Upgrading Strategy of Small and Medium Manufacturing Enterprises (SMMEs) to Smart Manufacturing

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Abstract. The contribution of Medium Manufacturing Enterprises (SMMEs) will not only weaken but also be strengthened under the background of smart manufacturing. It is the key point of achieving mass individualized production that lots of SMMEs with specialized and excellent manufacturing capability connect to smart manufacturing network. Nowadays, SMMEs of China are facing survival pressure and various severe challenge. Meanwhile, the developing experience and characteristics of SMMEs of China leads to the particularity of their upgrading process to smart manufacturing. The problems of process normalization, essential data, talents, and funds restrict SMMEs from upgrading to smart manufacturing seriously. It is very important for government, professional organizations, scientific research institutions, enterprises to do well on division of work and cooperation aiming at the key problems that enterprises are confronting now, in order to push forward the upgrading task to smart manufacturing together.

1. Introduction
With a new round of scientific and technological revolution profoundly changing the holistic society, traditional manufacturing industry is evolving into a new form under the impacts of new technologies such as Internet of Things, big data, cloud computing and 3D printing [1-3], necessitating changes of Medium Manufacturing Enterprises (SMMEs) [4-6]. Facing the future-oriented manufacturing industry, countries around the world have proposed their own development strategies. Based on a good industrial base, Germany has proposed the Industry 4.0 strategy, which has aroused strong repercussions worldwide. In order to revive the manufacturing industry, the United States put forward the development goal of the industrial internet in combination with its own information technology advantages. Japan has fully utilized its advantages in the field of robotics and proposed a robot-driven industrial revolution strategy. China has also clearly stated that it is necessary to speed up the construction of a manufacturing power. In terms of these manufacturing upgrading strategies, the major industrial countries are all oriented towards the full application of advanced information technology in the manufacturing industry, striving to achieve interoperability between production factors and integrating intelligent software and hardware into the whole process of production and management to finally achieve smart manufacturing [7-9]. Essentially, mass customization is the core goal and development trend of smart manufacturing [10-12].
It is necessary to pay special attention to the fact that the role of SMMEs will be further strengthened instead of being weakened under this new wave of industrial transformation and upgrading [13,14]. The integration of many high-quality small and medium enterprises with distinct manufacturing technologies and experience into the smart manufacturing system is the key to achieving mass
customization. However, compared with the urgent need for smart manufacturing upgrades, China’s SMMEs are still far behind in terms of the overall development level and facing a series of complex problems. How small and medium-sized manufacturing enterprises realize the upgrading and development of smart manufacturing has become one of the important issues to be solved immediately to build China into a manufacturing power. To this end, this paper systematically sorts out the current situation of China’s SMMEs, and comprehensively studies the upgrading goals, major difficulties and effective measures of SMMEs in China for smart manufacturing, and present direction suggestions and policy reference for SMMEs to implement upgrading of smart manufacturing.

2. Development status and upgrading requirements of China’s SMMEs

2.1. Development Status of China’s SMMEs

2.1.1. Contributions of China’s SMMEs. In the 1990s, developed countries shifted manufacturing industries to the outside world due to cost and other reasons, and China became the largest recipient of manufacturing capacity. The booming development of the manufacturing industry enabled China to quickly become a “world factory” and surpass the United States becoming the largest manufacturing power of the world in 2010. Thousands of small and medium enterprises serve as the basis for China’s huge manufacturing system, which just like the thousands of capillaries of a huge living body that transport blood to such a “giant” as “Made in China”. Since the end of the last century, small and medium manufacturing companies have provided more than 70% of new industrial output value, more than 60% of total exports, and more than 80% of urban jobs in China.

2.1.2. Classification of China’s Small and Medium Enterprises. According to China’s current classification standard for small and medium enterprises, enterprises in the industrial sector with employees less than 1,000 units or operation revenue less than 400 million CNY are defined as small and medium enterprises. Specifically, enterprises with more than 300 but less than 1,000 employees and operation revenue of 20 million CNY and above are medium enterprises; enterprises with more than 20 but less than 300 employees and operation revenue of more than 3 million CNY are small businesses. By the end of 2016, the total number of small and medium enterprises in China exceeded 24 million.

