelligence and an era in which actual

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production is integrated with the virtual production of the Internet. The essence of "Industry 4.0" is the change from an industrial perspective. Instead of using the level of supply-side productivity development in the manufacturing industry as a starting point, the concept of "Industry 4.0" is used as the starting point of the entire industrial chain and provides customized products and services to achieve rapid , Effective, personalized product production and delivery, so that all aspects of the entire industrial chain to achieve collaborative optimization. An important feature of Industry 4.0 is that the manufacturing process and manufacturing value extend to the process of using. This is a revolutionary change that the entire industrial manufacturing system is going to be fully intelligent. It not only needs to meet the real needs of users, but also uses the big data platform to tap the potential demand of users Of the gap, the use of modular production methods to efficiently meet the diverse needs of production from a centralized shift to decentralization, product from convergence to personality change, and ultimately maximize the value of the product.

Manufacturing industry is the mainstay of the national economy, is the foundation of the country, rejuvenating the country, the foundation of a powerful country. The developed countries in Europe and the United States all adopt the mode of organic integration of organic and informatization to enhance the manufacturing level. In 2012, the German government proposed a national development strategy based on Industry 4.0, which is centered on smart products and smart factories. In February 2012, the U.S. government issued the "National Strategic Plan for Advanced Manufacturing Industry." In January 2013, the US Presidential Executive Office, the State Science and Technology Commission and the High-end Manufacturing National Project Office jointly released the Preliminary Design of a National Manufacturing Innovation Network. At the core of the US innovation network plan is the concentration of research, production and research to promote the innovation and development of advanced manufacturing industries such as smart manufacturing, new energy and new material applications, so that the United States will seize the first chance in the global transformation of manufacturing industry and continue to maintain its leadership position . In order to promote technological innovation in our manufacturing industry and upgrade the industrial structure and achieve leapfrog development, the "Proposal of the Central Committee of the Communist Party of China on Formulating the Thirteenth Five-Year Plan for National Economic and Social Development" clearly states that accelerating the building of a powerful nation with information and technology Depth integration of industries, implementing "Made in China 2025" and building a new manufacturing system focusing on intelligent manufacturing are the national strategies to enhance China's overall national strength and international competitiveness and ensure national security and national rejuvenation.

Intelligent manufacturing is a typical complex product with complex customer needs, complex product mix, complex product technology, complex manufacturing process, complicated test and maintenance, complex project management and complex working environment. It focuses on the high precision in industrial manufacturing and information industry It is best known as the "crown jewel" of modern

industry and has now become the key breakthrough of "Made in China 2025" and "National Defense Science and Technology 2025".

2. Intelligent manufacturing socialization needs

2.1. Service resource sharing of Intelligent manufacturing enterprise

Intelligent manufacturing enterprises (Intelligent Manufacturing Enterprise, IME) to share service resources and access to external service resources, will become a norm. In addition to traditional manufacturing equipment, material inventories, process expertise, troubleshooting solutions, carbon footprint indicators and technical expert advice capabilities are all new requirements under social collaboration. New requirements for manufacturing services can be further refined to include various attributes such as service availability, processing tolerances and quality standards. Services may come from fixed partners or may come from unknown manufacturing organizations, as follows: (1) Socialized collaborations have a flexible and scalable meaning with respect to the subject of collaboration, and the partners are not fixed. (2) Socialization is a loosely coupled coalition based on the subject, and the conversation is temporarily established. Cooperation is terminated as the demand is satisfied. (3) Co-sponsors face more choices of resources. Service providers may be either business organizations or freelancers, such as designers or experts who provide services in an individual capacity. (4) The co-sponsor can select one candidate from multiple service providers, or choose a service combination. (5) In the entire social cooperation network, resources are extremely large. Individual business needs are in a dynamic state of change and require rapid decision-making to meet the needs of the market. Social-collaborative decisions should be real-time and self-organizing. (6) Intelligent enterprise's information system does not need to be completely redeveloped. The change from loosely coupled collaborative relationship to loosely coupled socialized collaboration is shown in Figure 1.

