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Research on Application of Intelligent Manufacturing Technology in Building Industrialization

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ABSTRACT
This paper explores the application of intelligent manufacturing technology in construction industrialization and its impacts. As a key driver for industrial transformation, this technology revolutionizes traditional construction methods, significantly enhancing industrialization levels and efficiency. Core elements include the Internet of Things, big data, cloud computing, artificial intelligence, and robotics. These technologies hold immense potential in construction industrialization. The paper discusses applications such as digital modeling and analysis, intelligent construction robots, prefabricated production models, factory systems, and energy-efficient green manufacturing. It highlights how intelligent manufacturing advances automation, intelligence, and efficiency in building production processes. The article introduces domestic and international cases of intelligent manufacturing in construction industrialization, summarizing achievements in efficiency, cost reduction, and quality assurance. Challenges include technology integration, talent training, policies, standards, and more. Targeted strategies and suggestions are proposed to address these issues.

KEYWORDS
Intelligent manufacturing technology; Construction industrialization; Application research

1 Xu theory

In the Industry 4.0 era, intelligent manufacturing technology rapidly transforms traditional manufacturing. The construction industry, a vital economic pillar, requires urgent upgrading. Construction industrialization, focusing on standardized design, prefabricated production, assembly, and information management, aims to modernize. Intelligent manufacturing, leveraging IoT, big data, cloud computing, AI, and robotics, enhances construction processes, boosting efficiency, quality, and reducing costs and energy consumption. This paper delves into intelligent manufacturing's application in construction industrialization, examining its benefits, challenges, and strategies. Core elements and application value are summarized, with discussions on digital modeling, intelligent construction, prefabrication, and green manufacturing. Case studies highlight successful experiences. Coping strategies and suggestions address current challenges[1].

2 Overview of intelligent manufacturing technology

2.1 Definition and development of intelligent manufacturing technology

Intelligent manufacturing integrates IT, automation, AI, and other advanced technologies to achieve smart, automated, and efficient product lifecycle management, from design to sales. Originating in the US in the 1980s, it has gained global popularity due to computer and network advancements. In the 21st century, IoT, big data, and cloud computing have brought unprecedented opportunities, making intelligent manufacturing a key driver of global industrial transformation and upgrading.

2.2 Analysis of the key technologies of intelligent manufacturing technology

2.2.1 Internet of Things technology

The Internet of Things technology connects objects in the physical world with the Internet through sensors, RFID (RF identification) and other devices to realize the real-time collection, transmission and processing of information. In the industrialization of construction, the Internet of Things technology can be applied to the tracking and management of building components, environmental monitoring of the construction site and equipment failure warning, so as to improve the transparency and controllability of the production process[2].

2.2.2 Big data technology

Big data technology refers to the technology of storing, processing and analyzing massive data. In building industrialization, big data technology can be applied to the performance analysis of building materials, the optimization

of production process and the prediction of building energy consumption. By mining and analyzing the valuable information in the big data, enterprises can more accurately grasp the market demand, optimize the production process, and improve the production efficiency.

2.2.3 Cloud computing technology

Cloud computing technology is an Internet-based computing method, through which the huge computing processing program is automatically divided into countless smaller subroutines, and then handed over to the huge system composed of multiple servers after search and computing analysis to send the processing results back to users. In the industrialization of buildings, cloud computing technology can be applied to the storage and sharing of building information models, real-time analysis of production data and remote collaboration, so as to improve the synergy and flexibility of the production process[3].

2.2.4 Artificial intelligence technology

Artificial intelligence technology refers to the intelligence of a system made by people. In the industrialization of buildings, artificial intelligence technology can be applied to the intelligence of architectural design, the automatic control of production process and the intelligent management of building energy consumption. Through the introduction of artificial intelligence technology, enterprises can realize the intelligent decision-making and optimization of the production process, and improve the production efficiency and product quality.

2.2.5 Robotics Technology

Robotics is a machine device that can perform its work automatically. In the industrialization of construction, robot technology can be applied to the automatic production of building components, the automatic construction of the construction site and the automatic recovery of construction waste. By introducing robotics technology, enterprises can significantly reduce production costs and human resource consumption, and improve production efficiency and safety[4].

3 The Integration of construction industrialization and intelligent manufacturing technology

3.1 Definition and development trend of construction industrialization

Construction industrialization employs advanced manufacturing and scientific management to transform traditional manual construction into mechanized, automated production, enabling standardized design, prefabricated production, and assembly construction. Its goal is to enhance production efficiency, quality, while reducing costs and resource consumption through factory production and on-site assembly. Trends include: rising popularity of standardized design for building components, improving prefabricated component production technology with automation and intelligent lines, innovating assembly techniques for efficiency and accuracy, and enhancing information management with IoT and big data for real-time monitoring. These advancements support sustainable development and meet urbanization demands[5].