2.1.3. Characteristics of China’s SMMEs. Some of China’s SMMEs are to make up for the early market vacancies of large enterprises, and more are to provide support for large enterprises. Since most of them have been at the medium-and low-end of the industrial value chain since their establishment, they are generally short of core technologies and weak in independent innovation. With low added value, their products are less competitive than international rivals.

2.1.4. Survival Condition of China’s SMMEs. In recent years, the continuous rise in labor costs has gradually deprived China’s manufacturing industry of its traditional advantage of low cost. In 2003, the comprehensive labor costs of China were only about 40% of that of the United States. According to Oxford, the labor costs of China’s manufacturing industry had approached that of the United States by the beginning of 2016. Meanwhile, the United States significantly reduced corporate income tax and strongly promoted “manufacturing returns”; while Southeast Asia and South Asia are taking advantage of the low cost of labor to absorb manufacturing capacity shifts. Therefore, China’s manufacturing industry is facing severe challenges from developed and other developing countries. Specifically, SMMEs are under marked impacts. On the other hand, China fails to pay enough attention to environmental cost management for economic development for a long time, which has caused environmental problems to intensify. China is gradually approaching the limits of natural resources carrying capacity. Therefore, there has been no living space for the previous production model with high emissions and high pollution. Increasingly stringent emission standards have also brought unprecedented pressure on companies, especially small and medium manufacturing companies.
2.2. Upgrade Requirements of China’s SMMEs towards Smart Manufacturing

2.2.1. Upgrade of the Manufacturing Industries in Developed Countries. After the financial crisis in 2008, major developed countries re-recognized the importance of the industry-based real economy and launched national strategies torevitalize manufacturing industries. These industrial development plans of developed countries are not to continue the traditional industrial road, but aiming at a new round of scientific and technological revolution. The plans are committed to deeply integrating information technology and traditional industrial technology [15-18], to building cloud factories [19-21], complementing the shortcomings of the workforce via large-scale robotic applications [22], and further consolidating and strengthening industrial superiority through continuous innovation. Its focus lies in developing high-end manufacturing industry, creating high value-added links and restructuring the manufacturing industry chain [23].

In developed countries, particularly Germany and Japan, a large number of small and medium enterprises that are in absolute dominant positions in various sub-sectors have taken shape due to long-term industrial accumulation, namely “invisible champions” in sub-sectors. In the future, in the smart manufacturing system, these SMMEs are expected to form an interconnected manufacturing platform with large manufacturing enterprises, thereby greatly improving the overall competitiveness of the manufacturing industry [24]. In contrast, China’s small and medium manufacturing companies are relatively weak, which has become one of the major bottlenecks hindering the upgrading of China’s manufacturing industry towards smart manufacturing. To this end, how China’s SMMEs can grasp strategic opportunities under current situations and realize transformation and upgrading towards smart manufacturing as soon as possible becomes crucial.

2.2.2. Upgrade Goals of China’s SMMEs toward Smart Manufacturing. For upgrading towards smart manufacturing, China’s SMMEs need to achieve two objectives from the internal to the external. The internal goal is to realize intelligent production, establish a complete corporate IoT, and have an efficient and integrated MES (manufacturing execution system) and SCADA (supervisory control and data acquisition) to realize the full digitization of business processes. The external goal is to gradually get integrated into the increasingly intelligent industrial chain and fully connected with upstream and downstream partners at the digital level, in order to achieve efficient interaction with other links of the industry.

3. Major difficulties faced by upgrade of China’s SMMEs toward smart manufacturing

In terms of development from traditional manufacturing to smart manufacturing, China’s SMMEs not only face a series of common basic problems, but also many specific difficulties.

