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Research on the Application of Artificial Intelligence Technology in Mechanical Design and Manufacturing

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Abstract: As a product of the new century, artificial intelligence has been continuously developed and advanced. It has been applied to many fields, especially in the field of mechanical design and manufacturing. With the support of artificial intelligence, mechanical design and manufacturing can not only reduce input costs but also significantly reduce the demand for labor, playing a positive role in improving the design efficiency and quality of mechanical manufacturing [1]. This paper studies how to apply artificial intelligence technology to the mechanical design and production process to achieve greater application and development.

Keywords: Artificial intelligence technology; Mechanical design and manufacturing; Application research

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1. Introduction

The rapid development of artificial intelligence has brought new development opportunities and challenges to the manufacturing industry. The application of artificial intelligence in enterprises can not only improve production efficiency but also promote enterprise innovation and product quality improvement, thus promoting the sustainable development of enterprises [2]. Nowadays, machine design and manufacturing enterprises can achieve a more intelligent and flexible production mode through artificial intelligence technology. This paper conducts an in-depth analysis of the application of artificial intelligence in the field of mechanical design and manufacturing, including its current application status and future development direction. Based on artificial intelligence, it explores aspects such as design optimization, production automation, and quality control. This paper also elaborates on its specific applications in mechanical design and manufacturing from three perspectives: supply chain management, equipment maintenance, and human-machine interaction [3]. In addition, this paper focuses on the development trends in fields such as artificial-intelligence-assisted design, collaborative robots, and quantum computing. The

application of blockchain and sustainable development are two trends that will profoundly affect this field.

2. Significance of the application of artificial intelligence technology in mechanical design and manufacturing

2.1. Promoting the transformation of the mechanical design and manufacturing industry

In the 1930s, Western developed countries had already applied intelligent technology to mechanical manufacturing. Compared with foreign countries, China started relatively late in the research of machine design and manufacturing. Only a small number of regions still adopt traditional design and production methods. In the design and production of mechanical products, it mainly relies on human labor, which seriously restricts the development of the industry. Since the new century, China has made great progress in the economy and science and technology. Under such circumstances, artificial intelligence technology has also been widely applied to mechanical design and production [4]. After the introduction of artificial intelligence, China's machine-building industry has reached a new height. As a manufacturing power, China needs to actively introduce artificial intelligence and explore its resources to comprehensively achieve industrial transformation and upgrading, promote industrial development, and keep China's manufacturing industry at the forefront of the world for a long time [5].

2.2. Reducing labor costs and improving production efficiency

Traditional mechanical design and manufacturing methods mainly rely on human labor. However, with the help of artificial intelligence technology, not only is the labor cost greatly reduced, but also the productivity is significantly improved. This is the goal and use of artificial intelligence technology [6]. In the mechanical design and production industry, labor costs account for a large proportion, sometimes even exceeding the cost of raw materials, causing great economic pressure on enterprises. With the development of artificial intelligence technology, enterprises can use a large number of human resources to purchase intelligent products, which not only reduces the economic burden of enterprises but also increases their profits. Modern machine design and production no longer require a large amount of human labor. Technicians only need to prepare the program in advance, input it into the artificial intelligence system, and then load the raw materials and parts to be processed. The intelligent device can operate automatically without 24-hour monitoring. If a fault occurs during operation, the system will immediately issue an alarm and alert the manager. Even the system can accurately locate the fault, analyze it, and come up with corresponding solutions to prevent the further expansion of the accident [7]. Machines designed based on artificial intelligence are even more accurate than handmade ones.

2.3. Optimizing the design and manufacturing process

In the field of modern machine design and manufacturing, the complexity of the process and the huge demand for human labor make efficiency and accuracy crucial. According to statistics, the human error rate in traditional manufacturing processes is as high as 5–10%, which not only affects product quality but also increases costs and time consumption. To overcome these challenges, the application of artificial intelligence (AI) technology has become an important means to improve production efficiency and reduce the error rate. The integration of AI technology has significantly optimized the design and manufacturing process. For example, AI can automatically optimize the processing path, predict equipment failures, and adjust parameters to improve the processing quality of parts. Research shows that the optimization of the design and manufacturing process with the help of AI is as shown in **Table 1**. From the table, it can be seen that the manufacturing process time can be reduced by 30%,

and the quality defect rate can be reduced by 50%. In addition, the application of AI in the design stage is also becoming increasingly important. Through machine learning and bionic design, AI can help designers predict product performance, optimize design parameters, and even generate new design schemes. A study shows that AI-assisted design can improve design efficiency by 60% and significantly enhance product performance [8]. In China, with the advancement of the "Made in China 2025" strategy, large-scale machine-tool manufacturers are actively adopting AI technology [9]. According to data from the China Machinery Industry Federation, as of 2023, more than 80% of large-scale machine-tool enterprises have introduced AI technology into their production processes, and this number is expected to increase by 30% in the next five years.

