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Intelligent Development of Marine Equipment in China

Tang Min, Li Feng, Zeng Li, Hua Lin

Wuhan Marine Machinery Plant Co., Ltd, Wuhan 430084, China

Abstract: With the extensive integration of information technology with the manufacturing industry, intelligent promotion and upgrading is necessary for boosting the competitiveness of China's marine equipment industry and for developing China's shipbuilding power. In this paper, the current scenario and trends with respect to the development of intelligent marine equipment by other countries are summarized. Subsequently, the constraints restricting the intelligent development of marine equipment in China are analyzed. Furthermore, the general concepts and implementation approaches, as well as a top-level framework are established for intelligent development of marine equipment in China. Moreover, suggestions are proposed for development, including establishing a reasonable product structure based on demand, promoting demonstrations and guidance values of major projects, and enhancing cooperation among different industries.
Keywords: marine equipment industry; intelligent equipment; shipbuilding powerhouse

1 Introduction

Marine equipment are important components of ocean engineering equipment and high-tech ships and mainly include electromechanical systems, ship power systems, and electrical automation systems having characteristics such as large quantity, wide operational range, advanced technology, and high value-added benefits. In the 11th Five-Year Plan, the Chinese government began to invest heavily in research on core intellectual property products. The marine equipment industry has developed rapidly; these developments include continuous improvements in the industrial systems, advancements in the development of core components, significant improvements at the industrial scale, and continuous improvements in local supporting equipment. However, compared with developed countries, the marine equipment industry in China is still plagued by numerous problems, such as an imperfect industrial chain, weak R&D capability, monopolized high-end products, low production efficiency and product reliability, and insufficient service capacity. In summary, the lack of development of the marine equipment industry has become one of the primary causes of poor growth of shipbuilding capabilities in China.

In light of the adjustments in the global manufacturing patterns and significant changes in China's economic environment, the extensive integration of information technology with the manufacturing industry is currently of profound impact. The "Internet + advanced manufacturing" strategy for the marine equipment industry is an important developmental step in the transformation of the national shipbuilding industry and strengthening of manufacturing power. The industries supporting shipbuilding need to be improved via promoting intelligent equipment capacity, manufacturing competitive branded products, and maximizing the advantages of technology, branding, and industrial chain, to achieve comprehensive growth with respect to R&D, core manufacturing, and

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Corresponding author: Tang Min, senior engineer of Wuhan Marine Machinery Plant Co., Ltd. Major research field is ships and marine engineering. E-mail: tangmin@wmmp.com.cn
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global service level of the industry. This would also promote the transformation of the marine equipment industry and strengthen China's shipbuilding sector.

2 Development status of marine equipment industry in other countries

2.1 Status of marine equipment industry in other countries

Upon analyzing the development trends of foreign marine equipment industries, it was inferred that Europe, Japan, and South Korea had obvious advantages, including superior R&D capability, product quality, and after-sales service capability. In recent years, with the transfer of the world shipbuilding center to the Asia-Pacific region, the shipbuilding companies of Europe, Japan, and South Korea have corresponded their development strategies to the development of China. The foreign enterprises gradually changed from technology transfer, joint venture, and cooperation models to wholly owned factories in China. These enterprises export their products to China or raise the standards of technological introduction to increase their holding ratios in joint ventures. At the same time, for the after-sales service, the foreign enterprises have undertaken global service businesses for domestic enterprise-brand products as well as for other enterprise-brand products. Thus, the development of the marine equipment industry in China is facing an unprecedented adverse situation owing to technology source contraction [1].

2.1.1 Status of the European marine equipment industry

Being the birthplace of the shipbuilding industry, Europe has a long history of success in the marine equipment industry. European marine equipment has become a globally famous brand having a strong brand image as a result of many technological revolutions. Over hundreds of years, the enterprises in Europe have always attached importance to advanced techniques, reliability, and stability of products. They have maintained high value-add capabilities for marine equipment and led the advancement in marine equipment technologies for a long time through continuous research, development, and product optimization. The European marine equipment enterprises have formed a global after-sales service network and provide convenient maintenance and upgradation services around the world based on their technological strength. In addition, the major European marine equipment enterprises compete for supporting markets around the world through strategic cooperation of transnational groups by forming technological joint forces.