3.1. Common Basic Problems Faced by Upgrade of China’s SMMEs toward Smart Manufacturing

3.1.1 Lack of Correct Understandings of Upgrade Towards Smart Manufacturing. After the financial crisis in 2008, multiple factors such as continuous shrink of the market, labor constantly rise of costs and increasing pressure on environmental protection have significantly deteriorated the survival environment of substantial SMMEs, which places many operators in constant anxiety, who hence have a sense of urgency and show little interest in businesses that cannot immediately realize profitability. Although most small and medium manufacturing companies have realized that upgrading towards smart manufacturing is the future development direction of enterprises, they lack sufficient understanding of the urgency and long term, which results in slow actions and ineffective measures. At the same time, many small and medium enterprises have serious deviations in understanding the relationship between smart manufacturing and lean production. Some companies believe that since smart manufacturing is an upgraded version of lean production, intelligent upgrade is enough while research and promotion of lean production are unnecessary, or upgrade towards smart manufacturing will not be considered before doing a good job in lean production. In fact, this is a completely wrong understanding. Smart manufacturing and lean production are two dimensions. The most important
thing behind lean production is the concept of lean, which directly refers to the essential demands of the manufacturing industry and will never be outdated; smart manufacturing provides new technical means for a higher level of lean production [25]. In other words, lean production is the goal while smart manufacturing is the path, allowing no upgrade or replacement. SMMEs must take actions now to constantly improve their own hardware and software capabilities for smart manufacturing and try to do a better job in lean production in a down-to-earth manner [26].

3.1.2 Shortage of Talents. Most of China’s SMMEs are mainly engaged in simple processing and manufacturing and employees are generally not highly educated, short of high-level professionals and information talents [27, 28]. In addition, in terms of upgrade towards smart manufacturing, SMMEs generally lack talents for planning, and even the on-the-spot management and maintenance personnel are seriously inadequate. Therefore, the shortage of talents is also one of the main factors hindering the upgrade of SMMEs towards smart manufacturing.

3.1.3 Low Level of Equipment. Many SMMEs have been at the low end of the industrial chain for a long time, resulting in low level of product technology, low accuracy of machining, outdated production equipment and low degree of automation [29, 30]. For smart manufacturing upgrades, priorities should be given to automation, digitization and connectivity of production equipment, which requires a substantial increase in investment, resulting in insufficient power of enterprises for upgrade.

3.1.4 Nonstandard Management. Due to low starting point, most China’s SMMEs have been lacking standardized management processes since the foundation. In the process of upgrading towards smart manufacturing, it is difficult to digitize unsystematic management process, and even a successful digitization cannot truly meet the business demands. Therefore, the establishment of a scientific and standardized system management process is an important prerequisite for intelligent upgrade of SMMEs.

3.1.5 Financial Difficulties. Increasingly fierce market competition has caused continuous decline in profit of SMMEs in China, resulting in long-term lack of sufficient financial accumulation. Many SMMEs suffer from time-consuming collection period and get bogged in a financial strait. On the other hand, small and medium enterprises have difficulty in obtaining low-interest financial support from the financial sector due to the lack of sufficient physical collateral [31, 32]. Therefore, facing capital investment in the upgrade towards smart manufacturing, SMMEs lack adequate capabilities.

3.1.6 Lack of Service Capabilities. Given the reality that China's information technology industry started late, and the industry featured a backward base, China is far behind countries with advanced industries in terms of smart manufacturing upgrading service. The software for upgrade lacks a sound and complete system-wide support. The software products themselves are not mature enough, and even defective, posing high risks in maintenance and upgrade[33, 34]. Meanwhile, the imperfect engineering service market, smart manufacturing upgrade-related service institutions with varied quality and general upgrade solutions result in poor application effects.

3.2. Specific Problems Faced by Upgrade of SMMEs Towards Smart Manufacturing

3.2.1. Equipment Interconnection. In terms of upgrade towards smart manufacturing, SMMEs should give priority to solving the problem of equipment networking and do a good job in developing the Manufacturing Execution System (MES) and Supervisory Control and Data Acquisition (SCADA) based on the internet. With different service lives, the production devices of various SMMEs are often scattered, chaotic and small. Some can be directly connected through intelligent components, while others need to be modified before connecting. In the meantime, there exists such a problem as
inconsistent software and hardware interfaces, which not only makes the construction process cumbersome and difficult, but also leads to trouble in cost control and great difficulties in upgrade.