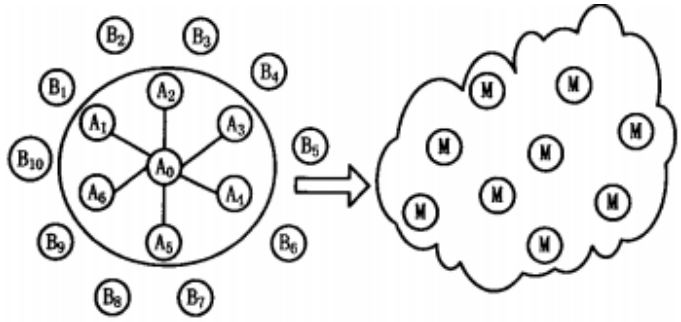

Fig. 1. Collaborative demand is changing from the tight coupling of the centralized evolution to the equation

In tightly coupled collaboration, the virtual organization is centered around one

or a few manufacturing firms, such as A0. Collaboration between enterprises is master-slave, such as the relationship between A0 and A1 $\sim$ A6. Collaborative relationships need to be established in advance, resources can enter the resource pool, which is then created by the application of the algorithm or filter conditions found and use. B1 $\sim$ B10 did not enter the virtual organization. Resources can not be used by A0 $\sim$ A6. In the Internet environment on the right of Figure 1, each enterprise is in a peer-to-peer state, and any M can initiate collaborative requests as needed, and any M can publish resources within the Internet. After the demand side finds available services in the network, the service is invoked by establishing a temporary session, authorized to invoke the service, and the service is released as the temporary session is over.

2.2. Model-based data integration

Data integration is the foundation and guarantee for manufacturing collaborative design and manufacture. The unified digital definition of products is the cornerstone of smart manufacturing. The product definition went through two-dimensional drawing digitization, two-dimensional digital drawing + three-dimensional model to model-based product digital definition. MBD is not so much a product digital representation method as a unified product digital definition model. MBD is a method that defines the model by defining the relationship between features and control features. At the heart of MBD is a three-dimensional model based on feature definitions, which integrates information about design, process, manufacturing, inspection, and other departments around a three-dimensional model to form a single source of data that becomes the interface between product design and design, design and manufacturing, and manufacturing and manufacturing Unified information carrier, and according to the collaborative development needs to provide different views for assembly, simulation, process design. At the same time, MBD can semantically describe the engineering features such as design and manufacture, and integrate renewable engineering knowledge. The MBD model mainly manages two types of numbers. According to one type of geometric information (geometric model); one is non-geometric information (annotation information). Non-geometric information is not independent of the basic existence, but with the geometric characteristics, and relations through the relationship between features. The geometric information is managed by the CAD system. Instead of the geometric information being stored and managed by the product data management system, geometric information and non-geometric information are highly integrated through this mechanism. This integration mechanism solves the problem of data integration in the design and design, design and manufacturing, manufacturing and manufacturing synergies in manufacturing product development (Figure 2).

(1) Design and Design Collaboration Process: During the process of design and design collaboration, due to the complicated structure of manufacturing industry, frequent design changes and difficulty in satisfying the previous two-dimensional design patterns, the design data can not be correlated and the design changes are increased Of the workload; at the same time can not guarantee the overall and

unit design parallel collaborative design. Based on the MBD model, the manufacturing component design unit can set up multi-disciplinary simulation environment of aerodynamics, structure, strength, heat, heat transfer and combustion to carry out multidisciplinary comprehensive optimization design techniques and realize the coordination and parallelism of major professionals in the design process.

(2) Design and Manufacturing Synergistic Process: There is design and process synergy in manufacturing design. The main task is to make manufacturability analysis and process review on the design of the product. At the same time, for some parts with long production preparation cycle, Process design (blank design, tooling design, etc.). Based on the single data source of MBD, the process design and process preparation can be guaranteed under a unified data model, and the design and manufacturing synergy can be achieved for the key parts of long cycle.

(3) Manufacturing and Manufacturing Synergy Process: The manufacturing process covers many aspects of process design, tooling design, processing and assembly. Data exchange and integration exist between these manufacturing activities. Tooling design, NC machining and assembly process design all require data Model as a single data source for parallel collaboration.