2.1.2 Status of Japanese marine equipment industry

Japan is a rising star in the shipbuilding industry. As Japan became a big shipbuilding power in the 1950s, the shipbuilding demand has driven the rapid development of supporting industries. Through technological introduction, technical cooperation, R&D capital reserve, and other means, the marine equipment industry in Japan has realized rapid expansion in scale. During the period of industrial development, Japan has established a complementary management system for the marine equipment industry. With effective division of labor among government, industry organizations, and enterprises, coupled with the strengthening of technological innovation, Japan has formed a centralized advantage. This resulted in different professional division of labor, avoided the negative competition among enterprises, and gradually established an industrial system, which has the characteristics of complete varieties, complete systems, and large scale. Currently, with a stable supply system and an efficient and lean production management strategy, Japan can exceed the localization rate of 95% [2] and realize a large number of exports to foreign countries. At the same time, drawing on the experience of Europe, Japan has established a perfect global service system in terms of after-sales service, and is committed to making product development, application and market demand change synchronously.

2.1.3 Status of South Korean marine equipment industry

Since the 1980s, under the guidance of the government, South Korea has actively promoted the marine equipment protection policy and gradually established a relatively complete ship support system by limiting the import of ship supporting products, coordinating shipyard supporting, and strengthening the introduction of European and Japanese technological cooperation, among other means. Therefore, South Korean marine equipment industry produces equipment having an advanced technology level with a localization rate of 85%. At the same time, South Korea encourages the cooperation with famous foreign companies, and strives to enhance the core competitiveness of products and brand influence in the world.

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To summarize, the leading foreign marine equipment enterprises have built large-scale, high-quality, and competitive product systems that are equipped with strong technological R&D ability, lean manufacturing ability, and global after-sales service networks. They have always occupied the high-end position in the supporting industry market and led the industry development through the cooperation of the industrial chain among high-precision enterprises.

2.2 Intelligent development of marine equipment in foreign industries

With the development of science and technology, a new generation of technology represented by Internet information, big data, and artificial intelligence is rapidly and profoundly affecting all industries worldwide. Globally, the industries are moving toward information and intelligence. For the shipbuilding industry, with the wide application of network technology and information technology, marine automation mechanical and electrical equipment, power equipment, and electrical systems for communication and navigation are also delving toward the direction of distribution, networking, and intelligence [3]. The development of intelligent ships by the support of intelligent equipment has become the general trend.

In recent years, the International Maritime Organization (IMO), the International Standardization Organization, and other international organizations have considered intelligent ships, as an important subject under discussion. The “e-navigation” strategy promoted by IMO is also supported by ship intellectualization. As the technical rules and standards are becoming increasingly clear, international agencies, including the China Classification Society, have set clear specifications and guidelines, and established specific intelligent ship symbols. The major shipbuilding countries of the world are rapidly promoting the process of ship intelligence and are competing to develop various intelligent ships, related systems, and equipment.

Nowadays, with the development of automation technology and information technology, the information level of the ship power system is relatively high, and digital control has been realized. With features, such as intelligent monitoring and energy efficiency management, the power systems can realize state monitoring of nuclear power equipment, such as those for the main engine and propeller, and some ship types can even realize collaborative control. However, there are many kinds of marine equipment, with a wide range of technical coverage and technical level. Therefore, the degree of digitalization, networking, and intellectualization of supporting equipment is uneven; some equipment still rely on human operation and pose no automation ability. Some equipment preliminarily realizes digitalization by manual issuance of control instructions. Some equipment allow ability for independent analysis and decision-making standby intelligence function. Arguably, China and the developed countries with respect to shipbuilding are basically in the same running line in the field of research on intelligent mechanical and electrical marine equipment. Whoever first breaks through the key technologies of intelligence supporting equipment and creates competitive intelligent supporting equipment could seize the market of intelligent ship matching, under the new situation.

