

A Project Guide for the Numerical Control Generation Demonstration Project to Promote the Application of Generic Enabling Technology in Small and Medium Enterprises

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Abstract: Numerical Control (NC) technology is a key and generic enabling technology to promote the upgrading of mechanical products. Considering the technology and capital barriers, among others, that affect small and medium enterprises (SMEs), and which may lead to market and organization failure, there is a serious “valley of death” phenomenon observed in the application of generic enabling technology. The working principle of the NC Generation demonstration project is to take demand as traction, innovation as the driving power, and enterprise as the main body of technological innovation; next, it combines multivariate innovation among industry, universities, academic research, finance, and government, as well as breakthroughs at key points, and successfully demonstrates NC Generation projects. The NC Generation demonstration project applies NC technology to the mechanical products of a typical industry, essentially improving the product performance. In general, it speeds up the overall upgrading of mechanical products and promotes the transformation and upgrading of an enterprise toward sustainable development. In this way, the NC Generation demonstration project bridges the gap between generic enabling technology R&D and enterprises’ innovative production. This project has led to some remarkable accomplishments, and is a successful example of the application of generic enabling technology. The NC Generation demonstration project provides a helpful reference and establishes a solid foundation for the further implementation of the comprehensive popularization of NC technology in various industries and regions.

Keywords: demonstration project; generic enabling technology; technology innovation diffusion; small and medium enterprises; transformation and upgrading

1 Introduction

The implementation of innovation-driven development strategy is the fundamental driving force for manufacturing transformation and upgrading [1,2]. Over the years, China has emerged as the world’s preferred manufacturing center. However, many

enterprises are at a lower level of production efficiency and innovation, and structural imbalances that cause a demand-supply mismatch have prevented the desired release of China’s economic kinetic energy. In the future, structural reforms will be the main focus, supply-side reforms will be further promoted, and innovation will continue to meet the requirement of con-

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stant upgrading and development of demand. The upgrading of manufacturing industry mainly includes two aspects: first, the development of emerging high-tech and related industries, and second, the development of traditional advantageous industries. The upgrading needs to be facilitated through the promotion and application of a generic enabling technology [1,3].

A generic enabling technology is used to solve the general problems faced by product upgrading in various industries [4,5]; it can effectively activate the potential of traditional manufacturing and promote its structural optimization and upgrading. The promotion and application of a generic enabling technology is based on: technological innovation; market orientation, especially the goal of improving the core competitiveness of the industry; and a focus on the diffusion of innovative technologies among enterprises, as well as industries. In order to seize the commanding heights of global economic and technological competition, some international organizations and countries have formulated the development strategy for generic enabling technologies. In September 2009, the European Commission issued the *Common Strategy for the Development of Critical Enabling Technologies in Europe*. In November 2012, the UK Technology Strategy Committee announced the *2012–2015 Enabling Technology Strategy*. The European Commission believes that key enabling technologies will greatly promote the development of communications, medical equipment, automobiles, and aerospace, and thereby, enhance the EU's international competitiveness in the next 10 years [6].

On the whole, the spillover and sharing of a generic enabling technology leads to a shortage in the supply of pure market mechanisms and market failure. The advancement and risk of a generic enabling technology leads to a particularly complex technological innovation activity. A single technology innovation subject can hardly shoulder the load all the activities in the process of diffusion of technological innovation, and organizational failure may occur [4,5,7]. For small- and medium-sized enterprises, the biggest obstacle to the promotion of generic enabling technologies, both domestically and overseas, is that there is often a gap between the technology research and development (R&D) supported by key technologies and the innovation and production that the industry has focused on, that is, the “valley of death” phenomenon [7,8]. This leads to an extremely poor conversion of scientific research into production. If many scientific research achievements fail to successfully cross the “valley of death” and cannot be transformed into productive capacity in enterprises to improve national competitiveness, the efficiency of science and technology investment will be greatly reduced, and the value of scientific and technological R&D results will not be fully realized. Therefore, the government needs to play a guiding and service-oriented role that: mobilizes the enthusiasm of enterprises and various types of innovation organizations through limited government resources; promotes the organic integration of innovation chains, industrial chains, and financial

