

Exploration of Mechanical Design Technology Based on Intelligent Manufacturing Requirements

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Abstract: With the continuous progress of science and technology and the rapid development of industry, mechanical design, as one of the core fields of modern manufacturing, has become increasingly important. Especially in the context of intelligent manufacturing, mechanical design technology is facing new challenges and opportunities. At this time, intelligent manufacturing, as a technology that combines traditional mechanical manufacturing processes with modern industrial technology, can improve production efficiency, product quality, and flexibility through highly automated, intelligent, and integrated production methods. Therefore, mechanical design technology must keep up with the pace of the times, constantly innovate and develop to meet the requirements of intelligent manufacturing. Therefore, this article explores the mechanical design technology required by intelligent manufacturing, hoping to be helpful to readers.

Keywords: Requirements for Intelligent Manufacturing; Mechanical Design; Technical Exploration

1. Introduction

Intelligent manufacturing, as a new manufacturing model in the new era, is gradually replacing some manual operations and inefficient processes in traditional manufacturing. Through the combination of modern technologies such as information technology, artificial intelligence, big data, and cloud computing, it achieves the intelligence of equipment, automation of processes, and refinement and transparency of manufacturing processes. In the development process of intelligent manufacturing, mechanical design technology plays an increasingly important role as the core of support and implementation. In order to adapt to the new production mode

of intelligent manufacturing, mechanical design technology needs to comprehensively innovate and adjust its methods, tools, and techniques. Especially in the fields of automation, digitization, and intelligent design, how to improve design quality, shorten development cycles, and adapt to large-scale customized production has become an important issue that urgently needs to be addressed in the field of mechanical design.

2. Requirements of Intelligent Manufacturing for Mechanical Design

2.1 Highly Integrated and Intelligent Design

One of the requirements of intelligent manufacturing for mechanical design is to achieve high integration and intelligent design, which requires mechanical design not only to meet the functional requirements of products, but also to be seamlessly integrated into intelligent manufacturing systems to achieve automation and intelligence of production processes. For example, in the design process, technologies such as computer-aided design (CAD) and computer-aided engineering (CAE) need to be used to achieve functions such as 3D modeling, virtual assembly, and mechanical analysis. These technologies can help designers gain a more intuitive understanding of the structure and appearance of products, identify potential design issues in advance, and optimize design solutions through simulation^[1]; In addition, intelligent manufacturing also requires mechanical design to have self-learning and optimization capabilities, continuously adjusting design parameters through big data analysis and artificial intelligence algorithms to achieve optimal performance goals.

2.2 High Precision and High-Quality Manufacturing Standards

Intelligent manufacturing also requires mechanical design to achieve extremely high

precision and consistency in specifications, dimensions, material selection, and other aspects to ensure the stability and reliability of products in intelligent manufacturing systems. For example, in the field of precision machining, intelligent manufacturing requires mechanical design to achieve micrometer or even nanometer level machining accuracy, which requires fine design and optimization of machining methods, fixtures, measuring tools, etc. in mechanical design; At the same time, intelligent manufacturing also requires mechanical design to meet high-quality standards in material selection, heat treatment, surface treatment, and other aspects to ensure the wear resistance, corrosion resistance, and service life of products.

2.3 Flexibility and Scalability Design

The requirements of intelligent manufacturing for mechanical design also emphasize flexibility and scalability design, because nowadays with the continuous changes in market demand and the increasing demand for personalized customization, mechanical design needs to have the ability to quickly respond to market changes. So this requires mechanical design to adopt modular design thinking, decomposing the product into several functional modules, each module having independent functions and interfaces. During design, different modules can be selected and combined according to user needs to quickly generate products that meet specific requirements; In addition, intelligent manufacturing also requires mechanical design to have scalability, that is, the ability to expand or reduce functions by adding or reducing modules without changing the overall structure [2]. This requires mechanical design to have a high degree of standardization and normalization in interface design, communication protocols, data structures, and other aspects to ensure seamless integration and collaborative work between different modules.

3. Development Trends of Mechanical Design Technology

3.1 Precision, Intelligence, and Multifunctionality

One of the development trends of mechanical design technology is precision, intelligence,

and multifunctionality. The development of precision technology can enable mechanical products to provide more accurate and reliable performance, meeting the market's demand for high-precision and high-quality products; The development of intelligent technology integrates advanced sensors, control systems, and algorithms to enable mechanical products to have the ability of self-learning, autonomous decision-making, and autonomous execution, thereby improving production efficiency and flexibility; The development of multifunctional technology integrates multiple functional modules to provide mechanical products with more functions and uses, meeting the diverse needs of the market. For example, in the field of intelligent manufacturing, the application of precision machining technology, laser machining technology, CNC machining technology and other precision technologies enables mechanical products to achieve micrometer or even nanometer level machining accuracy, meeting the production needs of high-precision components; At the same time, the application of intelligent technologies such as intelligent robots and intelligent production lines enables mechanical products to independently complete complex production tasks, improving production efficiency and flexibility; In addition, the application of multifunctional technologies such as multifunctional machine tools and multifunctional machining centers enables mechanical products to simultaneously complete multiple processing tasks, improving production efficiency and resource utilization.