However, under the impact of a new round technological revolution in intelligent ships, the leading international marine equipment companies have started to form strong alliances with automation control companies and are trying to build a new generation of intelligent ship ecosystem to become the strategic suppliers to provide solutions for the future maritime industry, and compete for the market of intelligent ship supporting equipment. For example, in July 2018, Rolls Royce sold its commercial marine business to Kongsberg, including marine equipment division (propulsion system, deck machinery, automatic control system, etc.), ship remote health management system, ship design, and after-sales service business, which represents the birth of a new giant in the field of intelligent ships.

3 Status and intelligent development of marine equipment in Chinese industries

3.1 Status of marine equipment industry in China

In recent years, the shipbuilding industry in China has developed rapidly, occupying the third rank in the world for many years. Two Chinese shipbuilding enterprises are present among the top ten ship enterprises. The global influence of the Chinese enterprises in the ship assembly and construction is growing. However, the domestic marine equipment enterprises have fallen behind in the world, the localization rate of marine equipment is 30%–40%, and even the rate of a high-tech ships is less than 5% [4], which restricts the rapid development of the Chinese shipbuilding industry.

3.1.1 Industry system is unsound and strategic guidance is insufficient.

From the perspective of product distribution and industrial chain layout, the products of the Chinese marine equipment industry include products of deck machinery, a few products of cabin machinery, power plant products, and most outfitting parts, which are monopolized by a few foreign brands in terms of automation systems, ship hatch cover, and other high-tech products. The high-pressure pump, high-precision hydraulic servo control of deck machinery valve, and other core components also rely on imports. Simultaneously, the domestic marine equipment enterprises face issues such as small scale, large number, low integration, and no obvious scale effect. For example, there are 11 low-speed marine machinery manufacturing enterprises in China, whose products are in a homogenous competition pattern. Under the high-pressure competition, these enterprises have been anxious about their survival and regulation. The lack of consistent development strategy, planning, and persistent professionalism, shows that the market competitiveness of these enterprises is not strong.

3.1.2 Insufficient R&D investment and technology accumulation

Being restricted by the industry prospects and enterprise benefits, the Chinese marine ship equipment product and technology systems are not complete, and the innovation mode is still in the follow-up type. The investment in research and development of new technology is not enough, and the proportion of marine engineering equipment and high-tech ship supporting equipment is significantly lower than that of Japan and South Korea, especially in deep-water equipment. At the same time, the tracking mechanism after product delivery is not perfect, and the cycle of new product and traditional product iterative upgradation is long. The accumulation mechanism for R&D knowledge is not perfect, and the technical team is not stable, thereby lacking a strong sustainable development momentum.

3.1.3 Insufficiency in overall solution ability with a weak product competitiveness

Domestic marine equipment enterprises primarily focus on product R&D rather than manufacturing, installation, application, maintenance, and other engineering and technological research. There is a significant gap in the specialized manufacturing capacity and the refined management level between domestic and foreign industries. For example, in product development, there is essentially no means to trace product quality. Once there is a quality problem caused by assembly, the subsequent maintenance cost of equipment is extremely high, which affects a series of indicators, such as enterprise operation cost, production efficiency, product defective rate, etc. Therefore, it is difficult to establish the brand image of products.

3.1.4 Insufficient product service capacity and high maintenance cost

Currently, the service consciousness of domestic enterprises is weak, the global service network is not perfect, and the feedback of service to the industry is not enough. In addition, in terms of fault diagnosis, monitoring, and service support technology, the related technical research and application of domestic products are relatively weak, and a basic environment for their overall application is lacking. Mechanical and electrical equipment operate with the ship, and it is practically impossible to repair them offshore. Their maintenance can only be carried out on the dock, resulting in considerable losses in terms of time and cost. In such a maintenance process, problems such as long repair time and low after-sales efficiency of supporting equipment cannot be avoided.

