

The Application Research of Simulation Technology in Mechanical Design and Manufacturing

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Abstract: With the rapid development of technology, the application of simulation technology in the field of mechanical design and manufacturing is becoming increasingly widespread. This paper briefly introduces simulation technology, analyzes its application in mechanical design and manufacturing, and proposes some effective measures to enhance the application of simulation technology. The aim is to provide theoretical support and technical guidance for practical applications in related fields, and to promote the innovative development of the mechanical design and manufacturing industry.

Keywords: simulation technology; mechanical design and manufacturing; application

Introduction

Mechanical design and manufacturing, as a core component of the modern industrial system, directly affect the overall competitiveness of the manufacturing industry. Currently, traditional methods of mechanical design and manufacturing are struggling to meet the modern industry's pursuit of efficiency, precision, and cost-effectiveness. Therefore, exploring new technological means to optimize the mechanical design and manufacturing process and improve product performance has become a hot research topic. Simulation technology, as an advanced technology based on computer simulation, has broad application prospects in the field of mechanical design and manufacturing because it can predict product performance in the design phase, optimize design schemes, and reduce testing costs.

1. Overview of Simulation Technology

Simulation technology, as an interdisciplinary and comprehensive technology, plays an increasingly important role in the development of modern science and technology. It integrates knowledge from various disciplines such as computer science, mathematics, and physics to construct virtual systems or environments that simulate the operation processes of the real world, thereby providing powerful support for research, education, industry, and other fields. (1) From a definition perspective, simulation technology refers to a technical means of using computers or other specialized simulation devices to simulate certain phenomena or processes in the real world for the purpose of prediction, analysis, and optimization. The core of this technology lies in constructing a highly realistic virtual model that can reflect the basic characteristics



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and behavioral patterns of the real system. (2) The application scope of simulation technology is extremely wide. In the field of scientific research, simulation technology is used to explore unknown areas, validate scientific hypotheses, and optimize experimental schemes. For example, in physics, researchers can use simulation technology to simulate complex processes such as particle collisions and cosmic evolution; in biology, simulation technology can help researchers simulate processes such as the growth, reproduction, and spread of diseases in organisms. In the field of education, simulation technology provides strong support for practical teaching by simulating real operating environments, allowing students to practice under safe and controllable conditions, thereby improving their skills. In the industrial field, the application of simulation technology is particularly prominent, from product design to production process optimization, from equipment failure prediction to system performance evaluation, simulation technology plays an irreplaceable role. For example, in the automotive manufacturing industry, simulation technology is used to simulate processes such as vehicle collisions and aerodynamic resistance to optimize vehicle design and improve safety; in the aerospace field, simulation technology is used to simulate the operation of aircraft in extreme environments, providing important basis for aircraft design and manufacturing. (3) With the continuous development of science and technology, simulation technology is also constantly innovating and improving. On the one hand, the continuous improvement of computer hardware performance provides strong support for the development of simulation technology; on the other hand, the emergence of new algorithms and models provides more possibilities for simulation technology. For example, the introduction of artificial intelligence technology enables simulation systems to have stronger adaptability and learning ability, thereby better simulating the complexity and uncertainty of the real world.

2. Application of Simulation Technology in Mechanical Design and Manufacturing

2.1 Application in Mechanical Structure Design

In the field of mechanical design and manufacturing, simulation technology plays a crucial role, especially