chains; and closely combines generic enabling technologies with enterprise needs. In order to achieve numerous technological research breakthroughs, especially the application of research results of generic enabling technologies to various industrial fields, they need to successfully cross the “valley of death,” achieve industrialization and enter the market (Fig. 1). In order to bridge this gap, many countries or regions have established a technological innovation system that includes technical research, product demonstrations, etc.; the system stresses the development and application of generic enabling technologies, and places a special emphasis on adopting new policy measures to support industrialization and marketization of a generic enabling technology achievements. For example, the German Fraunhofer Institute is mainly engaged in research on the application of generic technology. It brings together various types of scientific research institutes to provide enterprises and industries with technology and information services to realize the transformation of scientific and technological achievements, and assists enterprises, especially the small- and medium-sized ones, to develop new products. It successfully established a collaborative innovation bridge between generic enabling technology R&D and successful industrial applications.

At present, there are some unresolved problems in the process for implementing scientific research achievements in China. The disconnection between R&D and the commercialization of a technology still exists. The conversion rate of scientific and technological achievements, the conversion rate of patents, and the rate of patent promotion in China are not only far lower than those in the developed countries in the West, but also not as high as those in the newly industrialized countries. This is mainly because there are serious disconnects between the technological chain and the industrial chain in the technological innovation chain.

NC technology is a generic enabling technology combining advanced information technology and machinery manufacturing technology [1,3]. The NC innovation of mechanical products has distinctive features and essential laws. It is of great practical sig-

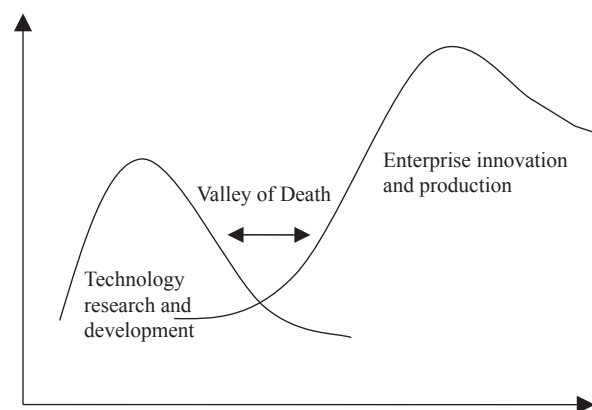


Fig. 1. The “Valley of Death” phenomenon in the transformation of scientific research.

nificance to the transformation and upgrading of manufacturing industries. The combination of NC technology and mechanical products of various industries can lead to fundamental changes in mechanical products, resulting in the improvement of their functions and performance. However, a qualitative leap is needed to comprehensively enhance the competitiveness of the manufacturing market. As far as the NC technology is concerned, the Western developed countries have spent more than 60 years carrying out the generalization and application processes. The majority of SMEs in China have a strong demand for NC upgrades. However, considering their own technical, financial, and other obstacles, as well as market and organizational failures, NC technology faces many difficulties in the process that combines innovation with corporate machinery products. Therefore, government-guided demonstration projects need to be carried out to promote their application in SMEs [9,10]. To ensure the overall strategic development of the manufacturing industry, China launched the “NC Generation” mechanical product innovation application demonstration project (also referred to as “NC Generation” demonstration project) during the “Twelfth Five-Year Plan” period. After several years of practice, the “NC Generation” demonstration project effectively led and facilitated the promotion and application of NC technology in small- and medium-sized enterprises in key industries, and bridged the gap between generic enabling technology R&D and product innovation applications. Impressive results have been achieved. This is a successful example of the promotion and application of generic enabling technology, and has accumulated valuable experience for all industries and regions in the next phase.

2 A project guide for the NC Generation demonstration project to promote the application of NC technology in small and medium enterprises

2.1 NC technology is a key generic enabling technology that promotes the upgrading of mechanical products

For a long time, productivity growth in the manufacturing industry has mainly come from technological innovation and the industrialization of technological achievements. The historical

evolution of the industrial structure adjustment and mechanical product upgrade implementation process is shown in Fig. 2. The steam engine technology advances the era of manual production to the mechanized era (Industry 1.0 or the Mechanical Generation). Electrical technology ends the mechanized era of the machinery industry and ushers in the electrification era (Industry 2.0 or the Electric Generation). NC technology is moving the machinery industry from the age of electrification to the digital era (Industry 3.0 or the Digital Control Generation). Smart technology will take the machinery industry from the digital era to the intelligent era (Industry 4.0 or the Smart Generation) [3,11].

