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Industrial Approach Towards the Computer Numerical Controlled (CNC) Machines For Improving Production

By

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Abstract

Machines are part of industries as most of the operations are made by machines. The lathe machines are used for many years in the industry as there are now different types of machines in the market having different and unique functions. As the world is getting atomized so industries are also getting automatic with the new and updated machines in which the one of mostly used highly automatic and productive machines is known as the computer numerical control (CNC) machine. So the focus of the study is to know the importance of CNC machines in the industry and their impact on developing industrialization for mass production. There are different studies made for developing advanced methods to enhance the working of CNC machines. Thus, CNC machines are increasing in industries for different purposes, and their ability to perform multifunction reduce the machining time required for different machines and tools. The study further on CNC machines will help in developing the different tools, and programs for performing various multifunctions in the machines to increase effective mass production.

Keywords: CNC Machine, Codes, Industry, Production, Programs.

1. Introduction

The technological and mechanical control for machining machinery is known as numerical control, sometimes known as CNC or computerized numerical control. A CNC machine executes encoded program directions to process concentrates mainly to match criteria that do not necessitate adjusting the position immediately monitoring the milling operation [1], [2]. A CNC machine is a motorized manipulable tool and, more often, a motorized easily manipulated stage that is controlled by a computer using exact contribution commands. A CNC machine obtains commands in the procedure of software that performs device regulator commands such as G-code and M-code consecutively. The programmer can be generated by hand or, more commonly, using CAD or CAM technologies that create graphical designs. In the instance of three-dimensional printing, each share to be published is "sliced" before the commands are created (or software). 3D printers also employ G-Code [3]–[5].

G-codes are employed to straighten a machine's precise motions , such as puncturing operations. The plurality of G-code programs begin on the first line with a percentage (%) symbol, then go on to the second line with an "O" and the program's numerical name (for example, "O0001"), and finally ends on the last line with another percent (%) sign.

A G-code is formatted as the letter G preceded by two or three numbers, such as G01 for example. G-code , for instance, varies a little depending on whether using a mill or a lathe:

1. [G00 Rapid Motion Positioning]
2. [G01 Linear Interpolation Motion]
3. [G02 Circular Interpolation Motion-Clockwise]
4. [G03 Circular Interpolation Motion-Counter Clockwise]
5. [G04 Dwell (Group 00) Mill]
6. [G10 Set offsets (Group 00) Mill]
7. [G12 Circular Pocketing-Clockwise]
8. [G13 Circular Pocketing-Counter Clockwise]

Compared to non-computerized machining, which requires human control (e.g., using tools like hand wheels and otherwise levers) or control equipment using which was before pattern guides, CNC is a significant improvement. Modern computer numerical control (CNC) systems greatly automate both the mechanical product's design and its manufacturing plan. The product's mechanical qualities are translated into production instructions with the use of computer-aided manufacturing (CAM) software. After the instructions have been generated, they are transferred to a computer numerically controlled machine (CNC), where "post-processor" software converts them into the precise commands required by the machinery used to construct the components [6]–[8].

Numerical control, the forerunner of the contemporary CNC machine, is often attributed to John T. Parsons (1913-2007), founder of Parsons Manufacturing in Traverse City, Michigan. John Parsons is often regarded as the "father of the second industrial revolution" due to his many contributions. As he looked into the future of making helicopter blades, he saw that computerization of production was the way of the future. Components made with computer numerical control machines are used in practically every market today. CNC machines have allowed us to achieve a higher standard of living, more national security, and greater access to relatively inexpensive items than was previously conceivable. This study will look into the evolution of CNC machines, the many CNC machine designs, the programming of CNC machines, and the industry-standard practices of CNC machine builders [9], [10].

Modern machines sometimes integrate many tools into a single cell since any one component can require the usage of several distinct tools, such as drills, saws, etc. [16], [17]. In some setups, the component is moved from different machines by human or robotic workers under the control of an external controller. In either scenario, the process required to create any component is largely automated and results in a part that nearly resembles the original CAD model. [18]-[23]. Researchers working in e-Science fields such as meteorology, connectomics, sophisticated physics simulations, biology, genomics, and environmental studies meet difficulties. [16]- [41].

2. Literature Review

Guo et al. (2020) [11] evaluated that the study of intelligent manufacturing as the future of industrial systems has gained a lot of attention. Since computer numerical control (CNC) machine tools form the backbone of most discrete manufacturers, these facilities must have access to data collecting and monitoring capabilities. Business production efficiency must be increased, and information islands must be eradicated. The problems with keeping tabs on and collecting data from CNC machine tools in manufacturing facilities are addressed in this article.

The purpose of this research is to examine and improve the data attainment and checking system for "CNC machine tools" in an intelligent industrialized workspace using the FOCAS data gathering method. This research shows that CNC machine tool data gathering and storage needs can be satisfactorily met by using an equipment information model based on the "MTConnect protocol and FOCAS."