3.2.2. Business Digitization. It is another big problem for SMMEs to digitize daily production and management processes and to integrate them into management software according to business characteristics. The businesses of SMMEs vary widely, even though enterprises of the same kind face many differences in management modes. Therefore, the development of management software for small and medium enterprises requires close cooperation between software developers from service providers and business personnel of enterprises. It is also very difficult for the both parties to fully understand each other.

3.2.3. Integration into the Supply Chain. Another core issue for upgrade towards smart manufacturing is to integrate SMMEs into the industrial supply chain in the digital world. SMMEs should connect with upstream and downstream partners based on digitization, and realize data connectivity across the supply chain under the precondition of enterprise information security[35]. Thus, SMMEs will truly become extended workshops of large enterprises, allowing quick and efficient interaction with the latter for synchronous R&D and instant production. Clearly, the dominance of such connection lies in the hands of large enterprises rather than small and medium enterprises in most cases, and the latter will not be accepted by the former if they do not have enough accumulation and improvement in smart manufacturing.

3.2.4. Software Integration. The last problem of smart manufacturing upgrade is how to achieve effective system integration between different software, especially protocols between existing sophisticated software systems and unification of enterprises’ database format, which are very critical. The solution requires joint efforts from both the enterprises aiming for upgrade and service providers.

In summary, the main problems facing SMMEs in smart manufacturing upgrade are shown in Chart 1.

Figure 1. Main problems faced by SMMEs in smart manufacturing upgrade

4. China’s SMMEs’ measures for smart manufacturing upgrade
Based on the above-mentioned current situation of China’s SMMEs and the widespread difficulties in upgrades, as well as the overall situation of China’s society and industry, this paper has sorted out and proposed the measures and key issues for China’s SMMEs upgrade towards smart manufacturing as follows:

4.1. Overall Division of Jobs of Related Participants
Upgrade of China’s SMMEs towards smart manufacturing is a systematic project that requires the participation of all stakeholders and should be implemented as a national strategy. Based on the
existing reality that China’s SMMEs do not have adequate strength, China should provide specific and efficient support for small and medium enterprises. The government should play a leading role in top-level design and macrostructure to promote the formulation and improvement of relevant policies, laws and regulations. Industrial organizations should fully leverage their own advantages in industrial platforms to assist the implementation of policies and regulations and organize various social resources for smart manufacturing upgrade of small and medium enterprises. Research institutes can conduct in-depth related technical research and project consulting services based on their own research and talent conditions to provide technology and talent support for smart manufacturing upgrade. Finally, as the subject of smart manufacturing upgrade, small and medium enterprises should actively integrate into the wave rather than evade, hesitate or wait. They should do their best to win all available resources according to their own strength, design suitable upgrade solutions and promote upgrade in an active and orderly manner. The division of jobs and cooperation between the relevant subjects in the smart manufacturing upgrade of China’s SMMEs are shown in Chart 2.

**Figure 2.** The division of jobs and cooperation between relevant subjects in smart manufacturing upgrade of small and medium

### 4.2. Supportive Measures Required from the Government and Industrial Organizations

#### 4.2.1. Innovative Financial Mechanism

The expenditure required for smart manufacturing upgrade is a great financial pressure on most SMMEs. Solving such a problem cannot rely solely on enterprises themselves, because the government, industrial organizations, financial institutions and leading enterprises receiving supporting services from many small and medium enterprises are all stakeholders. The government should fully play its role and practically provide as much support as possible for SMMEs in taxation and financial policies. For instance, governments at all levels can provide tax reduction and exemption for enterprises related to smart manufacturing upgrade and coordinate financial resources to provide enterprises with long-term credit loan, financial leasing and so on, which will greatly accelerate the upgrade of enterprises. At the same time, large leading enterprises should also be encouraged to provide certain financial support for supporting small and medium enterprises in shortening the payment days and credit guarantees based on long-term strategic demands and returns.