Historically, two main methods have led to the evolution of mechanical products [1]. First, innovative working principles or working devices cause extremely fundamental disruptions. The second method involves the innovation of mechanical power devices and transmission. Traditional mechanical products mainly include power devices, transmission devices, and working devices. The NC of mechanical products involves innovation in the power and transmission devices (Fig. 3).

The NC innovation has typical characteristics and essential laws that can be applied to various types of mechanical products; this leads to the upgrading of mechanical products and profound changes in the manufacturing industry. The NC technology core has two aspects [1]. First, the servo motor drive system replaces the traditional power and transmission devices. Second, it uses a computer control system to control the mechanical movement and work process. NC technology can fundamentally change the connotation and performance of mechanical products, and is a generic enabling technology that promotes the innovation of mechanical products.

The technical route for applying NC technology to the innovation of mechanical products is clear, and the technology is mature and stable. It can be applied for the comprehensive innovation of mechanical equipment and products in various industries [1,3]. For example, it can be applied to the building and construction materials machinery, printing and packaging machinery, textile machinery, light industrial machinery, metal processing machinery, plastics processing machinery, glass and ceramic processing machinery, electronic components processing machinery, food and beverage processing machinery. Further, it can also be introduced to other machinery and

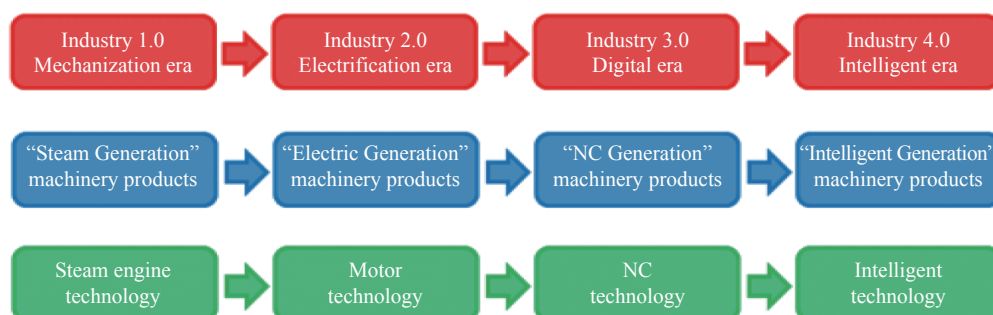


Fig. 2. Mechanical product upgrade process.

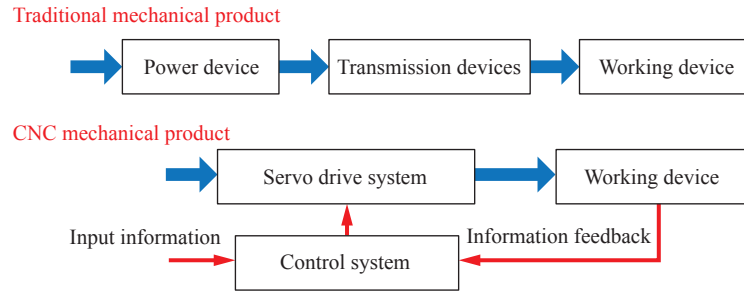


Fig. 3. Comparison of the structure of traditional and computer numerical control (CNC) mechanical product.

equipment, as well as national defense and military equipment, transportation equipment, lifting and transportation equipment, engineering machinery equipment, medical equipment, research and teaching equipment, office equipment, service equipment, and other machinery products. It can be seen that NC technology can be universally applied to the innovation of various types of mechanical equipment and products, thereby promoting the upgrade of mechanical products and leading to profound changes in the entire machinery industry.

2.2 Organization and implementation of the “NC Generation” demonstration project

At the beginning of 2011, 18 members of the Chinese Academy of Engineering jointly proposed relevant recommendations for the implementation of NC technology in the application of innovative mechanical products, which were valued highly by the central government. In 2012, the Ministry of Science and Technology, the Ministry of Industry and Information Technology, and the Academy of Engineering jointly initiated the “CNC-Generation Innovation and Application of Mechanical Products Demonstration Project” and the *12th Five-Year Plan of the CNC-Generation Mechanical Product Innovative Application Demonstration Project*.