3.2 The application value of intelligent manufacturing technology in construction industrialization

3.2.1 Improve the production efficiency

Intelligent manufacturing technology through the introduction of automatic production lines, robots and other equipment, to achieve the efficient and accurate production of building components. For example, the use of CNC intelligent steel truss welding machine, CNC intelligent steel bending machine and other equipment, can greatly improve the production efficiency and quality of steel processing. At the same time, the remote monitoring and intelligent scheduling of production equipment are realized through the Internet of Things technology, which can further optimize the production process and reduce the waste of waiting time and resources. According to statistics, after the introduction of intelligent manufacturing technology, the production efficiency of building components can be increased by more than 30%[6].

3.2.2 Reduce the production cost

The application of intelligent manufacturing technology helps to reduce the production cost of construction industrialization. On the one hand, through the efficient production of automated production lines, robots and other

equipment, manual intervention and error can be reduced, and the rejection rate and rework cost can be reduced. On the other hand, through the deep mining and analysis of the production data through the big data analysis technology, we can find out the key factors affecting the production cost and take corresponding improvement measures. In addition, intelligent manufacturing technology can also achieve customized production of building components, avoid inventory overstocking and overproduction, and further reduce storage costs and scrap rates.

3.2.3 Improve product quality

The application of intelligent manufacturing technology in construction industrialization plays a significant role in improving product quality. On the one hand, the high-precision processing capacity of automatic production lines and robot equipment can ensure that the dimensional accuracy and surface quality of building components meet the design requirements. On the other hand, the real-time monitoring and early warning of the production process are realized through the Internet of Things technology, which can find and solve the potential quality problems in time to ensure the stability and consistency of product quality.

4 The specific application of intelligent manufacturing technology in the construction industrialization

4.1 Intelligent construction and robot technology

4.1.1 Application of intelligent instrument in construction

Intelligent instruments acquire, process, transmit, and display data, crucial for construction monitoring. They provide real-time support, such as full-station monitoring for elevation, angle, and distance to ensure accuracy, and environmental monitors for temperature, humidity, and PM2.5 to ensure safety. These instruments also control machinery, automating processes: intelligent cranes adjust boom height and angle, while excavators adapt excavation strength and speed to soil hardness[7].

4.1.2 Advantages and challenges of robotic production

Robotic technology utilizes robotic equipment in construction industrialization, offering high precision, efficiency, and quality in production and construction. It adapts to complex environments, reduces risks, and enables 24/7 operations, shortening timelines and lowering costs. However, challenges include high costs for R&D and purchase, the need for skilled professionals for operation and maintenance, and the need to improve adaptability in complex environments. Addressing these issues is crucial for the widespread adoption of robotic technology in construction.

4.2 Prefabricated production and factory mode

4.2.1 Production and application of prefabricated components

Prefabricated members refer to the building members pre-made in the factory, such as prefabricated beams, prefabricated boards, prefabricated walls, etc. These components have the advantages of accurate size, stable quality and convenient construction. In the production process of prefabricated components, advanced production equipment and technology can be used, such as automatic production line, CNC cutting machine, welding machine, to improve production efficiency and product quality. Prefabricated components have a wide range of applications and can be used in residential, commercial buildings, public facilities and other fields. Through the use of prefabricated components, the construction cycle can be shortened, the construction difficulty and cost can be reduced, and the quality and safety of construction products can be improved.

4.2.2 Optimization of factory production mode

Factory production mode refers to that the production process of building components is concentrated in the factory to realize the standardization, process and automation of the production process. This production mode has the advantages of high production efficiency, stable product quality and strong cost control ability. In the optimization of factory production mode, the Internet of Things and big data in intelligent manufacturing technology can be introduced. Through the Internet of Things technology, the operation status of the production equipment and the data information of the production process can be monitored in real time, providing a basis for production management and optimization. Through the big data technology, the production data can be deeply mined and analyzed to find out the bottlenecks and

problems in the production process, and the improvement measures and optimization schemes can be put forward[8].

4.3 Energy conservation, environmental protection and green manufacturing

4.3.1 Automatic energy-saving and consumption-reduction measures

Automatic energy-saving measures in building product production and construction involve using automation technology to reduce energy consumption and emissions. Prefabricated component production can employ automated lines and CNC equipment, while construction sites can use intelligent lighting and temperature control systems. Additionally, companies can introduce energy management and intelligent monitoring systems to real-time track energy use, suggesting improvements and optimization strategies for energy efficiency.

4.3.2 Research and development of green building materials

Green building materials are eco-friendly, energy-saving, and renewable. They reduce energy consumption, carbon emissions, and enhance indoor environments. Intelligent manufacturing technology has advanced their development, including materials with efficient thermal insulation, soundproofing, fire resistance, and eco-friendly renewables. These green materials improve building products' environmental performance and sustainability, fostering the construction industry's green development.