#### 4.2.2. Promote Cross-Organizational Cooperation

It is significant to carry out cross-organizational cooperation based on requirements of upgrade towards smart manufacturing of SMMEs. It is difficult to change the reality in short term that small and medium enterprises are weak in technologies and
short of innovation capabilities. Since they have great difficulties in dealing with basic information-based problems, they may have no idea of where to start once encountering new technological, interdisciplinary and cross-field problems. However, these technical problems facing SMMEs during the process of upgrade towards smart manufacturing are often “multiple, small, and scattered” and cannot be skipped, thus requiring more effective support from the external “think tank”. Although cooperation between enterprises and research institutions is also promoted at the level of governments and industrial organizations, the mode is generally outdated and inefficient. With high connectivity in today’s world, it is possible to give full play to the advantages of the network platform and try new models such as accurate demands, joint R&D and building & operation of virtual innovation space, so as to “melt” practical difficulties in the upgrade towards smart manufacturing of SMMEs. Details are shown in Chart 3.

Figure 3. Cross-organizational cooperation during upgrade towards smart manufacturing of SMMEs

4.2.3. Promote the Establishment of a New Talent Use Mode. Although enterprises face varied talent problems, SMMEs have particularly serious problems in such aspect. However, in a highly informationalized era, the government and industry organizations should break the old talent service mechanism and provide “talent sharing” service across the society. SMMEs should seize the opportunity to actively try and fully utilize innovative talent use modes. Certainly, a series of problems, such as which industries and talents are suitable for sharing, how to share knowledge, skills and experience of talents, and how “large, medium and small” enterprises mutually share talents and avoid competition conflicts under the “talent sharing” mode still require more in-depth research and discussion. In order to support the industry transformation and upgrade, governments and industrial organizations at all levels should actively promote top-level design and innovation mechanism, and establish talent use and service modes suitable for smart manufacturing development requirements as soon as possible, which is particularly valuable for the upgrade of SMMEs.

4.3. Upgrade Measures Taken by SMMEs

4.3.1. Promote the Standardization of Main Business Processes. Standardized business process is the foundation for enterprises to promote digitization, informatization and smart manufacturing. Due to limited financial resources and technical level, it is difficult for SMMEs to propose a systematic process normalization suitable for most enterprises in the industry. Moreover, a single enterprise has neither the motivation to promote efficient processes to the outside, nor the authority to formulate standardized process standards. Therefore, in addition to the active promotion of the government and industry organizations, large leading enterprises should make full use of their organizational advantages and management conditions, and effectively unite with software experts to standardize the industry business process. Subsequently, it can be defined in the form of industry recommended standards. Although SMMEs cannot lead this process, they must take an active part and firstly realize
the standardization of their own processes.

4.3.2. **Achieving the Standardization of Critical Basic Data.** After completing internal transformation towards smart manufacturing, manufacturing enterprises must get integrated into the industrial chain as well to realize efficient interaction with upstream and downstream enterprises and the market. Chaotic data format will greatly increase the difficulty of information exchange between enterprises. Similar to process normalization, data standardization should also be guided and promoted by the government and industry organizations. From the perspective of interaction requirements, it is not only necessary to internally achieve data consistency, but also externally. It is necessary for basic data, including enterprise material code, department code, customer code and so on, to be unified in format and to gradually form recommendation standards, as shown in Figure 4. In this process, SMMEs shall not stand by but take an active part and constantly optimize their own data standards.

4.3.3. **Fostering “Craftsmanship Spirit”**. Facing upgrade toward smart manufacturing, SMMEs will greatly improve internal operation efficiency and externally achieve good integration with the industrial chain. On this basis, SMMEs still need to stay faithful to their original aspiration, focus on core businesses, commit to specific fields, and continuously optimize and refine technologies and processes to finally provide high-quality personalized products and services and truly become a solid foundation for the smart manufacturing system. In the smart manufacturing system of tomorrow, the importance of “Craftsmanship Spirit” will increase rather than decline. Enterprises ought to be required and guided by the spirit continuously, and make improvement on upgrading and transformation.