During the “Twelfth Five-Year Plan” period, the “NC Generation” demonstration project adhered to the promotion and application of NC technology, and strived to: improve the independent innovation capability of the machinery industry enterprises; continuously improve product quality and production efficiency; increase the added value of machinery and equipment products; and realize products. The transformation and upgrading of mechanical equipment have promoted scientific and technological progress in the field of mechanical engineering in China [12,13]. Through the implementation of the “NC Generation” demonstration project, breakthroughs were achieved in key technologies, such as CNC machine design, special control, and process optimization. It also led to specialized design tools, control systems, and process software, which are widely used for product innovation in key industries. The promotion and application of key areas have achieved positive results, laying a solid foundation (Fig. 4) for the further promotion of the universal application of

NC technology in various machinery industries across the country. The working principle of the “NC Generation” demonstration project is to focus on breakthroughs and successful demonstrations by taking demand as the main traction, innovation as the driving force, and enterprises as the main body. Further, it seeks to achieve “integration of industry, university, research, fund, and government” through close cooperation [13].

Demand traction: The purpose of the development of mechanical product manufacturing enterprises, the transformation and upgrading of mechanical product manufacturing industries, and the development of local pillar industries are always taken as the goal; the deep integration of the company’s core business and NC technology is realized around the business process of the enterprise.

Driven by innovation: Make full use of high-tech achievements, such as digital control technology, computer technology, power device technology, motor technology, digital design technology; in addition, play a leading role in science and technology, and improve the independent innovation capability and comprehensive competitiveness of machinery and equipment companies.

Service companies: Taking “improving enterprise efficiency and efficiency” as the fundamental goal of CNC machinery product innovation, combine the development of key industries and local pillar industries, doing it in a “deep,” “pervasive,” and “precise” manner.

Industry demonstration: Select printing and packaging machinery, light industry building materials machinery, textile machinery, plastics, and other related industries’ machinery and a number of industries with strong, highly connected, and typical representatives with significant influence in the manufacturing industry.

Regional demonstration: This is according to the strategic needs of regional “turning modes and adjusting structures” in the regions of the Yangtze River Delta, the Pearl River Delta, major industrial areas in the central and western regions, and the old industrial bases in the northeast, in the form of professional towns, demonstration provinces and cities, local governments and science and technology. The departments responsible rely on the implementation in the organization.

Organization form: The “industry, university, research, fund,

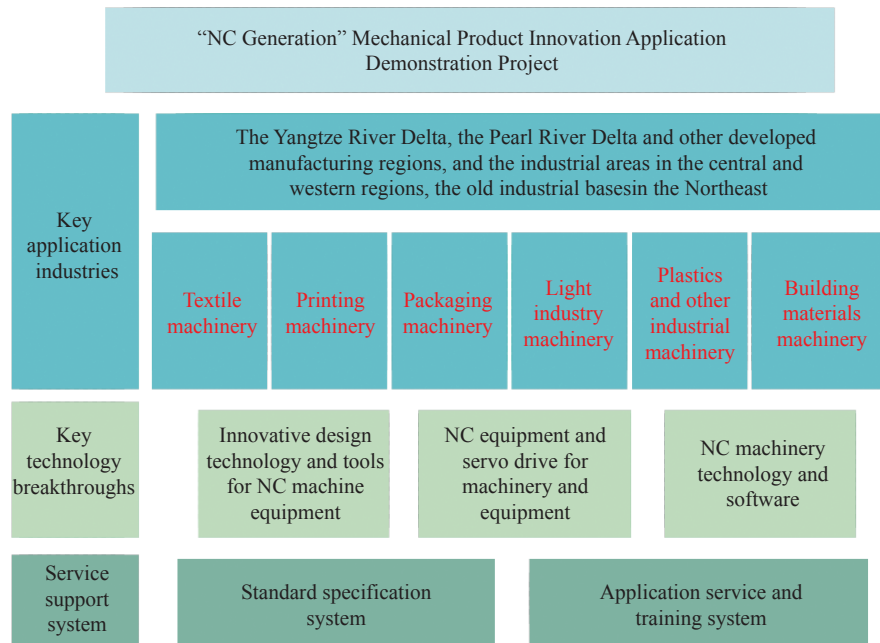


Fig. 4. Framework of the "NC Generation" demonstration project.

and government" are closely integrated, market-oriented, and the enterprise is at the core; further, the multiple-innovation subjects focus on common goals for collaborative innovation. In addition, organizational protection was strengthened. Leading groups, expert groups, and expert advisory groups were established. They were responsible for approving overall planning, coordinating and guiding work, grasping development strategies, and providing technical guidance and advice.

