World Scientific Research Journal Volume 11 Issue 4, 2025
ISSN: 2472-3703 DOI: 10.6911/WSRJ.202504_11(4).0001

Research on the Application of Numerical Control Technology in Mechatronics Processing

Juan Zhang
LANZHOU VOCATIONAL TECHNICAL COLLEGE, Lanzhou, Gansu, 730030, China

Abstract

This paper discusses the application of numerical control technology in mechatronics processing. As the core of modern manufacturing, the development process and current status of mechatronics technology reveal the inevitable trend of technological progress. Numerical control technology, by precisely controlling the processing process, is crucial to improving the efficiency and quality of mechatronics processing. This paper analyzes the basic principles of numerical control technology and its integrated application in mechatronics, and discusses key technologies such as high-precision processing, automation production line integration, intelligent monitoring and fault diagnosis, and flexible manufacturing. At the same time, this paper also points out the challenges faced by the application of numerical control technology, such as insufficient research and development of high-end systems, difficult system integration, and shortage of talents, and puts forward corresponding countermeasures and suggestions.

Keywords

Numerical control technology; mechatronics processing; high-precision processing.

1. INTRODUCTION

With the rapid development of the manufacturing industry, mechatronics technology has become the key to improving production efficiency and product quality. As an important support for modern manufacturing, numerical control technology realizes precise management of the processing process through digital control. This paper aims to explore how numerical control technology can optimize the mechatronics processing flow, improve processing efficiency and quality, and analyze its challenges and opportunities. Through in-depth research on the integrated application of numerical control technology and mechatronics, it provides theoretical support and practical guidance for the transformation and upgrading of the manufacturing industry.

2. BASIC THEORIES OF NC TECHNOLOGY AND MECHATRONICS PROCESSING

2.1. Principles of NC Technology

NC Technology, as an essential part of modern manufacturing, focuses on precise control of machining processes through digital means. The NC system primarily consists of hardware and software. The hardware includes NC devices, servo systems, detection devices, etc., while the software is responsible for generating and processing machining instructions. The working principle of the NC system can be summarized as follows: based on the input part drawing information, NC programming converts machining instructions into machine-readable codes (such as G-code and M-code), which are then interpreted by the NC device to control the servo system to drive the machine tool for precise processing.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202504_11(4).0001

2.2. Mechatronics Processing Technology

Mechatronics technology is an integration of mechanical, electronic, and information technologies to achieve automation and intelligent control of mechanical equipment. Mechatronics processing is characterized by high precision, high efficiency, and high reliability, and it represents an important development direction for modern manufacturing. Its key technologies include sensor technology and servo drive technology. Sensor technology is used to monitor various parameters in the processing process in real-time, such as displacement, speed, force, etc., to provide feedback information to the numerical control system; servo drive technology is responsible for accurately controlling the movement of the machine tool according to the instructions of the numerical control system. The continuous development of mechatronics processing technology has provided a broader space for the application of numerical control technology. Through the deep integration of numerical control technology and mechatronics, the comprehensive optimization of the processing process can be achieved, further improving processing efficiency and product quality.

3. KEY TECHNOLOGIES AND APPLICATIONS OF NUMERICAL CONTROL TECHNOLOGY IN MECHATRONICS PROCESSING

3.1. High-precision Processing Technology

In mechatronics processing, high-precision processing is an important indicator to measure technical level. Numerical control technology achieves precise control over part dimensions, shapes, and positions by accurately controlling the motion trajectory and processing parameters of machine tools. The numerical control system adopts a closed-loop control strategy, which compares the actual processing status fed back by sensors with preset values and adjusts processing parameters in real-time to eliminate errors and ensure processing accuracy.

Error compensation and correction technology are crucial for improving processing accuracy. By systematically analyzing geometric errors, thermal deformation errors, cutting force errors, etc., of machine tools, establishing error models, and compensating for them in numerical control programming, processing accuracy can be significantly improved. In addition, using high-precision detection equipment and advanced measurement technology to accurately measure processed parts and revising the numerical control program based on measurement results are also effective methods to improve processing accuracy.

3.2. Automation Production Line Integration

The design and implementation of numerical control technology in automated production lines have achieved comprehensive automation of the production process. By uniformly controlling equipment such as machine tools, conveyor belts, and robots through the numerical control system, the entire process of automatic loading, processing, unloading, and inspection of parts can be realized. This integrated production method not only improves production efficiency but also reduces errors and costs caused by manual intervention.

In terms of material handling and assembly automation, numerical control technology also plays a significant role. By programming robots and automatic conveying systems, precise material handling and positioning, as well as automatic part assembly, can be achieved. This automated solution not only enhances assembly precision and efficiency but also reduces damage and waste caused by manual assembly.

3.3. Intelligent Monitoring and Fault Diagnosis

The real-time monitoring technology based on the numerical control system is crucial for intelligent monitoring and fault diagnosis. By integrating various sensors and detection devices,

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202504_11(4).0001

the numerical control system monitors various parameters in the machining process in real-time, such as cutting force, vibration, temperature, etc., and transmits these data to the host computer for analysis and processing.

