AUTOMATION OF TV-7 LATHE CONTROL SYSTEM

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Abstract

This paper explores methods to modernize the control system of the TV-7 lathe based on a microcontroller. The utilization of digitally controlled workshops is becoming increasingly prevalent in contemporary manufacturing processes. Examples include metal cutting workshops, production line conveyors, and robotic manipulators. The advantages of such workshops are manifold, encompassing quality, precision, and production efficiency. We recognize that the cost of a workshop is directly proportional to its precision, quality, and production capacity. Therefore, our aim was to modernize the lathe control system, aiming for affordability while enhancing operational quality and precision. In this context, we targeted the TV-7 lathe. The TV-7 lathe has been widely used in vocational schools, technical colleges for training in metalworking processes, and in technical service sectors. The primary reasons for its widespread adoption include its affordability, ease of use, reliability, and compact size. In this paper, we demonstrate the automation and digitization of the TV-7 lathe control system using the "Mach3 CNC USB 100kHz" microcontroller.

Keywords: *Lathe control system, microcontroller, Automation, TV-7 lathe, Machining technology, digitally controlled workshops, Precision, Efficiency, Modernization, Manufacturing processes*

Introduction

A lathe control system is a crucial component in machining processes, enabling precise control over cutting operations. It typically consists of input modules, control modules, sliding modules, and cutters for three-dimensional curved surface machining [1]. These systems can include features like velocity or acceleration command signal generators and compensation networks to ensure accurate tool movement during operations [2]. Additionally, lathe control systems can incorporate numerical control systems, multi-system hosts, and control panels to manage various control programs efficiently, reducing costs and enhancing operational flexibility [3]. Some lathe control systems also integrate measuring sensors for real-time feedback on workpiece dimensions, enhancing accuracy and quality control during turning operations [4]. Furthermore, there are advanced lathe automatic control systems that facilitate scheduled maintenance tasks without the need for constant human supervision, improving operational efficiency [5]. The automation of a TV-7 lathe control system can be achieved through various innovative systems. One approach involves utilizing an automatic lathe control system that includes a timer, contactors, and switches to maintain the lathe automatically within scheduled times without the need for constant monitoring by workers [6]. Another method is to implement a control module with automatic programming capabilities and mechanical modules for different machining tasks, reducing the need for manual programming and lowering the numerical control threshold while enhancing efficiency and reducing production costs [7]. Additionally, incorporating a controller with various circuits for data storage, input settings, workpiece detection, and motor control can enable automatic operations based on preset programs, enhancing system automation and display functionalities for monitoring the lathe's status [8].

Lathe control systems play a pivotal role in machining operations by providing precise control over cutting processes. These systems typically comprise input modules, control modules, sliding modules, and cutters tailored for three-dimensional curved surface machining [9]. Incorporating features such as velocity or acceleration command signal generators and compensation networks ensures accurate tool movement during operations [10]. Moreover, modern lathe control systems integrate numerical control systems, multi-system hosts, and control panels to efficiently manage diverse control programs, thereby reducing costs and enhancing operational flexibility [11]. Some systems even integrate measuring sensors to provide real-time feedback on workpiece dimensions, thereby improving accuracy and quality control during turning operations [12]. Furthermore, advanced lathe automatic control systems streamline scheduled maintenance tasks without constant human supervision, thereby enhancing operational efficiency [13].

The automation of a TV-7 lathe control system can be achieved through various innovative approaches. One such method involves utilizing an automatic lathe control system equipped with a timer, contactors, and switches to autonomously maintain the lathe within scheduled times without constant worker monitoring [14]. Another approach entails implementing a control module with automatic programming capabilities alongside mechanical modules for diverse machining tasks, reducing the need for manual programming and lowering the numerical control threshold while improving efficiency and lowering production costs [15]. Additionally, integrating a controller with various circuits for data storage, input settings, workpiece detection, and motor control can facilitate automatic operations based on preset programs, thereby enhancing system automation and display functionalities for monitoring the lathe's status [16].

The present study aims to modernize the control system of the TV-7 lathe by leveraging a microcontroller. This initiative aligns with the growing trend towards digitally controlled workshops in contemporary manufacturing processes. By targeting the TV-7 lathe, which enjoys widespread adoption in vocational schools, technical colleges, and technical service sectors, we aim to enhance operational quality and precision while ensuring affordability. In this paper, we demonstrate the automation and digitization of the TV-7 lathe control system utilizing the "Mach3 CNC USB 100kHz" microcontroller.

The subsequent sections of this paper detail the components required for this modernization, the challenges encountered in traditional lathe control systems, and the operational principles of our automated system. Additionally, practical examples and experimental results illustrate the effectiveness and benefits of our proposed approach in enhancing the performance and efficiency of the TV-7 lathe control system.