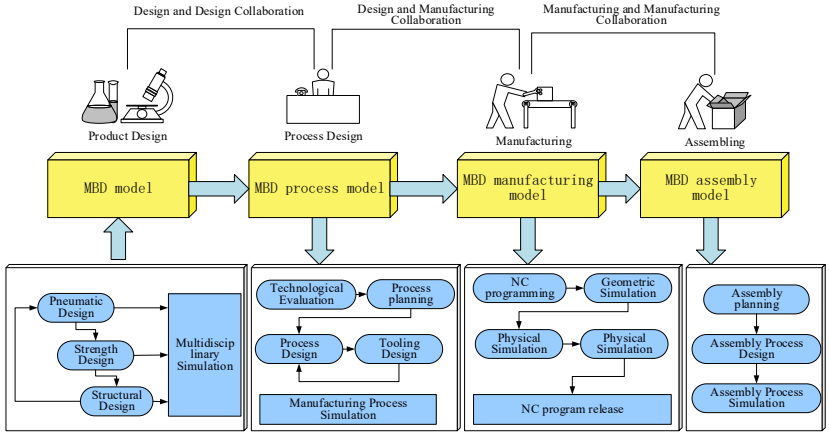

Fig. 2. MBD-based design and manufacturing collaboration

3. Key technologies of Intelligent manufacturing

To realize intelligent manufacturing of a production system, a breakthrough must be made in real-time automatic identification and processing of information, wireless sensor network, information and physical integration system, and network security, which mainly involve the key technologies of intelligent manufacturing such as radio frequency identification technology and real-time location tec

3.1. Radio frequency identification technology

Radio Frequency Identification (RFID) technology, also known as radio frequency identification, is a wireless communication technology that can identify a specific target by radio signals and read and write relevant data without identifying the mechanical or optical system between the system and a specific target contact. Compared with automobiles and aircraft, shipbuilding is characterized by strong discreteness, large site, dense personnel and higher order of parts and components. In the shipyard warehouse, radio frequency identification technology is used to input and output various kinds of production materials, supply chain management and Asset management, the status of a large number of parts to achieve information technology is an important step to achieve smart ship manufacturing.

3.2. Real-time positioning system

Intelligent manufacturing industry is divided into groups, parts, sub-segments, the total segment of about several stages, in different stages, but also require different processing of steel plate processing, this process requires a variety of materials, parts, tools , Equipment and other assets for real-time tracking management, in order to place in time, evacuated, make full use of production planning to achieve a reasonable arrangement to shorten the shipbuilding cycle. At the same time, due to the huge size of the ship, its construction safety is also very important. The development and application of the real-time location system will help Shaanxi accept information sources and evacuate construction workers in case of danger.

3.3. Wireless Sensor Network

A wireless sensor network is a network of wireless communication computers that consists of many spatially distributed automated devices that use sensors to monitor physical or environmental conditions at different locations such as temperature, sound, vibration, pressure, motion or Pollutants, etc.), the shipyard's working environment with noise, dust, vibration and other characteristics, and the environment is complex, both the reliability requirements of the equipment itself, or the layout of the plant are very important to solve the entire plant wireless sensor Network building is a very challenging issue.

3.4. Information Physics Fusion System

Information Fusion System (CPS) is a multidimensional and complex system that integrates computing, network and physical environment. It realizes the real-time perception, dynamic control and information of large-scale engineering system through organic integration and deep cooperation of 3C (Computation, Communication, Control) service. CPS to achieve computing, communications and physical systems of the integrated design, make the system more reliable, efficient, real-time collaboration, has important and broad application prospects. In the Industrial 4.0 era, CPs are required for all industries.

3.5. Network Security Technology

Digitization has driven the manufacturing industry to a large extent thanks to computer network technology. In recent years, the key technologies of intelligent manufacturing have been developed rapidly. Internet technology is an important key technology for realizing intelligent manufacturing. With the continuous production of large amounts of data, transmission and storage, network security technology is particularly important to ensure that data is not stolen and lost, do the appropriate backup and protection work. For shipyards, information security is even more important. The shipbuilding industry is one of the important areas for national defense and military industry. Most shipyards undertake military tasks, possess the appropriate secrets qualification and have more restrictions on the use of network technologies. If not, To effectively solve the problem of network security, the shipyard is unable to achieve true intelligent manufacturing. It can be said that the issue of network security technology is the key to opening the door to the first shipyard intelligent manufacturing.

4. Smart Manufacturing Architecture for Social Collaboration

Social networking services-based Collaborative Intelligent Manufacturing (SCIM) is a peer-to-peer network collaboration mechanism between smart enterprises or between smart enterprises and consumers. SCIM has the following characteristics: (1) The system in a single enterprise is autonomous, and its existing operating system does not change significantly. (2) Every enterprise has the resources or services to share in the social network, and can also find the resources or services shared by other enterprises. (3) When an enterprise accepts the service demand of other enterprises, it decides whether to allow access by means of security authorization. (4) Collaboration among enterprises is decentralized and does not require the decision of the central arbitration institution. (5) Continuous collaboration among enterprises will trigger the improvement of each individual's manufacturing wisdom and cause the overall evolution of the enterprise population.