Policy model: The demonstration project is carried out in the form of a national science and technology support plan. With limited financial input, it actively mobilizes the enthusiasm of all parties and effectively stimulates the input of a large number of social resources. According to the model of "assessing upstream with downstream, components with complete machine, technology with application, and products with market," the promotion and application of NC technology is realized.

After several years of unremitting efforts, the "NC Generation" demonstration project has achieved fruitful results and won wide acclaim and praise from the business community. In June 2016, the "National NC Innovation Application Engineering Work Conference" was held to summarize and analyze the experience, achievements and improvement direction of the demonstration project during the "Twelfth Five-Year Plan" period [2].

2.3 "NC Generation" demonstration project to promote the transformation and upgrading of SMEs

2.3.1 The promotion and application of NC technology in enterprises to achieve the upgrading of mechanical products

The "NC Generation" demonstration project is to popularize and apply advanced and practical NC technology, and it is

also a process of revolutionary integrated innovation of various types of machinery equipment in various industries using a generic enabling technology. The project revolves around market demand, and through the application of technological innovation, the scientific and technological innovation results are closely integrated with China's needs. In the key industries, a large number of advanced NC equipment has been researched and developed. This process of transformation of achievements is a process of redesigning, redeveloping, and recreating new products that are oriented toward the needs of professional application markets. During the "12th Five-Year Period," China has successfully developed more than 200 kinds of NC equipment, popularized 220,000 sets, built more than 70 NC demonstration production lines, trained more than 20,000 person-time professionals, and achieved a series of innovative results. A large number of SMEs in the demonstration industry have upgraded their mechanical products [2].

2.3.2 Leading the transformation and upgrading of key manufacturing industries

The "NC Generation" demonstration project has promoted the upgrading of traditional machinery equipment and products by vigorously promoting the advanced and innovative NC technology, which has effectively proved its application to a wide range of key industries and significantly improved the production efficiency and product quality of traditional manufacturing industries. The transformation and upgrading of the traditional machinery industry, with extensive support, has achieved tremendous economic and social benefits. For example, in the textile machinery industry, NC machine tools have been successfully developed to carry out automatic weaving of various mate-

rials and create intricate patterns. The efficiency of each device is equivalent to that of 8 hand-held looms, and each worker can operate six NC looms simultaneously. Thus, the NC loom has increased the labor efficiency of individual workers by a factor of 48, and has been widely used in the weaving industry throughout the country, resulting in significant economic benefits. Another example is from the plastic machinery industry. Here, the servo-driven NC injection molding machine equipment is vigorously promoted, a large-scale technological transformation of the old equipment is performed, and the mainstream domestic new production injection molding machines have all adopted NC technology; they achieve, on average, an energy saving of more than 50%. The higher efficiency has produced significant social benefits (Fig. 5).

2.3.3 Supporting the concentration of manufacturing industries for sustainable economic development

The “NC Generation” demonstration project closely integrates with the development of local pillar industries and selects key industries and regions for the purpose of demonstration. Through the demonstration project promotion, electronic manufacturing equipment, gear manufacturing and industrial robots, auto parts manufacturing equipment, and textile machinery have become the new growth areas for industrial development in various regions. This has led to an upsurge in the improvement of the NC rate of mechanical products. The related NC product industry chain has enhanced the capability to undertake independent innovation of mechanical products in the region and add value to products, thereby promoting industrial agglomeration and cluster development. For example, aiming at the actual de-

mand for manufacturing equipment of auto parts manufacturing enterprises in Hubei Province, the company will realize the innovation of auto parts processing equipment and increase the share of domestic key equipment in auto parts industry through the demonstration application and NC transformation of domestic NC equipment. Numerical control equipment for auto key parts such as chassis, engines, transmissions, and hydraulics has been popularized and applied among many manufactures in the Hubei Thousand-li Automobile Corridor, thus to conduct NC transformation to traditional equipment. The major technical indicators have reached the advanced international benchmarks. Another example is related to the needs of enterprises in the gear industry in Chongqing. Here, work has been carried out in the R&D of NC technologies for gear manufacturing processes and equipment, R&D of digital control gears, application and demonstration of digital control gears, and industrialization, to promote the gear processing industry in Chongqing. The application of various kinds of NC equipment amounts to about 5,000 sets, of which more than 3,000 are NC machine tools, which have made important contributions to the promotion of regional economic development.