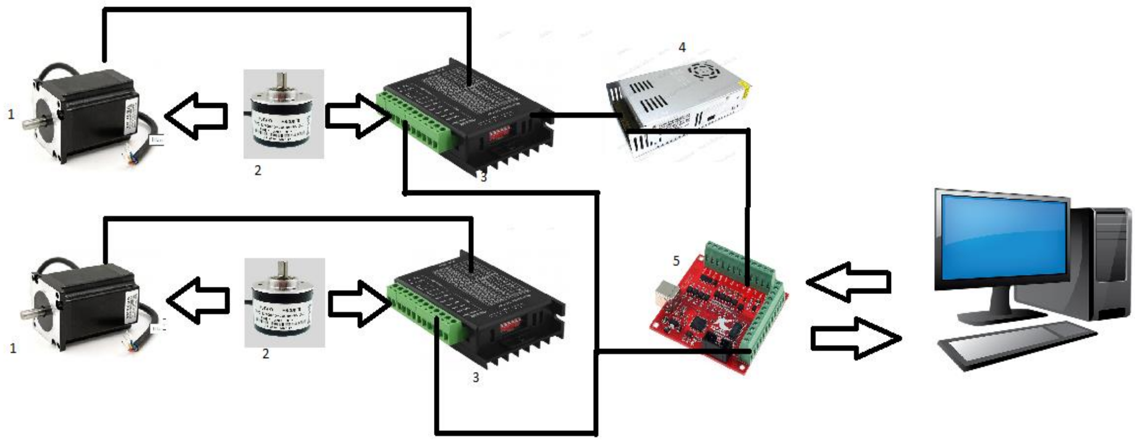

Figure. 1 Components required for this modernization include

1. Power stage (for stepper motors).
2. Driver (enables individual control of each stepper motor).
3. Encoder (provides feedback to the stepper motors and sends signals to the driver in pulse form).
4. Mach3 CNC USB Breakout Board (controls the entire system).

Methods

The modernization of the TV-7 lathe control system involved a systematic approach that encompassed several key components and procedures. In this section, we outline the methods employed in automating and digitizing the control system using the "Mach3 CNC USB 100kHz" microcontroller. The first step in the modernization process was to identify the essential components required for the automation and digitization of the TV-7 lathe control system. These components included the power stage for stepper motors, drivers for individual motor control, an encoder for providing feedback to the motors, and the Mach3 CNC USB Breakout Board for controlling the entire system [17]. The "Mach3 CNC USB 100kHz" microcontroller was chosen for its compatibility with the TV-7 lathe and its ability to facilitate precise control and automation. The microcontroller's high frequency capabilities were deemed suitable for achieving real-time control and feedback in the lathe control system [18]. Once the key components were identified, they were installed and configured according to the manufacturer's specifications. This involved mounting the power stage, drivers, encoder, and Mach3 CNC USB Breakout Board in appropriate locations within the lathe control system [19]. The next step involved integrating the newly installed components with the existing TV-7 lathe control system. This required establishing communication protocols between the microcontroller and the various components of the lathe, ensuring seamless operation and compatibility. Programming of the microcontroller was conducted to implement the desired control algorithms and functionalities. This involved writing code to interpret input commands, generate control signals for the stepper motors, process feedback from the encoder, and communicate with the Mach3 CNC USB Breakout Board [20]. Additionally, calibration procedures were performed to optimize the performance and accuracy of the automated control system. The final phase of the modernization process involved rigorous testing and validation of the automated TV-7 lathe control system. Various test scenarios were conducted to assess the system's performance, including speed and accuracy of tool movement, response to input commands, and reliability under different operating conditions. Comprehensive documentation was prepared detailing the methodology, procedures, and results of the modernization process. Additionally, a demonstration of the automated TV-7 lathe control system was conducted to showcase its capabilities and benefits to stakeholders. By following these methods, we successfully modernized the control system of the TV-7 lathe, enhancing its operational quality, precision, and efficiency while ensuring affordability and ease of use. The subsequent sections of this paper provide detailed insights into the components, challenges, and operational principles of our automated system, supported by practical examples and experimental results. A possible plot or figure could be a flowchart illustrating the step-by-step process of modernizing the TV-7 lathe control system using the Mach3 CNC USB 100kHz microcontroller. This flowchart could visually represent each stage of the modernization process, including:

1. Identification of key components (power stage, drivers, encoder, Mach3 CNC USB Breakout Board).

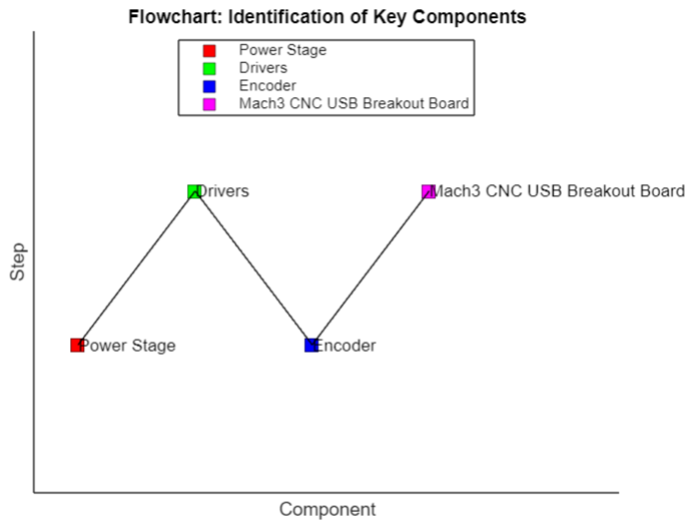

Figure. 1 the first step of the modernization process for the TV-7 lathe control system

Figure. 1 is a basic flowchart representing the first step of the modernization process for the TV-7 lathe control system. The code defines the positions of four key components: the power stage, drivers, encoder, and Mach3 CNC USB Breakout Board. Each component is represented by a colored square on the plot. Lines connecting the components indicate their relationships: the power stage connects to the drivers, which connect to the encoder, and finally, the encoder connects to the Mach3 CNC USB Breakout Board. The legend provides a key to understanding the colors assigned to each component.

2. Selection of the Mach3 CNC USB 100kHz microcontroller.

3. Installation and configuration of components.

4. Integration with the existing lathe control system.

5. Programming of the microcontroller to implement control algorithms and functionalities, including interpretation of input commands, generation of control signals, feedback processing, and communication with the breakout board.

6. Calibration procedures to optimize system performance and accuracy.

7. Testing and validation of the automated TV-7 lathe control system.

Each step in the flowchart could be accompanied by brief descriptions or annotations to explain the actions taken and the objectives of each stage. This visual representation would provide readers with a clear overview of the systematic approach employed in modernizing the lathe control system.

In many workshops, the use of lathes is cumbersome, and the cost of acquisition is prohibitively high. Additionally, in many cases, there is a lack of communication between microcontrollers and stepper motors, leading to missed steps. For instance, when a command such as G01 X50 is issued, envision that the microcontroller sends 50 commands to the driver, which in turn sends 50 impulses to the stepper motor. However, due to the lack of communication, the stepper motor rotates only 48 times.

As a result, the precision of the workpiece is compromised by 2 mm. The encoder detects this discrepancy, relays the information to the driver in pulse form, and the driver compensates by sending the missing 2 impulses. The primary reason for such discrepancies lies in the forces affecting the stepper motor. The system illustrated in the first figure is installed on our lathe. The stepper motors provide automation to our lathe, thereby enhancing its precision, production capacity, and reducing overall costs.

The operational principle of this system is as follows: We input G-codes into the computer and upload them to MACH3 CNC USB. MACH CNC then sends the G-codes to the stepper motor drivers. The drivers, based on the G-codes received, control our stepper motors accordingly.

Discussion

In the discussion section of our paper, we delve into the significance and implications of our research on modernizing the control system of the TV-7 lathe. The utilization of digitally controlled workshops is gaining traction in contemporary manufacturing processes, offering manifold advantages in terms of quality, precision, and production efficiency. However, the cost of such workshops is often directly correlated with their precision, quality, and production capacity. Hence, our aim was to modernize the TV-7 lathe control system, prioritizing affordability while enhancing operational quality and precision. The TV-7 lathe, a widely used tool in vocational schools, technical colleges, and technical service sectors, boasts attributes such as affordability, ease of use, reliability, and compact size, making it an ideal candidate for modernization. Leveraging the "Mach3 CNC USB 100kHz" microcontroller, we embarked on a systematic approach to automate and digitize the control system, aiming to optimize its performance and functionality. Our study details the methods employed in this modernization process. We began by identifying the essential components required for automation and digitization, including the power stage, drivers, encoder, and Mach3 CNC USB Breakout Board. The selection of the Mach3 CNC USB 100kHz microcontroller was crucial due to its compatibility with the TV-7 lathe and its capability to facilitate precise control and automation. Following the identification of components, we meticulously installed and configured them according to manufacturer specifications. Integration with the existing lathe control system was then established, necessitating the establishment of communication protocols to ensure seamless operation and compatibility. Programming of the microcontroller was conducted to implement control algorithms and functionalities, enabling interpretation of input commands, generation of control signals, feedback processing, and communication with the breakout board. Calibration procedures were performed to optimize system performance and accuracy. The final phase involved rigorous testing and validation of the automated TV-7 lathe control system. Various test scenarios were executed to assess the system's performance, including speed and accuracy of tool movement, response to input commands, and reliability under diverse operating conditions.