4.1. SCIM Architecture Reference Model

CIMS, CPS, cloud manufacturing is a typical representative of the collaborative model. CIMS from the traditional process-oriented development to the object-oriented, mainly divided into the control layer, monitoring layer, scheduling layer, management and decision-making, internal manufacturing processes as the center. The CPS architecture in Industry 4.0 builds the Internet of Things, Internet-based systems and services, serving the Internet and applications at all four levels. The system abstracts services and knowledge from manufacturing operations, making services and manufacturing applications and business processes more user-friendly by making hardware more transparent and reengineering manufacturing processes more viable. From the data backbone, basic services, service aggregation platform

and customer 4 levels to build intelligent factory information space. On the coordination mechanism, CPS can realize the synergy of different applications and manufacturing services in the enterprise through the horizontal integration, and realize the synergy of the plant IoT to the management application through vertical integration. The CPS architecture is suitable for the cooperation known to the smart factory industry chain. Cloud manufacturing consists of cloud infrastructure, cloud service models, and cloud service applications that focus on cloud computing and virtualization, moving an enterprise's manufacturing lifecycle from traditional local systems to centralized private or public cloud services. Cloud manufacturing deployment of cloud services suitable for SME manufacturing applications, intercluster collaboration among SMEs or tightly inter-industry collaboration between organizations. The SCIM architecture is for publishing, sharing, filtering and invoking inter-enterprise services. Its reference model is mainly divided into four layers: physical resource layer, intelligent resource layer, social cooperation layer and collaborative application layer.

The physical resource layer includes IT infrastructure, physical equipment, physical resources such as materials, materials, energy, etc., as well as virtual resources such as knowledge, experience, working hours and capabilities. Physical equipment, including industrial robots, automatic guided vehicles, flexible control unit, CNC machine tools. The intelligent resource layer defines the standardization process from physical resources to intelligent manufacturing resources (IMRs) and the packaging process encapsulated into micro-manufacturing services. Web Services in the application development appeared in the logical overlap, the trend of the service giant, is not conducive to reuse. As a further development of Service Oriented Architecture (SOA), Micro Service Architecture (MSA) is based on the principle of "single responsibility" in OOP and encapsulates only attributes and methods that are completely related to each other. Microservices enable the encapsulation and inheritance of business logic in legacy data and legacy systems. After the standard classification of physical resources, to give their manufacturing properties and behavior, constitute intelligent manufacturing resources. The IMR is MSA-packaged and is invoked in the form of Micro Manufacturing Service Units (MMSUs) for various manufacturing applications. Typical microfabricated service units can be encapsulated as (enterprise domain name URL, MMSU Server URL, MMSU number, IMR encoding, MMSU category, MMSU performance structuring description, MMSU semantic unstructured description, MMSU available period, MMSU current status, MMSU related method).

The intelligent resource layer includes the development environment, Application Programming Interface (API) manufacturing service nodes, and standalone applications. Manufacturing service node is a set of MMSI service middleware, both as a separate process to run, can also be made service application call. At the same time, the node receives the external service call request from the social cooperation layer as an agent and calls the corresponding MMSU. The MMSU is the base unit of the Enterprise Service Bus (ESB). ESB on the one hand to meet the vertical integration of enterprise systems and the need for horizontal integration, on the other hand can also provide an expansion interface for social collaboration. The

