Abstract

In the ever-evolving field of mechatronics engineering, the application of Computer Numerical Control (CNC) technology has become a pivotal aspect of modern industrial manufacturing. This project focuses on the development and implementation of a CNC four-axis milling machine with five degrees of freedom, designed specifically for the processing of soft materials such as plastics, wood, aluminum, and copper. The primary aim is to enhance precision, reduce time and effort, and lower costs compared to traditional three-axis CNC machines. By integrating an additional axis, this innovative technology allows for the fabrication of more complex and precise parts, broadening the scope of applications in various industrial sectors including automotive, aerospace, electronics, and construction.

The project involves a comprehensive study of the mechanical and electronic design elements essential for the construction of the CNC milling machine. This includes the development of a robust structure capable of withstanding high precision operations, the integration of advanced stepper motors and control systems, and the implementation of G-code programming for precise tool path generation. A detailed analysis of the selection and testing of suitable materials ensures that the machine can efficiently handle a variety of soft materials, maintaining high accuracy and quality in production.

Furthermore, the project explores the historical evolution of CNC technology, highlighting the advancements that have led to the current state of the art in four-axis CNC machining. This historical context provides a foundation for understanding the significance and potential of the developed machine. The study also delves into the cost implications of CNC technology, emphasizing the cost-effectiveness of the designed machine in comparison to high-end commercial CNC machines. This aspect is particularly crucial for small and medium-sized enterprises looking to adopt advanced manufacturing technologies without incurring prohibitive costs.

The control design aspect of the project is meticulously detailed, focusing on the core control components, the integration of the rotary axis, and the development of a user-friendly interface for machine operation. The G-code programming, a critical component for CNC operation, is thoroughly explored to ensure seamless and accurate machining processes. The project also addresses the challenges associated with machining different types of soft materials, providing solutions to optimize the milling process and enhance the machine's versatility.

The culmination of this research and development effort is a cost-effective, efficient, and versatile CNC milling machine that meets the demands of modern manufacturing. It is designed to offer increased precision, reduced production time, and significant cost savings, making it an ideal solution for various industrial applications. The project not only contributes to the field of mechatronics engineering but also provides a practical tool for enhancing manufacturing capabilities, improving product quality, and increasing operational efficiency in competitive and innovative manufacturing environments.