3 Enlightenment and significance of the “NC Generation” demonstration project

3.1 Successful attribute analysis of “NC Generation” demonstration project

3.1.1 Policy characteristics

In response to market failure, the government has played

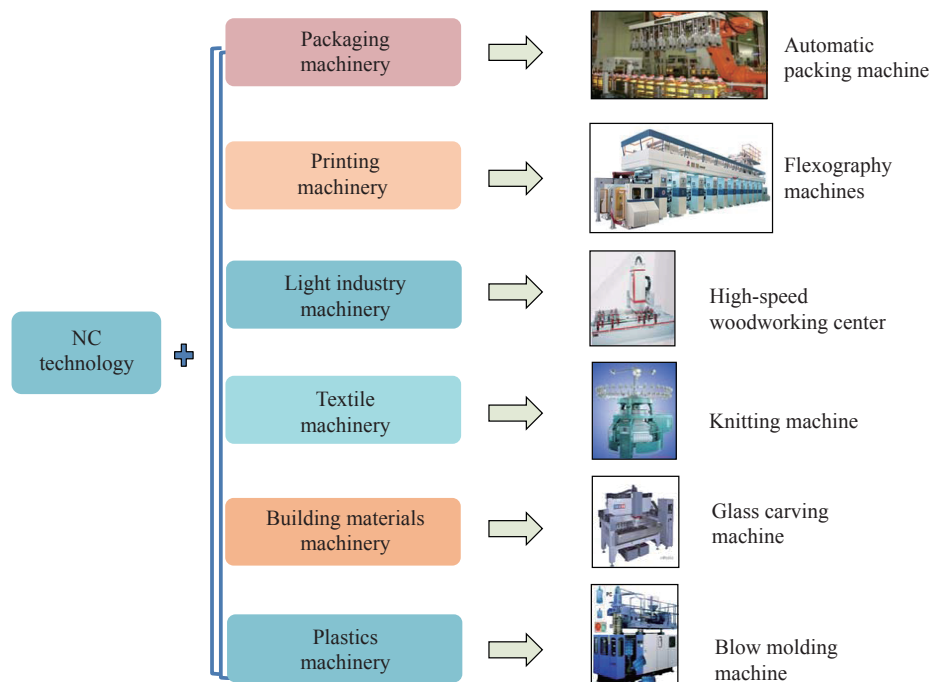


Fig. 5. Numerical control technology diffusion and mechanical products innovation.

an important role of guiding and promoting organizations. The “NC Generation” demonstration project was implemented in the form of a national science and technology support plan. A number of related supporting policies were issued by the central government to the governments at the provincial and municipal levels to integrate the resources of companies, universities, scientific research institutions, and other related organizations. The cooperation among industry, university, and research has been developed in depth, and the development and application of NC technologies and products have been developed in collaboration. The demonstration project has effectively improved the innovation ability and innovation efficiency of traditional industrial enterprises, and solved the problems encountered in supply and diffusion process of generic enabling technologies under the conditions of market economy.

The “NC Generation” demonstration project has effectively used a limited amount of financial investment to suitably incentivize a large amount of social capital input from institutions, such as enterprises and financial institutions, thereby providing funds for the smooth development of the project. Under the conditions of market economy, the dual failures of market and organization in the process of popularization and application of generic enabling technologies provides a sufficient theoretical basis for government intervention. The role of the government is to make up for market deficiencies, increase the efficiency of the allocation of innovative resources, and ensure the effective supply of generic enabling technologies. During the demonstration project, the government actively guided and provided services. Based on the premise of the country’s industrial development strategy and corporate technology requirements, it encouraged institutions, such as scientific research and finance to actively participate in economic construction, as shown in Fig. 6.

3.1.2 Technical characteristics

Technological innovation is the fundamental driving force. Since the 1970s, after many years of continuous R&D in the

field of NC technology, China’s NC equipment manufacturing and NC system has formed a more comprehensive system of generic enabling technology R&D. The domestically developed economical NC system has dominated the domestic market, and the mid-range NC system has achieved industrial scale. The high-end NC system exhibits a mastery of many key technologies. The stability, reliability, applicability, and safety of NC technology have been continuously improved, laying a solid foundation for promoting the popularization of NC technology and improving the innovation capability of mechanical products. China’s NC technology has entered a phase of mature, stable, and reliable quality. The basic conditions for popularization and application have matured.