3.2 Intelligent development needs of marine equipment industry in China

Aiming at the development trend of foreign industry, which is committed at improving the technology R&D ability, lean manufacturing ability, and global after-sales service ability of intelligent products. The domestic marine equipment industry needs to solve the problems of product quality and technology accumulation through the application of intelligent technology, to ensure the success of one-time delivery and high reliability of products. However, the domestic marine equipment industry needs to solve the problem regarding insufficient core competitiveness to reduce the product design cost, manufacturing cycle, and improve the maintenance efficiency. Furthermore, it is necessary to meet the requirements of safety and environmental protection, reduce domestic labor bottleneck, reduce the equipment manufacturing personnel cost, reduce the pressure of equipment operation cost, and develop the equipment with fewer people, low energy consumption, and high efficiency. In order to meet the high-end and personalized requirements under the new situation, we need to provide overall solution for equipment integration, installation, delivery, operation and maintenance support services, and ultimately improving the product quality and competitiveness. Therefore, promoting the transformation and upgradation of ship supporting industries, and achieving the strategic goal of shipbuilding powerhouse.

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4 Countermeasures and prospects for intelligent development of marine equipment

4.1 General course

According to the demand of Made in China 2025 for marine engineering and high-tech ships to become a powerful manufacturing country in the shipbuilding industry by 2025, we should focus on the technical specifications and industrial development needs, face the needs and characteristics of the shipbuilding equipment industry, and take ‘comprehensive digitalization and core intelligence’ as the starting point, to make up for the shortcomings of the industry and promote the intelligent upgrading of equipment as a whole goal. The overall planning and step-by-step implementation would create competitive brand products, form technological brand, industrial chain advantages, comprehensively improve the R&D, core manufacturing, and global service level of the industry.

4.2 Implementation approach

According to the needs of independent design, integrated supporting, core manufacturing, and full life cycle service of marine equipment, we focused on the primary line of breaking through intelligent key technology, creating intelligent manufacturing, and intelligent products by integrating the advantageous resources of the industrial chain, implementing it step by step, and gradually improving the intelligence level of the product research capacity, manufacturing capacity, and service capacity. The implementation approach is shown in Fig. 1. First, take the lead in realizing the digitalization of ship supporting, establish the integrated and interconnected information system in the product development process, and realize the remote monitoring of products. Second, realize the networking of ship supporting based on digitalization, establish the transparent visualization and data-based decision-making environment for the product manufacturing and management. Finally, realize the remote control of products and data-based decision-making and optimization along with digitalization and networking. The ship is equipped with intelligence to realize the prediction and adaptive optimization of an intelligent manufacturing system and to realize unmanned operation, adaptive control, and independent maintenance of equipment.

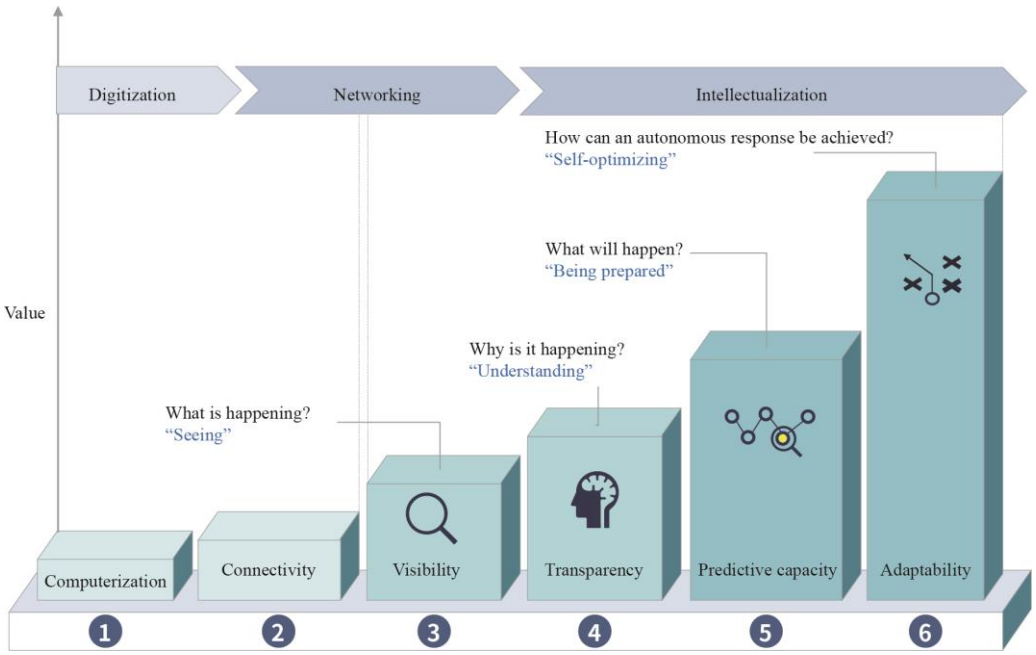

Fig. 1. Implementing approach of intelligent marine equipment.