4.4. **Supportive Measures Required of Scientific Research Institutes**

4.4.1. **Providing Flexible Scientific Research Cooperation and Intellectual Support.** The upgrading of small and medium enterprises towards smart manufacturing is a complex system engineering. In terms of necessary technologies and intellectual resources, SMMEs lack sufficient reserves and are difficult to make large investments. Universities and scientific research institutions have better technical capabilities and rich intellectual resources. They should reach effective cooperation. Previously, only large enterprises drew attention in this kind of industry-college-institute cooperation. Actually, small and medium enterprises have more urgent demands and require more extensive technologies. With increasingly mature information technology conditions, various scientific research institutions can fully cooperate with small and medium enterprise in innovative ways. SMMEs can obtain necessary intellectual support within their financial capacity by improvement and cooperation, as well as sharing of relevant resources through segmentation or integration.

4.4.2. **Innovative Talents Co-Development Mode.** Talent is the core factor in the process of enterprises’ upgrade towards smart manufacturing. Accordingly, the talent training mechanism must be greatly adjusted and innovated to meet the urgent needs of industrial transformation and development in the
future. Therefore, universities and scientific research institutes should face the talent demands of numerous SMMEs and try to develop talent co-development modes, and constantly expand the channels for talent interaction with small and medium enterprises, so that the latter that need support most can get continuous output of talents. This is another strategic task for universities and scientific research institutes in this round of scientific and technical revolution.

4.5. Other Key Issues in Upgrade of SMMEs Towards Smart Manufacturing

4.5.1. Timing and Capital Plans for Smart Manufacturing Upgrade. The transformation and upgrade of manufacturing enterprises towards smart manufacturing is a gradual process to integrate information technology into businesses. Enterprises should make good preparations for long-term promotion from the beginning rather than regard it as short-term and periodical work. It is also impossible to “accomplish the whole task at one stroke” by upgrading some hardware and software. At the same time, the implementation process involves almost all business departments inside enterprises, as well as cooperation and communication between enterprises and external service providers. Given that the work is pioneering and tentative, it is very normal to make changes and adjustments in time and capital. For the management of similar upgrade projects, it is inappropriate for enterprises to completely adopt traditional fixed time and capital budget methods but to leave certain flexible space while developing as good systematic and prospective planning as possible.

4.5.2. Conflict of Interest Handling in Smart Manufacturing Upgrade. The process of smart manufacturing upgrade will inevitably lead to significant changes of enterprises’ inherent business processes, which will bring a lot of inconvenience to the original business and easily cause resistance of some employees, especially when the process inevitably causes replacement of some manual jobs by automated hardware and software equipment, and fierce resistance of stakeholders. To this end, enterprises must make good preparations in advance for staff placement and persuasion to minimize unnecessary interference during the implementation.

5. Case analysis

We have studied a large number of cases in the upgrade towards smart manufacturing of SMMEs. This paper selects one typical case for brief analysis and explanation, namely the smart manufacturing upgrade of a medium automobile parts enterprise in a southwestern city in China.

5.1. Basic Situation of the Enterprise

As a typical medium enterprise, it has about 800 employees and delivers an annual output of less than 400 million CNY. Its main products include automotive sheet metal stamping and welding parts, provided for Changan Ford and Changan Automobile. In order to break through the bottlenecks hindering development and become a first-class auto parts supplier, the enterprise has implemented a smart manufacturing upgrade project since 2015.

5.2. Main Content of Upgrade

During the upgrade, the enterprise built a dedicated enterprise local area network (LAN) to isolate from the external public network with gateway software. The network is preset physical isolation measures in case of emergency, and connect PLC, industrial robots, CNC and other automation equipment to the public data collection platform for normal collection of data. A dedicated database was established and a post-processing data platform was developed. For the risk of quality defects caused by mold damage in some key process links, the enterprise deploys an optical automatic detection system and connect it to the public data platform. In addition, the key equipment control system was upgraded for safe control and product quality traceability.
5.3. Implementation Effects of Upgrade

The intelligent system delivered remarkable results soon after it was put into operation. The state of isolation between equipment in the past was completely broken, which allows the management layer to monitor the running status of all equipment in real time, to substantially reduce the waste of materials and to more flexibly switch between products. Some important products even allow automatic quality monitoring, with much smaller difficulties in quality maintenance and problem traceability.