The “NC Generation” demonstration project is a project to popularize and apply advanced and practical NC technology; it is also a process of revolutionary integrated innovation of various types of machinery equipment and the application to products of a generic enabling technology in various industries. NC technology, as a combination of generic enabling technology and mechanical product technology, can achieve digital control of mechanical equipment; this leads to fundamental changes in mechanical products, so that the functions of the products are greatly enriched and the performance undergoes a qualitative leap. This leads to revolutionary integrated innovation, which enhances the quality level and market competitiveness of mechanical products.

3.1.3 Organization characteristics

In view of the organizational failures, the “NC Generation” demonstration project is a typical demonstration and successful attempt to combine “application, industry, university, research, fund, and government.” It is truly realized that R&D practices and innovation needs come from companies, the innovation activities are led by companies, and the results of innovation are invested back in companies. The innovation results are mainly applied to enterprises, universities, and research institutes, where they play a supporting and promoting role. As a key generic en-

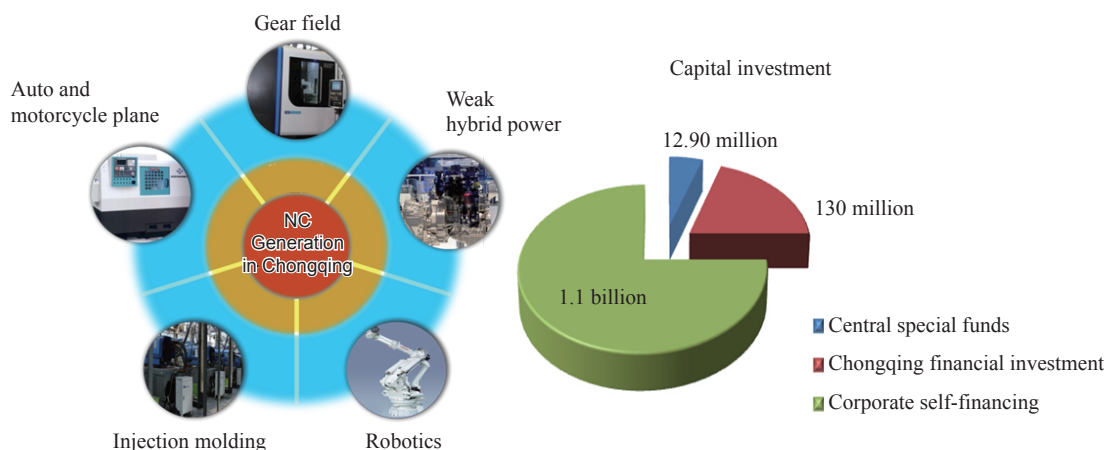


Fig. 6. Chongqing mobilizing money into “NC Generation” demonstration project in multiple areas.

abling technology in the manufacturing industry, the promotion and application of NC technology requires complex system engineering. Depending solely on the organizational strength of a company, a university, or a research institute is both insufficient and unrealistic. Working on the premise of the industrial development strategy and the real technical needs of enterprises, the integration of resources, the strength and wisdom of enterprises, universities, research institutes, and various types of innovation organizations can promote the application of NC technology in enterprises.

Diversified innovation organizations play a cooperative and collaborative role. In applied research, it is usually necessary to build an interdisciplinary and cooperative research team. In the NC development process of mechanical products, it involves both the basic problems of NC technology and the technology of mechanical products. Demand and the formation of innovation clusters between “industry, university, and research” are crucial for cooperation. In order to realize the goal of the numerical upgrade of mechanical products, various innovation organizations have targeted the development of R&D methods demanded by the industry; these methods not only have a clear division of scientific research, but also carry out frequent information exchange, resource exchange, and various forms with other organizations. The cooperation has resulted in the formation of a large number of demonstration projects and innovations by industry, university and research cooperation.

3.1.4 Market characteristics

The “NC Generation” demonstration project takes a majority of the manufacturing enterprises as the core subject, and closely focuses on the innovative application of the actual requirements in the production process. The majority of manufacturing companies have a strong demand for the NC upgrade of mechanical products. NC technologies and products have potentially a wide application market in China. Only by solving the problem of “bridge assistance” in the transformation of scientific research achievements, and solving the problem of the industrial relevance of scientific research projects at the source, can we successfully overcome the “valley of death”. In this process, the enterprise is no longer a purely production organization, but the main body of economic activities, as well as technological innovation. Thus, enterprises become the main practitioners of innovative applications in mechanical product innovation activities.