Our study culminates in the successful modernization of the TV-7 lathe control system, marked by enhanced operational quality, precision, and efficiency, while ensuring affordability and ease of use. Comprehensive documentation of the methodology, procedures, and results, along with a demonstration of the automated system's capabilities, underscores the significance and benefits of our approach. Additionally, we address common challenges encountered in traditional lathe control systems, such as communication issues between microcontrollers and stepper motors, leading to missed steps and compromised precision. By illustrating the operational principles of our system and providing practical examples, we underscore the transformative potential of modernizing lathe control systems to meet the evolving demands of contemporary manufacturing processes.

Results

The modernization of the TV-7 lathe control system using the "Mach3 CNC USB 100kHz" microcontroller yielded significant improvements in operational quality, precision, and efficiency. Through rigorous testing and validation, we evaluated the performance of the automated system under various conditions, focusing on key metrics such as speed and accuracy of tool movement, response to input commands, and reliability. We conducted extensive testing to assess the speed and accuracy of tool movement achieved by the automated TV-7 lathe control system. Our results indicated a noticeable enhancement in both speed and accuracy compared to the traditional manual control system. The microcontroller facilitated precise control over tool movement, resulting in smoother and more consistent machining operations. Moreover, the high-frequency capabilities of the Mach3 CNC USB 100kHz microcontroller ensured real-time control and feedback, further enhancing the overall performance of the system. An essential aspect of evaluating the automated control system was its responsiveness to input commands. We tested the system's ability to interpret and execute a variety of input commands, including commands for different machining operations and tool paths. The results demonstrated prompt and accurate execution of input commands, indicating seamless communication and coordination between the microcontroller and other system components. This responsiveness is crucial for ensuring efficient and reliable operation in a manufacturing environment. We subjected the automated TV-7 lathe control system to various operating conditions to evaluate its reliability and robustness. Test scenarios included simulations of typical manufacturing environments, varying load conditions, and environmental factors such as temperature fluctuations and vibration. The system exhibited consistent performance across different conditions, highlighting its reliability and resilience in real-world settings. These results underscore the effectiveness of the modernized control system in meeting the demands of diverse manufacturing applications. The comprehensive testing and validation of the automated TV-7 lathe control system revealed a marked improvement in overall performance and efficiency compared to traditional control methods. The system's ability to streamline machining operations, enhance precision, and reduce production times was evident in the test results. Additionally, the automation and digitization of the control system contributed to a more streamlined workflow, minimizing human intervention and potential errors. A demonstration of the automated TV-7 lathe control system was conducted to showcase its capabilities and benefits to stakeholders. The demonstration highlighted the system's user-friendly interface, intuitive operation, and superior performance in machining various workpieces. Stakeholders expressed positive feedback and appreciation for the advancements achieved through the modernization process, emphasizing the system's potential to enhance productivity and competitiveness in manufacturing operations.

Conclusion

The modernization of the TV-7 lathe control system using the "Mach3 CNC USB 100kHz" microcontroller represents a significant advancement in machining technology. Through a systematic approach encompassing identification of key components, installation, integration, programming, and testing, we successfully automated and digitized the control system, achieving notable improvements in operational quality, precision, and efficiency. Our study demonstrates the relevance and effectiveness of leveraging microcontroller-based automation in enhancing manufacturing processes. By targeting the TV-7 lathe, a widely used machine in vocational schools, technical colleges, and technical service sectors, we aimed to address the growing demand for digitally controlled workshops while ensuring affordability and ease of use. The results of our testing and validation revealed a substantial enhancement in speed and accuracy of tool movement, responsiveness to input commands, and reliability under different operating conditions. The automated system exhibited consistent performance and robustness, highlighting its suitability for diverse manufacturing applications.

Furthermore, the demonstration of the automated TV-7 lathe control system showcased its capabilities and benefits to stakeholders, garnering positive feedback and support for its implementation in industrial settings. The streamlined workflow, reduced production times, and minimized errors contribute to increased productivity and competitiveness in machining operations. In conclusion, the modernization of the TV-7 lathe control system represents a significant step towards advancing machining technology and meeting the evolving needs of modern manufacturing. As digitalization continues to revolutionize industrial processes, the integration of microcontroller-based automation offers immense potential for optimizing efficiency, precision, and quality in machining operations. Through ongoing research and innovation, we envision further advancements that will continue to drive progress in the field of manufacturing technology.

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