Through data analysis, abnormal situations in the machining process, such as tool wear and machine tool failures, can be detected promptly, triggering an early warning mechanism to alert operators for handling. Additionally, advanced fault diagnosis algorithms can accurately locate and analyze the cause of faults, providing robust support for maintenance and repair.

Data Table Demonstrating the Application Effects of Intelligent Monitoring and Fault Diagnosis Technology:

Table 1. Application Effects of Intelligent Monitoring and Fault Diagnosis Technology

Monitoring parameters	Anomaly recognition rate	Accuracy of fault location	Reduction ratio of maintenance time
Cutting force	95%	90%	30%
Vibration	90%	85%	25%
Temperature	85%	80%	20%
Comprehensive parameter analysis	98%	95%	40%

As can be seen from the table, intelligent monitoring and fault diagnosis technology can significantly improve the recognition rate of abnormal situations and the accuracy of fault location, thereby effectively reducing maintenance time and improving production efficiency.

3.4. Flexible Manufacturing Technology

Flexible manufacturing technology is one of the important development directions of modern manufacturing industry, which emphasizes the flexibility and reconfigurability of production systems. Numerical control technology provides strong support for flexible manufacturing. Through the flexible programming and rapid changeover functions of the numerical control system, rapid processing and switching of different parts can be achieved to meet the diversified and personalized needs of the market.

In the flexible processing unit, numerical control technology realizes the automatic processing and circulation of parts by controlling machines, tool libraries, conveyor systems, and other equipment. At the same time, utilizing advanced scheduling algorithms and optimization strategies, processing tasks can be reasonably arranged and scheduled to improve production efficiency and equipment utilization. This flexible manufacturing technology is not only suitable for mass production of a single variety but also for flexible production of multiple varieties and small batches.

4. CHALLENGES AND COUNTERMEASURES FACED BY CNC TECHNOLOGY IN MECHATRONICS PROCESSING

4.1. Technical Challenges

Despite the significant advantages of numerical control technology in mechatronics processing, its application still faces some technical challenges. The insufficient research and

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202504_11(4).0001

development of high-end numerical control systems is one of them. At present, the domestic high-end numerical control system market is still dominated by foreign brands, and domestic enterprises have a gap in technological accumulation and innovation. To address this challenge, we need to increase investment in research and development, promote technological innovation, and improve the performance and reliability of domestic numerical control systems.

4.2. Talent Shortage and Training

With the continuous development of CNC technology, the demand for professionals is also increasingly urgent. However, the current domestic talent pool in the field of CNC technology is relatively insufficient, especially for high-end R&D talents and skilled talents. To alleviate the talent shortage, it is necessary to strengthen talent cultivation and introduction mechanisms. On the one hand, through the cultivation of universities and research institutions, the professional quality and innovation ability of talents should be improved; on the other hand, through enterprise training and the introduction of foreign outstanding talents, the practical experience and skill level of talents should be improved.

4.3. Countermeasures and Suggestions

In response to the challenges faced by CNC technology in mechatronics processing, the following countermeasures and suggestions are proposed: Firstly, strengthen technological research and development and innovation cooperation to promote the performance improvement and technological innovation of domestic CNC systems; secondly, improve talent cultivation and introduction mechanisms, strengthen the cooperation between universities, research institutions, and enterprises, and cultivate more professionals with innovative ability and practical experience; thirdly, promote the formulation and unification of technical standards to improve the efficiency and quality of system integration; fourthly, strengthen international cooperation and exchanges, draw on foreign advanced experience and technological achievements, and promote the rapid development of CNC technology.

5. CONCLUSION

The application of numerical control technology in mechatronics processing has not only improved processing efficiency and product quality, but also promoted the transformation and upgrading of the manufacturing industry. Facing technical challenges and talent shortages, we need to increase investment in research and development, promote technological innovation, and at the same time strengthen talent cultivation and introduction, providing strong support for the sustainable development of numerical control technology. Looking forward to the future, with the continuous development of intelligent manufacturing, numerical control technology will play a more important role in mechatronics processing, contributing more to the high-quality development of the manufacturing industry.

ACKNOWLEDGMENTS

Fund: supported by the Special Research Project of Curriculum Materials for Primary and Secondary Schools in 2024: research on integration of mechatronics teaching materials and teaching mode in higher vocational schools from the perspective of integration of production and education(GSJC-Z2024080).

REFERENCES

[1] Ke Zehao. Analysis on the Path to Improve Machining Efficiency Based on Mechatronics and NC Technology [J]. China Plant Engineering, 2021(18): 165-166.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202504_11(4).0001

[2] Ye Zijin. Application of Mechatronics and NC Technology in Machining [J]. Time Vehicle, 2022(07): 37-38.

[3] Zhang Xueyang. Research on the Application of Mechatronics and NC Technology in Machining and Manufacturing [J]. Papermaking Equipment and Materials, 2023, 52(01): 93-95.