Table 1. Optimization effects of the design and manufacturing process

Application field	Optimization effect	Data source
Processing path optimization	Reduces time consumption by 30%	Research and analysis
Fault prediction and prevention	Reduces the quality defect rate by 50%	Research and analysis
Application in the design stage	Improves design efficiency by 60%	Research and analysis
Product performance enhancement	Enhances product performance	Statistics
AI application rate in domestic large-scale machine-tool enterprises	80% have applied AI technology	Data from the China Machinery Industry Federation
Expected growth rate of application in the next five years	Increases by 30%	Forecast data

3. Specific applications of artificial intelligence technology in mechanical design and manufacturing

3.1. Application of fuzzy inference technology

In an artificial intelligence system, fuzzy inference technology can simulate human thinking to judge and process data. Its analysis and processing speed far exceed that of the human brain, and it can also make better responses [10]. The information processed by fuzzy methods can be automatically integrated and transformed with the subject knowledge, ensuring the accuracy and reference value of the transmitted data. Fuzzy inference is currently a hot topic in artificial intelligence research. The complex data-analysis ability of fuzzy inference technology can quickly and accurately analyze and process a large amount of relevant data information in the mechanical design and manufacturing process. On this basis, using intelligent algorithms to analyze and process the data can better ensure product accuracy and lay a foundation for improving the design and manufacturing quality of mechanical products. Fuzzy inference technology has been used to describe the mechanical design and manufacturing process [11]. However, at present, there is still much room for improvement in the stability of system connectivity for fuzzy inference technology, which will be the main research direction for the application of artificial intelligence in the field of mechanical design and manufacturing in the future.

3.2. Application of neural network technology

First, using the neural network technology in the current field of artificial intelligence, data information can be uploaded to the network in a short time, and the storage, dissemination, and sharing of data information can be completed in a short time. Second, neural network technology can analyze data dynamically. In machine design and manufacturing, it mainly processes relevant data information quickly and accurately, and converts it into

machine operation instructions, enabling the automation of machine operations. Third, neural network technology, to some extent, simulates the human nervous system. With its neural response ability, it can automatically extract and process the results of data analysis. At the same time, it can also store and protect data about the human body. Just like our body, it relies on its powerful nervous system to perceive instructions, remember these commands, and then act according to them. At present, neural network technology is mainly used in the design and production of mechanical equipment [12]. In the processing process, artificial neural networks are used for process parameter evaluation and error prediction, and artificial neural networks are also used for error compensation in mechanical design and manufacturing. In the design and processing of parts, the method of artificial neural networks is used to guide the design of gear CD, shape, size, etc [13]. On this basis, a new strength design method has been proposed. At the same time, it improves production efficiency and quality while reducing potential economic losses.

3.3. Application of automatic identification technology

In mechanical design and production, traditional controllers generally perform dynamic control by modeling and then using dynamic equations. However, due to the complexity of its dynamic equations, in some mechanical design and production fields, it cannot meet the operating conditions required by the dynamic equations or the requirements of the system. In addition, the application range of traditional dynamic equations is not wide, and the early-warning judgment of mechanical project accidents is not reasonable and accurate enough. Applying artificial intelligence and automatic identification technology to mechanical design and manufacturing can monitor the relevant parameters of electromechanical equipment in real-time. When abnormal parameters are detected, the alarm device will be automatically activated, and the equipment will be shut down automatically [14]. After receiving the alarm, employees immediately turn off the power and conduct inspections. This system not only provides a safe working environment for employees but also ensures the rapid detection and processing of abnormal data. At the same time, by combining automatic identification, laser scanning, and ultrasonic detection, in the mechanical design and manufacturing process, the measured object can be accurately identified and combined with modern computer systems to complete corresponding commands. On this basis, a fuzzy-mathematics-based model has been proposed and improved.

3.4. Application of fault diagnosis technology

The failure problems that occur during the normal operation of mechanical equipment have become an important factor restricting production efficiency and quality. Therefore, it is particularly important to conduct fault diagnosis during the mechanical design and manufacturing process. Applying the fault diagnosis technology of artificial intelligence to the design and production of mechanical products can quickly and accurately locate the fault. On the other hand, it can efficiently troubleshoot the fault based on accurate fault warnings and assist in fault handling, reducing the costs caused by equipment failures and improving the operation efficiency and quality of the equipment. At the same time, using artificial intelligence technology to collect, analyze, summarize, remember, and store the relevant fault information and cases in the mechanical design and manufacturing process can further improve the speed and accuracy of fault early warning and recovery. In mechanical processing design, it is usually the user who issues a real-time monitoring command to the system through human-machine dialogue. After receiving the command, the system will combine it with the data information in the database, accurately analyze it, and determine the content of the command [15]. Subsequently, based on the diagnosis result, the system will automatically compare the command with the relevant case information in the database for accurate diagnosis, find

out the problem, and put forward suggestions for solving the problem. At this time, the user can correct or handle the fault according to the system's judgment and recommendations. On the one hand, it can reduce the costs of wrong handling and maintenance. At the same time, the research results of this project will further improve the convenience and efficiency of equipment fault diagnosis and handling, thereby achieving the goals of improving equipment operation efficiency and ensuring operation quality.

4. Conclusion

Artificial intelligence is a product of the new era and has been widely applied to domestic mechanical design and production. Its introduction plays a positive role. The emergence of artificial intelligence is not only a transformation of the mechanical design and manufacturing industry, but more importantly, it can reduce labor costs, improve production efficiency, and optimize the design and manufacturing process. At present, artificial intelligence has been widely used in the design of mechanical products, the process design of parts, the design and control of numerically-controlled machine tools, and has been studied in the production and processing of mechanical products and enterprise investment decisions. To better utilize the advantages of artificial intelligence, enterprises need to make preparations in advance, improve mechanical design and production plans, and ensure high-quality software and hardware.

Disclosure statement

The author declares no conflict of interest.

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