social collaboration layer provides a mechanism for enterprises to publish and discover resources and services on the Internet. After obtaining the necessary resources or services from the network, the enterprise screened according to the optimization selection algorithm and made the manufacturing task planning according to the resource scheduling algorithm. The optimal algorithm and scheduling algorithm itself is used by the enterprise's internal production resources and production plans. In SCIM, the algorithm can receive the input of collaborative resources from outside the enterprise. The social collaboration layer provides self-learning and genetic evolution mechanisms for applications. Authentication and authorization will ensure that MMSUs, Manufacturing Services nodes or IMRs are available and reachable. Virtual collaborative manufacturing bus as the ESB to the Internet extension interface, synchronization and update, and service calls. P2P sharing and discovery mechanism used to achieve the integration of private applications and P2P. Collaborative application layer mainly for collaborative pre-research, collaborative design, collaborative processes, collaborative manufacturing, collaborative inventory and collaborative operation and maintenance needs. Distributed Manufacturing Process Dynamic Configuration Mechanism Based on MMSU, manufacturing service node and IMR, it can exist as an independent application tool or be integrated into manufacturing service application to realize the dynamic reorganization of manufacturing process. Collaborative application layer is used to define collaborative work patterns. SCIM architecture is flexible. The physical resource layer incorporates virtual knowledge assets into manufacturing resources and services and defines physical devices and information assets as standard IMRs through MSA encapsulation. As a basic service to the enterprise service bus, the MMSU takes into account the integration of the legacy system. The workflow engine extends the process definition, on-demand reconfiguration, and dynamic configuration from the business logic within the application system to the manufacturing logic through the MMSU. SCIM's flexibility is also reflected in the ESB completely from the beginning, compatible with the needs of enterprise information systems integration.

4.2. Realizing SCIM system

Due to the autonomous system characteristics of all the enterprises in the SCIM system, IME should keep the independence of system R & D, deployment and operation to the maximum extent while following the SCIM reference model. ESB as a mainstream enterprise system to ask the integration of middleware and service collection, is being widely used. This article focuses on the traditional ESB, the following two optimization and expansion:

(1) manufacturing business logic micro-service. In accordance with the principle of uniform resource classification and virtual resource classification in the entity resource layer and the intelligent resource layer in the reference model, MSA is encapsulated into MMSUs to streamline the complicated business rules orchestration and message routing in the original ESB. MMSUs use similar JSON Light messaging mechanism to support rapid synchronous asynchronous interoperability between manufacturing processes.

(2) Distinguish between external service requests and internal service requests. In the ESB to increase external request processing module, the module includes IME service registration, service socialization, external intermediaries and security management mechanism. Among them, service registration is used for enterprises to release resources that can be externally shared according to business and privacy needs, service socialization is used for service synchronization, service discovery and selection of an inter-enterprise service registration center, and an external request broker is used to receive messages from external manufacturing applications And return the message. IME-SIP is a service exchange point between IMEs. All service requests from other IMEs extend the ESB over SIP. Security Management is used for authentication and authorization of service calls between IMEs. The optimized and expanded ESB is shown in Figure 3.

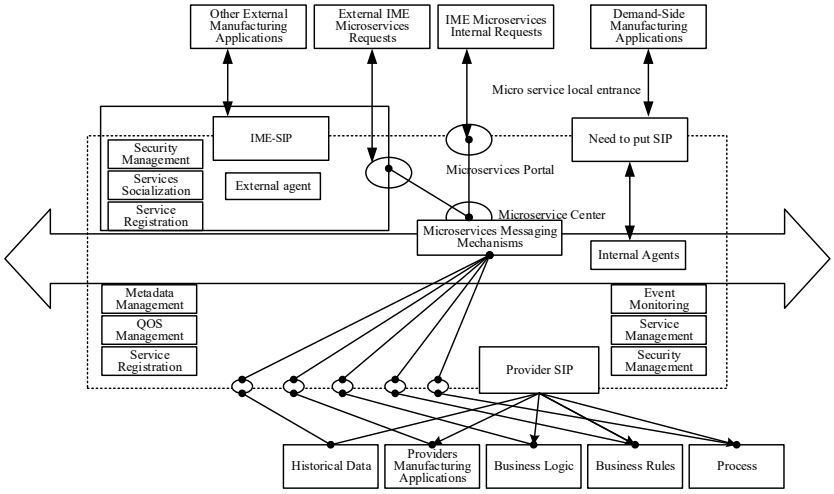

Fig. 3. Optimized and extended ESB structure

5. Develop intelligent manufacturing countermeasures in the background of Industrial 4.0

(1) Optimize and promote the policy system of intelligent manufacturing and development. During the "13th Five-Year Plan" period, a new round of industrial revolution accelerated the transformation of economic development mode and pushed forward the supply-side structural reform and formed a historic crossroads. This provided a rare opportunity for development toward new advantages of agglomeration and development in the late industrialization stage. Since 2015, the State Council has promulgated a series of strategic deployment documents entitled "Made in China 2025 Guiding Opinions on Actively Promoting the Internet +" Action and put forward that intelligent manufacturing should be the main direction. Intelligent manufacturing as a strategic new industry to cultivate the future competitiveness. The supporting policies for leading enterprises in emerging industries should be pre-

cise and detailed. A roadmap for the development of emerging industries and a road map for the growth of enterprises should be formulated. Major innovative projects should be organized and implemented so as to enhance the capability of independent innovation of enterprises. Through the optimization of the policy system for promoting the development of the smart manufacturing industry, we have eliminated institutional and institutional barriers, perfected the regulatory system and supporting laws and regulations, and better protected trade secrets and intellectual property rights. We vigorously promoted the strategy of "Internet + Manufacturing", Precision force, coordinate the promotion of intelligent manufacturing to achieve rapid development.