Praveen et al. (2022) [12] discussed that Computer Numerical Control (CNC) machine technology has reached a new level of development because of developments in computer-adapted engineering manufacture. These developments present a great opportunity for the manufacturing research community to profit from the study of computer-aided engineering in production engineering. The fall in the price of computer numerical control devices is largely responsible for this trend. Expensive CNC machines meant for mass production are inappropriate for the kind of widespread research activities carried out by students. Mini-CNC machines, because of their adaptability, are being used as research stand-ins. As a result, a miniature CNC machine was built to test the limits of emerging technologies like the Internet of Things, machine learning, and AI. This mini-CNC machine has been customized to manufacture a product for calligraphy students as a demonstration technique for studying AI.

Kim et al. (2019) [13] suggested that the smart factory is getting a lot of attention as a potential answer for the factory of the future in the new era of production ushering in the Fourth Industrial Revolution. Small and medium-sized businesses (SMEs) must apply smart industrial technologies to enhance productivity and remain competitive despite barriers such as short-term strategies and limited resources. This paper presents KEM (keep an eye on your machine), an innovative monitoring technique for SMEs that makes use of low-cost vision, such as a camera, and open-source technologies. The primary goal of this idea is to collect and analyze data about operations using simple and cheap hardware.

Xiao et al. (2021) [14] discussed that Nowadays, NC machining is widely used in mechanical manufacturing systems. "Processing costs and energy consumption can be drastically reduced with careful parameter selection. To reap the benefits of CNC machining in terms of reduced energy consumption and production costs, a procedure is outlined for optimizing the process parameters of a CNC machining center. Taking into account the real-world constraints of machine tool performance and tool life, researchers conduct an analysis of the energy flow characteristics of the machining center processing system, establish a multi-objective optimization model with milling speed, feed per tooth, and spindle speed as optimization variables, and introduce a weight coefficient to facilitate the solution to convert it into a single objective optimization model." The experimental findings validate the practicability and efficacy of the multi-objective optimization approach, suggesting it could help businesses strike a balance between energy use and processing costs, thereby realizing savings and minimizing environmental impact.

Ye et al. (2020) [15] evaluated that the demand for "CNC machine tools" that can improve intelligence in a variety of ways has risen alongside the "enlargement of mainframe, internet, and information technologies." By shortening the production cycle and bolstering process planning stability, intelligent process planning plays a vital role in the current market's volatility and the development of customized products. With the help of a cloud-based knowledge base and the ability to plan processes independently based on the design of the workpiece, a CNC controller is demonstrated that can be used to perform intelligent process planning. Before diving into the specifics of the intelligent CNC controller's complete process planning method, this paper provides a brief overview of the research done on information prototypical and cloud information base structure strategy. The query/infer method used by the knowledge base and the interaction between the knowledge base and the CNC controller are both demonstrated in depth. An example process planning case study for two shafts is provided to illustrate the usefulness of the intelligent process planning approach. Table 1 provides a summary of the literature review:

Table 1. *summary of the literature review*

Author	Methodology	Outcomes
Guo et al. (2020) [11]	CNC machine, MTConnect protocol, and FOCAS	This research shows that CNC machine tool data gathering and storage needs can be satisfactorily met by using an apparatus data prototypical based on the MTConnect protocol and FOCAS.
Praveen etbal. (2022) [12]	mini-CNC machine	Therefore, a small CNC machine was constructed to examine the capabilities of developing technologies such the IoT, ML, and AI.
Kim et al. (2019) [13]	SME, KEM	Using inexpensive vision hardware like a camera and open-source software, this study introduces KEM (keep an eye on your machine), a novel monitoring approach for SMEs.
Xiao et al. (2021) [14]	CNC machine	The results of the experiments corroborate the viability and effectiveness of the multi-objective optimization approach, indicating that it can assist businesses in finding a happy medium between energy consumption and processing costs, allowing them to save money and reduce their environmental impact.
Ye et al. (2020) [15]	CNC machine	Both the knowledge base's query/infer methodology and its connection with the CNC controller are shown in great detail. A process planning case study for two shafts is shown to illustrate the usefulness of the intelligent process planning approach.

3. Results and Discussion

In CNC, a clatter arises when the instrument performs in a manner that is detrimental to the equipment, the equipment, or the components being manufactured. This can occasionally cause sharp tools, mountable hooks, curved wrenches, and fixtures to bend or fracture, as well as damage to the machine itself by bending slats, breaking hard-driving screws, or causing structural parts to fracture or alter form under stress. A little collision can not cause damage to the equipment or the equipment, but it can cause damage to the part being machined and compel its scrapping. Many CNC tools, when turned on, lack an intrinsic sense of the techniques' or the table's actual positioning. It is frequently feasible to push a machine over the actual limits of the drive mechanism without risking a collision with the machine or harm to the drive system. In addition to mechanical limit switches, many machines also employ control settings that restrict axis motion beyond a certain point. However, the operator can often alter these characteristics.

Additionally, a lot of CNC tools are ignorant of their operating environment. On spindles and axis motors, certain machines can feature load-sensing systems, while some do not. They obediently execute the specified machining code, and it is down to operators to recognize when a crash is happening or about to happen, and then manually terminate the ongoing operation. Although machines with load detectors can halt axis/spindle motion in reaction to loaded conditions, a collision is still possible. It might simply lessen the harm brought on by the collision. Axis or spindle motors can never be overloaded in some accidents. Usually, the setup operator gives the quality department a first item piece so they can check the measurements and approve the setup. A machine operator is on hand to make sure the CNC machine or related machines are functioning, producing components as specified, and having raw materials.