4.3 Top-Level Architecture

According to the characteristics of the discrete manufacturing industry, a top-level architecture of “1 integrated environment + 3 key directions” digital factory is established, as shown in Fig. 2. “One integrated environment” refers to the establishment of an intelligent integrated environment, data system, and basic environment around the core management and decision-making for the enterprise. The “three key directions” refer to the establishment of

an intelligent virtual design environment, an intelligent lean production environment, and an intelligent digital twin environment for product R&D, manufacturing and service processes. The top-level architecture constructs an industrial cornerstone for the whole product life cycle process and could be realized gradually.

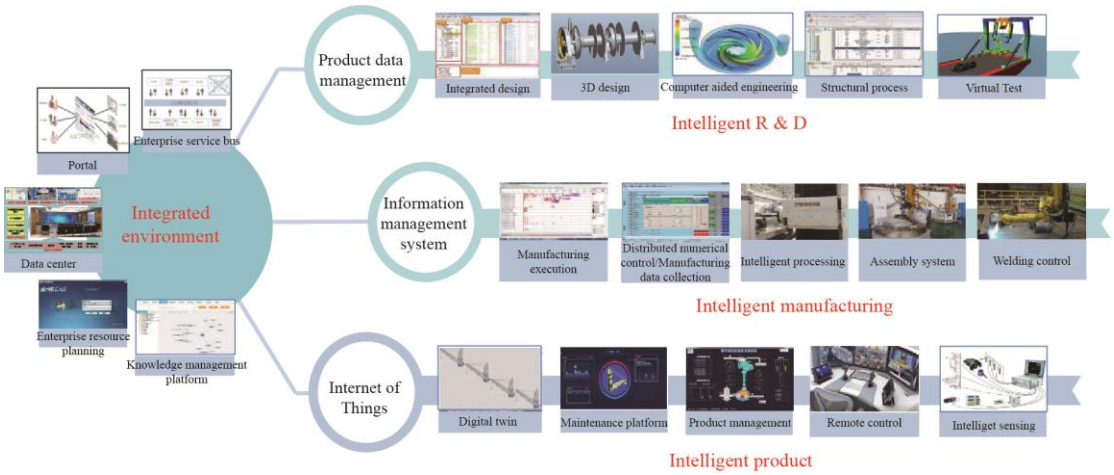

Fig. 2. Top-Level architecture of intelligent marine equipment.

4.3 Development proposal

Upon following the Made in China 2025 strategy, we suggest to focus on the needs of independent design, integrated supporting, core manufacturing, and full life cycle service, focus on the strategic positioning of industrial development, and accelerating the high-quality development process of the Chinese marine equipment industry through advanced intelligent manufacturing technology, thereby greatly improving the industrial capacity.

4.3.1 Project traction, demonstration leading

Considering the national scientific research plan as the strong traction, focusing on the whole process of project implementation, monitoring, evaluation, and improvement, we should strengthen the demonstration and driving of scientific research projects in the industry, and should not only restrict our attention to projects.

4.3.2 Demand comes first, architecture comes first

The carrying out of demand research, taking demand as the guide, integrating multi-field integration (ship, port, shore, etc.), integrating multi equipment integration, and providing overall solutions is suggested to improve the collaborative efficiency. At the same time, reasonable and scientific product architecture (product platform, function module, and system integration) should be established to meet the needs of the market more flexibly based on the idea of decentralization.

4.3.3 Open cooperation, cross-border integration

First, the opening of the industry should be encouraged, product innovation should be promoted with brand and marketing cooperation under the cross-border integration mode to obtain more resources and form greater advantages owing to the strength of open cooperation. Second, by relying on novel technologies and platforms, existing industries and resources should be integrated and utilized through mutual penetration, fusion, or fission to achieve extensions or breakthroughs in the industrial value chain.

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