(2) Relying on scientific and technological innovation and development of intelligent manufacturing. The Outline of the 13th Five-Year Plan of the Province proposes that we should speed up industrial transformation and upgrading, construct a modern industrial development system, vigorously develop the advanced equipment manufacturing industry, fully implement the "Made in China 2025 Program of Action", actively connect with German Industry 4.0 and promote a new generation of information Technology and equipment manufacturing industry to enhance the traditional manufacturing industry, accelerate the development of high-end equipment and major equipment, build an intelligent manufacturing and intelligent service system, and establish a strategic base and a core agglomeration area for the national high-end equipment and intelligent equipment manufacturing industry. By intensifying scientific and technological innovation, deepening industrial transformation, and gradually enabling the manufacturing industry to realize the production of machine control machines, that is, digitalization from end to end, the interoperability between products and between products and equipment will enable the production process to be highly automated and truly realized Intelligent manufacturing. The manufacturing industry needs to actively make innovations in all aspects of research and development, design and service in Germany, and update modern technology and equipment and processes in a timely manner. At the same time, manufacturing industries should be encouraged to increase their investment in independent R & D and the government should play an active role in tax support, industrial guidance , To create the environment and other aspects of the regulatory role.

Foster highly informative, intelligent manufacturing collaborative innovation system. Intelligent manufacturing is the first serious task facing from the information age to the intelligent age. Innovation and smart manufacturing have risen to national strategies. Only by catching on innovation and smart manufacturing, they have also captured the core of proactive pilot policies. It has the practical basis for the implementation of the integrated development strategy of industry, education and research, and builds a synergistic manufacturing system for manufacturing industry, including enterprises, universities and research institutes, intermediary service organizations, brand and marketing model innovation, etc. Through the expansion and agglomeration of the two ends of the industrial value chain Motivation, the "two" deep integration as an important focus to promote intelligent manufacturing. The government needs to set up a special guide fund to "incubate" to foster strategic emerging industries such as mobile Internet, Internet of Things, and big data, at-

tract private capital to participate in investment and lead the manufacturing to a model of intelligent manufacturing. Robots are the "pearl of the crown at the top of the manufacturing crown." Robotics and its applications have become an important "front line" for a country or region to shape new strategic advantages and play an important role in adjusting its industrial structure and achieving sustained and healthy economic development. Promote the construction of industrial technology innovation strategic alliance to foster a highly informative and intelligent manufacturing co-innovation system to promote the "Internet + manufacturing" Traction of traditional industries has undergone qualitative changes in the context of Industry 4.0 to accelerate the upgrading of intelligent manufacturing quality and efficiency The key link.

Increase efforts to develop high-tech comprehensive talents. "The only way you can accomplish this is by widening your industry." People are performers and managers of production. The most crucial factor in achieving Industry 4.0 is people, and the hardest people are. The key to the Industry 4.0 strategy is to establish a smart industrial development phase where people, machines, and the Internet are combined. Without "smart" people, there can be no "smart" manufacturing process. Not only should we pay full attention to high-end scientific and technological personnel and management personnel, but also play a role as a skilled craftsman with long-term accumulation of manufacturing experience and a "craftsman's spirit Because the products are manufactured by workers, we also need to strengthen product quality supervision and tracking services. In intelligent machine tools, robots and other fields, has initially formed a more complete industrial system. Learn from Germany's "Industry 4.0" and take "digitalization + intelligence" as the core technology of traditional manufacturing restructuring. By cultivating high-skilled and comprehensive talents, and by innovating the service system of order-type talent cultivation, Universities and research institutes to integrate the resources and forces of all parties and jointly push forward the R & D and application of technologies to build various forms of alliances for technological innovation in production, teaching and research so as to promote the development of intelligent manufacturing in a targeted manner.

Acknowledgement

Teaching Quality Project of Guangdong Province (STZL201501).

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Received May 7, 2017