3.2 Modular Design

Modular design, as another important development trend in the field of mechanical design, mainly involves decomposing the product design and manufacturing process into multiple modules, each with independent functions and interfaces, in order to achieve rapid product design, manufacturing, and upgrading. This design method can not only improve the maintainability and scalability of the product, but also reduce production costs and cycles. In the context of intelligent manufacturing, the application of modular design is becoming increasingly widespread. For example, in smart factories, modular production lines can quickly adjust their layout and configuration according to production

needs, achieving flexible production; Secondly, modular design can also reduce waste and loss in the production process, improve resource utilization and production efficiency; Finally, modular design can promote standardized and serialized production of products, reducing production costs and cycles.

4. Application Strategy of Intelligent Manufacturing Technology in Mechanical Design

4.1 Deep Integration of Intelligent Design Software and Simulation Technology

One of the application strategies of intelligent manufacturing technology in mechanical design is the deep integration of intelligent design software and simulation technology. Intelligent design software, such as computer-aided design (CAD) and computer-aided engineering (CAE), can provide powerful support for mechanical design through modeling, simulation, and optimization functions. Designers can use these software for 3D modeling, mechanical analysis, thermal analysis, fluid analysis, etc. to obtain accurate design and performance parameters; At the same time, intelligent design software also has functions such as automated design, parametric design, and optimized design, which can greatly improve design efficiency and quality, and reduce errors in the design process^[3]. For example, finite element analysis (FEA) technology can simulate and analyze mechanical structures in terms of stress, fatigue, and vibration, providing scientific basis for optimized design. Moreover, through the deep integration of intelligent design software and simulation technology, designers can fully consider the actual working conditions and service life of the product during the design phase, ensuring that the designed product has high reliability and performance.

4.2 Integrated Application of Intelligent Manufacturing Equipment and Automated Production Lines

The application strategy of intelligent manufacturing technology in mechanical design also includes the integrated application of intelligent manufacturing equipment and automated production lines, because in intelligent manufacturing equipment such as

CNC machine tools, industrial robots, intelligent sensors, etc., through sensors, control systems, and automation technology, the processing, assembly, and testing of mechanical components can be achieved. For example, CNC machine tools can achieve high-precision machining of parts using computer control systems and sensor technologies. Industrial robots can complete tasks such as material handling, assembly, welding, and spraying on automated production lines, greatly improving production efficiency and product quality; In addition, intelligent manufacturing equipment also has self diagnosis and fault warning functions, which can issue timely alarms and provide fault handling suggestions when equipment malfunctions, thereby reducing production downtime and maintenance costs.

4.3 Real Time Monitoring and Optimization of Intelligent Detection and Control Technology in the Production Process

The application strategy of intelligent manufacturing technology in mechanical design also involves real-time monitoring and optimization of intelligent detection and control technology in the production process. Among them, intelligent detection technology monitors the working status of mechanical systems in real time through sensors, signal processing, and data analysis, ensuring that equipment operates in the best state.

Case: Real time monitoring and optimization in Sany Heavy Industry's intelligent factory

As a leading enterprise in China's construction machinery industry, Sany Heavy Industry's intelligent factory widely applies intelligent detection and control technology in the production process. Taking Sany Heavy Industry's "Factory 18" as an example, the factory simulates the production process in the product design stage through digital twin technology, and discovers and solves potential problems in advance. On the production line, intelligent detection and control technology has played an important role^[4].

In the welding workshop, Sany Heavy Industry has adopted an automated welding production line and equipped it with an intelligent detection system. This system can monitor key parameters such as temperature and pressure in real-time during the welding process to ensure stable welding quality. It is hoped that through

data analysis, welding parameters such as welding current and welding speed can be automatically adjusted to meet the welding needs of different materials. The application of these technologies has reduced the welding defect rate by 30% and increased production efficiency by 20%. Moreover, in the assembly workshop, Sany Heavy Industry can also use industrial robots and automated assembly lines, and is equipped with intelligent visual inspection systems. The system utilizes high-precision cameras and image processing technology to monitor and identify components in real-time during the assembly process, ensuring the accuracy and consistency of the assembly. Through data analysis, the system can automatically adjust the assembly sequence and force to meet the assembly requirements of different products. The application of this technology can reduce assembly error rates by 40% and increase production efficiency by 15%^[5].

Table 1. Real Time Monitoring and Optimization Effect Data of Sany Heavy Industry Intelligent Factory

Monitoring and optimization process	Data before monitoring and optimization	Monitoring and optimized data
Welding defect rate	5%	3.5%
Welding production efficiency	80%	96%
Assembly error rate	2%	1.2%
Assembly production efficiency	75%	90%

From Table 1, it can be seen that the real-time monitoring and optimization of intelligent detection and control technology in the production process have brought significant improvements in production efficiency and product quality to Sany Heavy Industry. The application of these technologies can not only improve the automation and intelligence level of the production line, but also bring more competitive advantages to the enterprise.

5. Conclusion

In summary, intelligent manufacturing has raised higher requirements for mechanical design and provided new opportunities for the development of mechanical design technology. For example, through the deep integration of intelligent design software and simulation technology, the integrated application of intelligent manufacturing equipment and automated production lines, and the real-time monitoring and optimization of intelligent detection and control technology in the production process, mechanical design technology can be comprehensively upgraded to achieve full chain intelligence from design to manufacturing. These application strategies can not only improve production efficiency, but also reduce production costs, ultimately achieving the goal of enhancing product quality and market competitiveness.

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