5.4. Support of the Government and Industry Organizations During the Upgrade

In order to reduce the burden of upgrade, the enterprise successfully applied to the local government for the subsidy for intelligent upgrade project during the process of implementation, which ensures the success of the upgrade. For some tough problems, the enterprise actively participated in many special lectures and consultations organized by the local industry alliance organizations with experts from the upstream and downstream of the industry.

5.5. The Enterprise’s Own Efforts During Upgrade

During the upgrade towards smart manufacturing, the enterprise leadership paid great attention to it and specially set up an information business unit. In addition, technology, production, quality, logistics, finance and other relevant departments are required to provide support during the whole process, and the responsible department should regularly report to the top leaders of the enterprise. In order to deploy intelligent production and management systems, the front-line employees of relevant service providers work together with the employees of all departments of the enterprise under the coordination of the information business unit to comprehensively sort out the process and initially standardized the process. In view of the chaotic data formats and codes of different departments, the enterprise also standardized data for unification. In order to minimize the impacts of the deployment of intelligent systems on the established production plans, the construction personnel and production personnel cooperated well during the installation process of hardware and software. In addition, for the changes of positions and responsibilities caused by the operation of the new system, the enterprise has fully explained and guided relevant employees in advance and made proper resettlement afterwards.

5.6. Cooperation with Research Institutes During Upgrade

In the process of system integration and personnel training, the enterprise actively carried out in-depth cooperation with relevant experts from local universities and a famous engineering university in Beijing, which greatly reduced the burden on system function integration and personnel training. In summary, the smart manufacturing upgrade of the enterprise is very typical. The local government, industry organizations, enterprises and some universities have participated in this process, with reasonable division of jobs and close cooperation. Great importance has been attached to the implementation of the project from front-line employees to the top leadership. Although the project has gone through all kinds of unexpected problems and setbacks, it has finally achieved the expected goal. Certainly, as a traditional small and medium manufacturing enterprise initially attempting smart manufacturing upgrade, its work is not that perfect, and there is still a gap between the performance and the ideal state of upgraded system functions. However, it has provided a basic prototype of smart plant for the enterprise and laid foundation for the gradual and continuous improvement in the future. This case shows that as long as SMMEs in China have explicit objectives, clear ideas, firm implementation, and down-to-earth practice, it is completely possible to make great breakthrough in smart manufacturing upgrade under existing conditions.

6. Conclusion
SMMEs are related to the overall development of the manufacturing industry, especially in the context of the global manufacturing industry upgrading towards smart manufacturing, the status of China’s SMMEs will become more prominent, and the demands for smart manufacturing will become more urgent. In the future, excellent SMMEs should achieve intelligent production internally, get fully integrated into the industrial chain externally, and build a bridge between the market and upstream and downstream digitally to achieve efficient interaction with other links in the industrial chain. At present, China’s SMMEs face many challenges in the upgrade towards smart manufacturing, such as common problems in business processes, software and hardware, talents and capitals, as well as specific difficulties in equipment interconnection, process standardization, data standardization, software system integration and so on. Therefore, this paper advises: the government, industry organizations, small and medium enterprises and scientific research institutes should have effective division of jobs and mutual cooperation in the process of upgrading towards smart manufacturing of SMMEs. Governments and industry organizations should carry out top-level planning and major promotion in developing new financial systems, promoting trans-institutional cooperation and developing new talents use modes. Colleges and universities and scientific research institutes should give full play to their advantages in technology and intellectual resources, break through the limitations of traditional cooperation, and explore innovative collaboration modes that provide direct support to SMMEs. SMMEs should actively take the initiative to meet this tide of upgrading, focus on promoting the standardization of process and data format, and integrate the cultivation of “craftsmanship spirit” into the upgrade towards smart manufacturing. Finally, SMMEs should know that the upgrade towards smart manufacturing is time consuming, systematic and uncertain, requiring thorough consideration of the possibility of time and capital changes in advance, as well as resettlement and treatment of employees who may suffer from such changes.

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