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Computer Numerical Control (CNC)

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ABSTRACT

The design of the CNC is a project that arises from a social perspective, considering that this project is developed with the purpose of obtaining machined parts for the PLM laboratory and thus assisting with the activities of the students at the Technological University of Tlaxcala. Therefore, the general stages of numerical control are described as a system that allows the control of a machining tool through a control panel and software. The commands are executed from the panel and sent to the machine to comply with the established guidelines. There are several basic principles in the operation of CNC machines, such as 3D programming and interpolation. The former allows users to create 3D digital models of the parts they wish to manufacture, enabling greater precision and control in the machining process. On the other hand, interpolation refers to the simultaneous movement of various machine axes to achieve a specific pattern or shape on the part during the machining process. This process allows the production of complex parts with high precision. The main components of a CNC machine include the CNC router with computer numerical control, which is essentially composed of the same elements as any other machine with this technology: a program, a controller, a machine tool, and a support structure. An analysis of the system's operation was conducted using variables such as initial and final values to compare theoretical data with the actual data obtained during the operation. The CNC machining process uses computer-controlled cutting tools to produce parts with precise shapes and sizes. One of the advantages of CNC programming is that multiple parts can be produced from a single CAD file, which increases efficiency and reduces costs. Additionally, the produced parts have high precision and consistency.

Keywords: CNC; automation; programming; automated processes.

INTRODUCTION

In the realm of modern manufacturing, Computer Numerical Control (CNC) has revolutionized the way parts and components are designed and produced. This technology enables the automation of machine and tool operations through programmed instructions, resulting in a significant increase in precision and efficiency in production processes. [1]

In a world where technological innovation constantly redefines production processes, Computer Numerical Control (CNC) stands as a key component in the manufacturing industry. For engineering students, understanding how CNC works is essential, as this technology will enable them to tackle complex challenges in creating high-quality products. Through this presentation, we will analyze the principles of CNC, its practical applications, and how its integration into manufacturing processes impacts business competitiveness.

Computer Numerical Control (CNC) has transformed how parts are designed and manufactured in key industries. This system uses computers to control cutting tools, allowing the production of parts with unprecedented precision and efficiency. CNC machines, such as milling machines and lathes, operate using a specific programming language known as G-code, which instructs the machine on each movement and operation. Since its introduction, CNC has enabled significant advances in the production of complex parts and the reduction of manufacturing times. [2]

Throughout this exploration of CNC, we will address its fundamental principles, its applications in various sectors, and the benefits and challenges it presents in the current manufacturing context. With this foundation, the goal is to understand not only how this technology works but also its impact on the evolution of industrial production, as it has revolutionized how we conceive manufacturing and the design of parts across different industries.

For university students preparing to face an ever-changing work environment, understanding how CNC optimizes production, reduces costs, and improves quality is essential. This introduction will offer an overview of CNC's technical principles and its real-world applications. Today, CNC technology lies at the heart of smart manufacturing, integrating with innovations such as the Internet of Things

(IoT) and Artificial Intelligence (AI). These advancements facilitate the creation of automated and flexible processes, where CNC machines not only execute operations but also optimize their performance in real time.

The importance of CNC in modern manufacturing is undeniable. With its ability to adapt to the demands for precision and customization, CNC represents the convergence of technology and high-quality production, paving the way for a future where innovation and efficiency continue to expand the boundaries of what is possible in the industrial field. [3]

METHODOLOGY

To carry out the construction of the project, a study will be conducted on existing CNC technology equipment used for cutting wood, with the aim of analyzing how they address different process requirements. This will allow for the development and implementation of solutions tailored to the specifications of the new prototype to be designed.

Based on this analysis, preliminary designs will be proposed for a machine capable of meeting the identified needs, including details about the considerations, components, and arrangement of the equipment's subsystems. Simultaneously, work will be done on determining the dimensions and verifying the feasibility of the structure and elements, ensuring they meet the proposed movement objectives. To conceptually approach all the components required for the equipment, the main tasks of its subsystems must be defined. This begins with the process of introducing the wood, controlling its movement, cutting, and concluding with its removal. To achieve this, the global objectives the equipment must fulfill will first be specified, which are:

- Receive the workpiece
- Perform controlled advancement of the workpiece
- Precisely control the movement of the drill bit through programming
- Execute cuts or drills on the workpiece
- Remove the workpiece

To meet these requirements, the following main structures that the equipment must have to perform the assigned task are listed:

(1) Workpiece receiving structure.
(2) Drill operation space.
(3) Elements for controlling the movement of the workpiece.
(4) Structures to guide the drill's displacement.
(5) Workpiece removal structure Considering the minimum number of subsystems required to meet the objectives, work will begin on the initial conceptual designs, which will lay the foundation for achieving a detailed design of each part of the equipment to be built. This process will take into account subsequent control stages and may be supplemented with additional structures to ensure the optimal performance of the machine, if necessary.

DEVELOPMENT OF SUBASSEMBLIES

After defining the most general aspects necessary to meet the expectations for the prototype's construction, some boundaries are established to begin detailing the design of the primary structures and developing the initial assemblies of the equipment. Therefore, considering the previously defined structures and elements that are superficially necessary to carry out the project in its entirety, a general sizing for each will be provided to establish a foundation for the development of each part. This dimensional approach will consider measurements aimed at ensuring operational comfort, process visualization, monitoring, industrial scale, and compatibility with the raw materials and elements detailed in the general design requirements. Since the structures related to the operation space and the delivery and removal of the wood are primarily responsible for defining the path of the board as it interacts with the equipment, they will receive initial sizing first. The goal is for the subsequent structures or elements designed later to adapt to these dimensions.