in the phase of mechanical structure design. The application of simulation technology not only enhances design efficiency but also significantly optimizes structural performance and reduces production costs. Firstly, through simulation technology, virtual prototypes of mechanical structures can be constructed on computers. These virtual prototypes can simulate the motion states, stress conditions, and performance of real mechanical structures. Designers can modify and optimize the structure multiple times in a virtual environment until the desired design effect is achieved. This approach not only avoids the tedious and costly process of repeatedly creating physical prototypes in traditional design methods but also greatly shortens the design cycle. Secondly, simulation technology can perform precise stress analysis on mechanical structures. By simulating stress conditions under different working conditions, we can understand the stress distribution, deformation, and potential failure modes of the structure. Based on these analysis results, designers can optimize the structure in a targeted manner to improve its load-bearing capacity and stability. Thirdly, kinematic simulation is another important application of simulation technology in mechanical structure design. By simulating the motion process of mechanical structures, we can understand motion parameters such as relative positions, velocities, and accelerations between components. This is important for evaluating the motion performance of mechanical structures, optimizing motion trajectories, and avoiding motion interference. Fourthly, in complex mechanical structure designs, it is often necessary to consider the coupling effects of multiple physical fields, such as thermal fields, electric fields, and magnetic fields. Simulation technology can perform coupled analysis of these multi-physical fields to comprehensively evaluate the performance of mechanical structures. For example, in motor design, we need to consider the interaction between electromagnetic fields and thermal fields; in the aerospace field, we need to consider the coupling relationship between mechanical structures and aerodynamics. Through simulation technology, we can conduct in-depth research on these complex issues and provide strong support for design optimization.

2.2 Application in Gear Design

Gears, as the core components in mechanical

transmission systems, play a crucial role in the overall operation of the mechanical system in terms of precision and performance stability. (1) Tooth profile design: The tooth profile is one of the most basic features of gears, directly affecting the transmission efficiency, noise level, and service life of the gears. Through simulation technology, designers can simulate the operation of gears with different tooth profiles under different working conditions on computers, analyze key indicators such as contact stress distribution, transmission efficiency, and noise level of the tooth profile. Based on simulation results, designers can optimize the tooth profile, find the best tooth profile parameters, and improve the transmission performance and stability of the gears. (2) Gear dynamic analysis: Gears produce various dynamic effects during transmission, such as vibration, impact, and noise, which not only affect the transmission accuracy and stability of gears but may also damage the entire mechanical system. Through simulation technology, designers can perform dynamic analysis on gears, simulate their dynamic responses under different speeds, loads, and conditions. Based on simulation results, designers can predict the vibration characteristics, impact loads, and noise levels of gears, thereby optimizing gear design targetedly and reducing the impact of dynamic effects on system performance. (3) Thermal analysis of gears: Under high-speed and heavy-load working conditions, gears generate a large amount of heat, resulting in temperature rise. Excessive temperature can affect the material properties and lubrication effectiveness of gears, thereby affecting the transmission performance and service life of gears. Through simulation technology, designers can perform thermal analysis on gears, simulate the temperature distribution and variation under different conditions. Based on simulation results, designers can select suitable materials and heat treatment processes, optimize the heat dissipation structure of gears, and ensure that gears can maintain good performance under high-temperature conditions. (4) In addition to the above applications, simulation technology can also be used for gear strength verification, life prediction, and failure analysis. With simulation technology, designers can perform accurate strength analysis and life prediction on gears, ensuring that gears can meet design requirements in practical use.

2.3 Application in Machining Design

In the gear machining design process, the application of simulation technology not only significantly improves design efficiency but also effectively optimizes the machining process and reduces production costs. Firstly, tool path planning: In the gear machining process, tool path planning directly determines the machining efficiency and quality. Through simulation technology, designers can simulate the motion trajectory of the tool on the gear surface on the computer, analyze the cutting force, cutting temperature, and tool wear under different paths. Secondly, prediction of material deformation: During the gear machining process, due to the action of cutting forces, the material undergoes a certain degree of deformation. If this deformation is too large, it can lead to a decrease in gear dimensional accuracy, affecting transmission performance. Designers can use simulation technology to predict the deformation of materials under different machining parameters, and then adjust machining parameters such as cutting speed and feed rate to reduce material deformation and ensure gear dimensional accuracy. Thirdly, prediction and optimization of surface quality after gear machining: The surface quality of gears has a significant impact on their transmission performance and lifespan. By reasonably applying simulation technology, designers can predict key indicators such as surface roughness and residual stress of gears under different machining parameters, and then optimize machining parameters and processes to improve gear surface quality. Fourthly, analysis of vibration and noise during machining: In the machining process, the interaction between the tool and the workpiece generates vibration and noise, which not only affects machining accuracy but may also pose a risk to the health of operators. Through simulation technology, designers can analyze the sources of vibration and noise during the machining process, formulate corresponding control measures, reduce vibration and noise levels, and improve the comfort of the machining environment.