5 Challenges and countermeasures faced by intelligent manufacturing technology in the construction industrialization

5.1 Challenges faced by intelligent manufacturing technology in construction industrialization

5.1.1 Technology Convergence and innovation

Technology convergence in construction faces bottlenecks due to data sharing issues and inconsistent standards, limiting intelligent construction technology's application. Achievement transformation is hindered by lack of unified standards and evaluation systems. Financial investment is crucial for R&D, but construction enterprises often face funding shortages, affecting innovation enthusiasm and technology promotion. Additionally, most basic software used in China, like drawing, finite element, and BIM software, are foreign and incompatible with local standards, reducing their practicability.

5.1.2 Training and introduction of talents

Intelligent construction technology requires interdisciplinary talents. Traditional training by categories and majors is challenging to adapt, and interdisciplinary training is not yet established. There's a lack of excellent teachers in intelligent construction, as most professionals are in industry. University teachers often come from related fields, causing a shortage. Teaching materials and curriculum resources are insufficient due to the major's novelty and rapid technology updates.

5.1.3 Preparation of policies, regulations and standards

The lack of unified technical standards and evaluation systems poses challenges in evaluating and applying intelligent construction technology, which spans multiple fields. Policies and regulations, though promoted by national and industry authorities, provide insufficient support. For instance, unclear fee standards and capital guarantee policies dampen enterprise innovation enthusiasm. Additionally, standardization of intelligent construction technology faces hurdles due to its significant differences from traditional methods, demanding higher digitalization, refinement, mechanization, and efficiency in the construction process.

5.2 Coping strategies and suggestions

5.2.1 Strengthen technology integration and innovation

We should promote the integration of enterprises, universities and research institutes, and establish a cross-professional and cross-industry collaborative innovation system led by large central enterprises, state-owned enterprises or private enterprises in the construction industry, and with the participation of software developers, manufacturing enterprises, universities and research institutes. Guided by practical engineering problems, it organizes a multi-disciplinary research and development team to develop a three-dimensional graphics engine and platform with China's

independent intellectual property rights and BIM software that meets China's construction needs. Through the breakthrough in core technologies, a number of core technologies and key high-end equipment, such as data collection and analysis, intelligent control and optimization, new sensing and perception, engineering quality detection and monitoring, fault diagnosis and maintenance. Research and development of intelligent digital design technology to solve the current engineering design low efficiency, long cycle, manpower input, high error rate.

5.2.2 Optimization of talent training and introduction

We should improve the training system, improve the training system for junior college and undergraduate personnel, and improve the training program for technical and technical personnel. By increasing the setting of professional points, improving professional teaching materials and course resources, strengthening the practice and training links, and cultivating the team of "double teacher and double ability" teachers, the career development channel of talents will be unblocked and the growth space of intelligent construction technical and skilled talents will be expanded. Constantly strengthen school-enterprise cooperation, promote the cooperation between universities and enterprises, establish practice and training bases, and provide students with practice opportunities. We should introduce high-end talents, increase the introduction of high-end talents, provide favorable treatment and a good working environment, and attract domestic and foreign outstanding talents to participate in the field of intelligent construction.

5.2.3 Improve the formulation of policies, regulations and standards

Unified standards must be formulated, and the state and the competent authorities of the industry should introduce the system construction standards of intelligent construction to promote the standardization and standardized development of intelligent construction. The direction and goal of the coordinated development of intelligent construction and industrialization should be clarified, and unified technical standards and evaluation system should be formulated. Policy support should be strengthened, and unified fee collection standards and fund guarantee policies should be formulated to provide strong support for the research, development and application of intelligent construction technologies. Through the cooperation and exchanges with international organizations, to enhance the international competitiveness of China's intelligent construction technology.

6 Research conclusions and prospects

6.1 Study Conclusion

The integration and innovation of intelligent manufacturing technology is the key to promote the process of building industrialization. Through the introduction of advanced technologies such as the Internet of Things, big data and artificial intelligence, the construction industrialization can realize the intelligence, automation and refinement of the production process, so as to improve the production efficiency and product quality. Talent training and introduction are an important basis to support the application of intelligent manufacturing technology in construction industrialization. At present, the training scale of intelligent construction professionals in China is too small, and the supply is difficult to meet the practical demand.

Therefore, it is necessary to improve the talent training system, strengthen the cooperation between schools and enterprises, and cultivate compound talents with the ability of multidisciplinary integration. The formulation of policies and regulations and standards is a necessary condition to ensure the smooth application of intelligent manufacturing technology in construction industrialization. The government should issue relevant policies and regulations to clarify the fee collection standards and fund guarantee policies for intelligent construction technology, so as to provide strong support for the research and development and application of the technology.

6.2 Research outlook

Technological innovation and application will be further deepened. Intelligent construction technology will be more intelligent, automated and integrated, and realize the digital management of the whole life cycle of the building. Industrial chain integration and coordination will be more close. Intelligent manufacturing technology will promote the integration and coordination of the construction industry chain, and form a more efficient and collaborative industrial chain ecology. Green construction and sustainable development will become an important direction. Intelligent construction will pay more attention to energy conservation and emission reduction, resource recycling and environmental protection requirements, and promote the development of the construction industry to a greener, smarter and more sustainable direction.

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