MATERIAL ESTIMATION, CONSTRUCTION, AND EQUIPMENT TESTING

This stage begins the process of materializing the work carried out in the design phases of the equipment, primarily focusing on acquiring the quantity and type of structural material required to build the machine's parts. Additionally, it involves detailing elements that do not correspond to general structures, specifically mechanical components that complement the various movements of the assemblies, contributing to their positioning and fixation. To carry out the equipment's manufacturing stage, it is first necessary to have a record, based on the designs, of the quantity and type of materials needed for all the assemblies and subassemblies that make up the entire machine.

For the construction phase, students from the Universidad Tecnológica de Tlaxcala will have access to a mechanical construction workshop where the required materials will be received, and the structural assembly of the machine will be carried out under the supervision of university staff. For this, the developed designs need to be provided in manufacturing drawings so that, once the necessary materials are available, the construction of the structure can begin following these guidelines. The manufacturing drawings delivered to the workshop detail the construction and assembly of all the assemblies that make up the machine.

RESULTS

As a result of this project, a design and manufacturing process for the cutting machine prototype was successfully achieved, taking advantage of the observation of existing, more complex equipment to create an initial adaptation of all its functions. Through detailing the initial scope that was required, satisfactory design proposals were delivered, allowing progress to the construction phase.

Finally, with this prototype, it was evaluated that a first step was taken toward creating a machine that can perform the tasks of more complex machines available in the market.

Additionally, through the final tests conducted, several aspects were identified that could be improved in this prototype, which opened the door for a continuation of this project that considers the work done, with the aim of improving it in each future version to be built. The following images show different CNC machines taken as examples for the creation of the prototype.

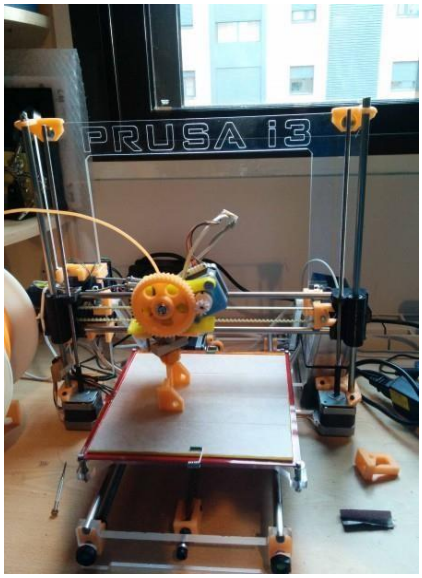

FIGURE 1: Existing CNC Example 1.
Source: PRUSA i3.

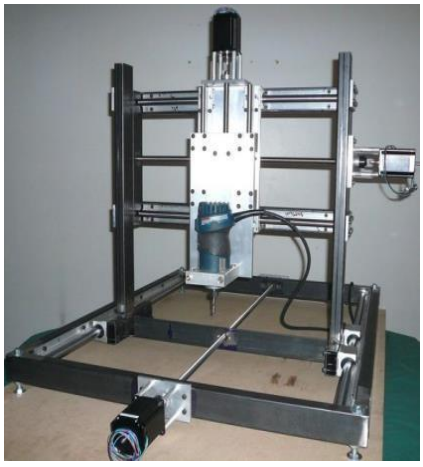

FIGURE 2: Existing CNC Example 2.
Source: Instructables.

In the following images, we can see a CNC machine built by the students of the Universidad Tecnológica de Tlaxcala.

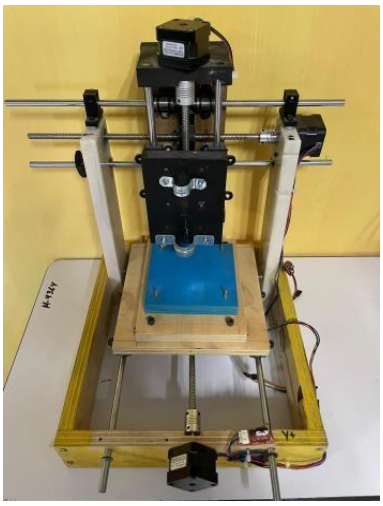

FIGURE 3: Front part of the CNC.
Source: Own.

FIGURE 4: Left side of the CNC.
Source: Own.

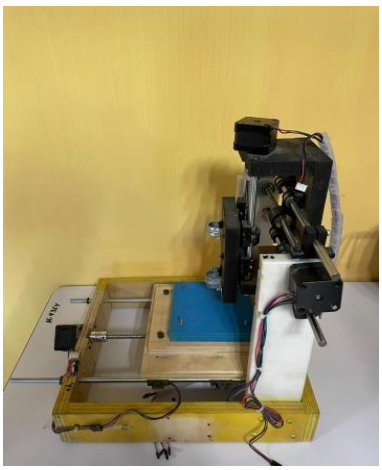

FIGURE 5: Right side of the CNC.
Source: Own.

FIGURE 6: Rear part of the CNC.
Source: Own.

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