The drive system merely pushes against the barrier and the driving motors "slide in place" if the drivetrain is weaker than the device's structural integrity. The machine tool might not notice the collision or slip, therefore, for instance, it can be at 32mm where it should be on the X-axis after hitting the obstruction and continuing to slide. To avoid further accidents with the clamp, vises, or even the machine itself, all upcoming tool movements will be about 178 millimeters off on the X-axis. Closed-loop stepper systems cannot do this until physical slippage between both the motor and driving mechanism has taken place, which is typical in open-loop stepper systems. Instead, inside a closed environment, the machine will keep trying to move against the weight until either the motor fails to reach the required location or the drive motor enters an overload state.

Collisions can be detected and avoided with the help of absolute current sensors (optical transceiver strips or discs) to confirm motion and torque detectors or electricity sensors just on the drive system to detect abnormal stress when the device should only be attempting to move and not having to cut. However, most home computing numerical tools do not include such sensors. However, most DIY CNC machines rely exclusively on the apparent accuracy of stepper motors, which rotate a fixed number of degrees in response to changes in the Earth's magnetic field. Since it is generally accepted that the stepper is always precise, the monitoring tool position consists solely of counting the number of pulses fed into the stepper over time.

For axis movement, industrial CNC metalwork machines employ closed-loop feedback controllers. A closed-loop system uses an absolute or progressive encoder to track the real location of each axis. Although proper control coding will lessen the likelihood of a crash, it is still the responsibility of the operator as well as the programmer to make sure the machine is run safely. But machining simulation software has advanced quickly in the 2000s and 2010s, and it is now commonplace to properly represent the full machine tool envelope with 3D solid models. This enables the simulation program to forecast quite precisely if a cycle will contain a crash.

Although this type of model is not new, improvements in computers have significantly altered its precision and market penetration. The three-dimensional Cartesian system of coordinates serves as the foundation for all G and M code locations. This is a common type of plane seen in graphing in mathematics. The machine tool routes and any other types of activities that must occur in a certain coordinate must be mapped out using this method. Absolute coordinates, which describe the (0, 0,0) location on the plane, are what are often utilized more frequently for machines. Before beginning the actual machining, this point is established on the bar stock to provide a beginning or "home position".

For controlling machine parameters and NC programs, Direct Numerical Controls were employed. It made it possible for the software to be sent across a network from the computer system to outboard computers called computer-controlled units (MCU). It was originally known as "Direct Numeric Control," and while it did away with a need for paper tape, all of its equipment failed when the computer crashed. By providing a program to the CNC, distributed numerical control employs a computer network to synchronize the functioning of several machines. The program is stored in the CNC memory, and the operators can retrieve, amend, and retransmit the program.

Today's DNC applications can perform the following:

- Comparing - Compare the unique and altered NC programs side by side to observe the edits.
- Editing – Run one NC program while the others are being edited.
- Job tracking – Operators could indeed clock into the jobs and track setup as well as runtime, for example.
- Exhibiting sketches – Show pictures, CAD illustrations of tools, fittings, and complete parts.
- Progressive screen crossing point - One touch crushing.
- Sophisticated database organization - Organizes as well as upholds information where it can be recovered easily.

Software for machine checking can be integrated into DNC as well as MDC programs or purchased independently. To give both historical and real-time insight into how jobs perform, machine information including setup, duration, and downtime was automatically gathered and merged with subjective information such as cause codes by machine monitoring systems. 200 different sorts of data can be collected by modern CNC machines, and machine monitoring tools can make that data relevant for everyone from the factory floor to the upper floor.

Software (Tempus), provided by businesses like Memex, can be used to collect data from any type of CNC machine and store it in a standardized database format for visualization in the form of useful charts and graphs. MT Connect is a data standard adopted by the majority of machine monitoring products and has gained popularity in the USA. These days, a lot of brand-new CNC machines are prepared to deliver data in just this format. With adapters, outdated equipment might still supply useful information. Only in the past few years has machine tracking for CNC machines gained widespread acceptance, and new software options are constantly being developed.

4. Conclusion

The design is created in CAD software by a design engineer and sent to a CNC operator. To choose the necessary tools and produce the NC program for the CNC, the designer accesses the document in the CAM application. He or she gives an operator a list of the appropriate tooling configuration while also sending the NC program to the CNC machine. A setup person arranges the tools and raw materials as instructed (or workpiece). Then, to ensure that now the Machine is producing components following specifications, he or she runs test pieces or measures them using quality assurance equipment. Depending on the task, CNC machines can frequently be operated "lights-out" without an operator present. The final components are automatically relocated to the desired location. Modern manufacturers are capable of automating practically any decision that was made with enough time, money, and creativity. A machine can accept raw materials and produce finished pieces that are packed and ready to use. Manufacturers rely on a variety of Machine parts to produce goods fast, precisely, and affordably.

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