2.4 Auxiliary Computation of Complex Data

In today's digital and information age, the processing and computation of complex data have become important challenges in many industries. Whether in scientific research, engineering, or business analysis, computation of complex data occupies a significant position. In this process, simulation technology, with

its unique advantages, provides powerful assistance for the computation of complex data. Firstly, simulation technology can help researchers and engineers build complex mathematical models. These models can be precise simulations of the real world or abstract representations of specific phenomena or processes. By constructing these models, researchers can gain deeper insights into the inherent rules and characteristics of the data, laying a solid foundation for subsequent computation and analysis. Secondly, in scientific research and engineering, there is often a need to deal with massive amounts of data, which are not only vast in quantity but also structurally complex. Traditional computational methods often struggle to cope with such challenges, while simulation technology can quickly and accurately process these data through simulation and optimization. Through simulation technology, researchers can quickly identify key information, discover hidden patterns and trends in the data, and provide strong support for decision-making. Lastly, in practical applications, many systems are complex and dynamic, and their operation processes and results are often influenced by multiple factors. Through simulation technology, researchers can simulate the operation processes of these systems, analyze the impact of various factors on system performance, and find methods to optimize system performance. Additionally, simulation technology can be used to predict the future behavior of systems, providing forward-looking guidance for decision-making.

3. Measures to Strengthen the Application of Simulation Technology

With the rapid advancement of technology, the application of simulation technology in various fields is becoming increasingly widespread, and its importance is also increasingly prominent. However, to fully unleash the potential of simulation technology, a series of measures need to be taken to strengthen its application.(1). Enhance research and innovation in the technology itself: Simulation technology, as a comprehensive technical system, involves knowledge from multiple disciplines such as mathematics, physics, and computer science. Therefore, to strengthen the application of simulation technology, it is necessary to continuously promote research and development in related disciplines and improve the accuracy and efficiency of simulation technology.

Encouraging cooperation and exchange between enterprises, universities, and research institutions is also essential to promote innovation and application of simulation technology.(2). Emphasize the training and introduction of simulation technology talents: The application of simulation technology requires a group of professionals with specialized knowledge and practical experience to support it. Therefore, efforts should be made to enhance the training of simulation technology talents through offering relevant courses, organizing training programs, etc., to improve their professional competence and skills. Additionally, actively introducing outstanding simulation technology talents from both domestic and international sources can provide more support for the application of simulation technology in China.(3). Strengthen the promotion of simulation technology application in industries: Different industries have different demands and application scenarios for simulation technology. Therefore, it is important to formulate corresponding promotion strategies based on the characteristics and needs of different industries. Activities such as industry seminars, technical exchanges, etc., can be organized to promote the deep integration of simulation technology with various industries. Moreover, modern information technology means such as the Internet and big data can be utilized to broaden the dissemination channels of simulation technology, thereby enhancing its visibility and influence in industries.(4). Establish comprehensive standards and specifications for the application of simulation technology: The application of simulation technology needs to adhere to certain standards and specifications to ensure the accuracy and reliability of its results. Therefore, efforts should be made to strengthen the standardization of simulation technology applications by formulating and improving relevant standards and specifications, providing robust institutional safeguards for the application of simulation technology.

Conclusion

In conclusion, through research on the application of simulation technology in mechanical design and manufacturing, it becomes clear the significant role it plays in improving design efficiency, optimizing product performance, and reducing production costs. With the continuous advancement of technology

and the expanding application areas, simulation technology will play an even more important role in mechanical design and manufacturing. In the future, relevant personnel need to further strengthen research and innovation in simulation technology, enhancing its application level and effectiveness in mechanical design and manufacturing.

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