During the demonstration process, the demonstration project takes the market-oriented concept as the forerunner and the problem as the entry point; it uses economic leverage and methods of market regulation to utilize extensive market resources as the input, and mobilizes multiple innovations in enterprises, universities, research institutes, and finance. The enthusiasm of the main body and the provision of relevant support, as well as the mobilization of large-scale manufacturing companies, is used to overcome various obstacles under the principles of the market

economy to actively carry out the innovation and application of NC mechanical products. Further, it introduces the NC technology in a market-oriented manner to SMEs to accelerate the pace of application.

3.2 The significance of the “NC Generation” demonstration project

To become a manufacturing power, China must not only strive to achieve breakthroughs in cutting-edge technologies and strategic high-end technologies, but also pay attention to how the traditional manufacturing industry, along with a wide range of industries, can achieve transformation and upgrading by taking a leapfrogging approach. The promotion of a generic enabling technology from the laboratory to the market to achieve transfer and transformation is not only a key task in implementing innovation-driven development strategies, but also a practical problem that exists. Since many non-profit research institutes in the past have undergone corporate restructuring, and SMEs have limited technical funds and face other obstacles, this problem is particularly prominent in traditional manufacturing industries. Therefore, the implementation of the “NC Generation” demonstration project has far-reaching strategic significance and has resulted in the following positive practical benefits.

The implementation of the “NC Generation” demonstration project effectively solved the two issues of disconnect among technologies and industries; it straddled the valley of death, where scientific and technological achievements were poorly translated. Further, it led and facilitated breakthroughs in the promotion and application of NC technology, and promoted the key similarities. Energy technology has achieved industrial transformation and upgrading in innovative applications in several of the key traditional manufacturing industries. It has established a bridge between the generic enabling technology R&D and enterprise innovative production. It is a successful and typical example (Fig. 7).

The “NC Generation” demonstration project aims at product innovation, uses economic leverage and market regulation, mobilizes the enthusiasm of various social resources when government resources are limited, and promotes the organic integration of the innovation chain, industrial chain, and financial chain, thereby achieving diversity. Innovative individuals collaborate to combine generic enabling technologies with corporate needs, continuously develop a variety of NC machineries in a variety of industries and promote their applications. Thus, they effectively implement the *Law of the PRC on Promoting the Transformation of Scientific and Technological Achievements*, which is universally representative. The demonstration project can provide a useful reference for following promotion and application of related generic enabling technologies.

As a key generic enabling technology, NC technology is an important foundation for the development and upgrading of the

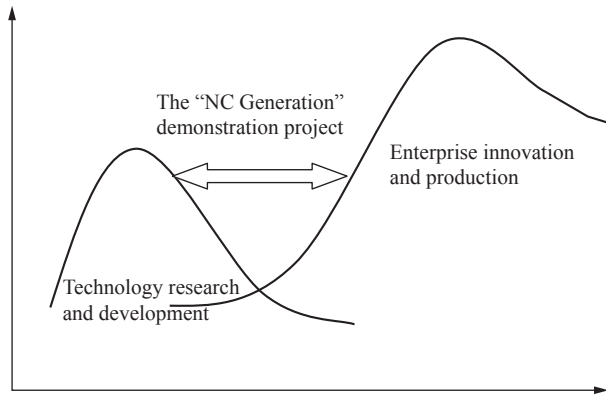


Fig. 7. The NC Generation demonstration project establishes a bridge between generic enabling technology R&D and enterprise innovative production.

national industry. Giving full play to the superiority of China's social system to carry out the "NC Generation" demonstration project has set a successful example of popularization and application of a generic enabling technology. This is expected to accelerate the overall upgrading of mechanical products, and further promote the demonstration project during the "13th Five-Year Plan" period. Carry out "NC Generation" promotion and application projects in various industries and regions, and establishing a "Smart Generation" demonstration project during the "13th Five-Year Plan" and "Smart Generation" promotion and application projects during the "14th Five-Year Plan" to lay a solid and powerful. The foundation will be realized as soon as possible. It is expected to realize the strategic goal of creating lessons for Industry 2.0, popularizing Industry 3.0, and establishing pilot demonstration projects for Industry 4.0, and thus, become a manufacturing power soon.

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