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Development of 3-Axis CNC Machine

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ABSTRACT - 3 axis Computer Numerical Control machines can cut, drill, and machine away materials in three dimensions. They do this by moving the platform with tools attached along each axisand rotating the platform around those axes using a controller. The tools used can be of different types depending on the materialbeing cut and the desired shape. The idea of making a compact and low cost 3 axis CNC milling machine comes from increasein demand of low cost and portable machine. So, we decided to make a portable machine which can mill the wood, plastics, thin sheet, and alloy. Design and fabrication are done using a precision stepper motor that combined with belt and pulley arrangement on the gantry type aluminum structure on which the x and y axis smoothly slide on rail bearing and for z axis we use threaded rod and arrangement for up and down motion that increases and more precisely is result obtained. It is a microcontroller (Arduinouno) based embedded system with standard PC user interface software for easy drawing. The system also features an offline G code parser and then interpretated on the microcontroller from an USB. Improved procedures are employed in the system to reduce the computational overheads in controlling a 3-axis CNC machine, while avoiding any loss in overall system performance.

KEYWORDS: CNC, router, 3-Axis, microcontroller, image processing, 2D, 3D, GRBL.

1.INTRODUCTION

A. Literature survey

While using automatic mechanical equipment, you must be precise, accurate, quick, reliable, and adaptable [1],[2].Com- puter numerical control is another name for numerical control (NC).By using a computer, CNC refers to the automated control of machining equipment (such as drills, boring tools, and lathes). Without a manual operator and by following preprogrammed instructions, an NC machine may modify a blank piece of material (metal, plastic, wood, ceramic, or composite) to fit exact specifications. Using particular input instructions, a computer core controls both a motorized ma- numerable tool and, frequently, a motorized maneuverableplatform in NC machines. A numerical control (NC) machine receives instructions in the form of graphic computer-aided design (CAD) files, which are then converted into a sequentialprogrammed of machine control instructions and executed the design of current CNC systems.

B. Related Works

The automatic manufacturing field has seen numerous attempts at building an automated production machine. The literature on machining by Khan, Mehtab, Hasan, and Hussain[3], a fully automated CNC machine for engraving and drillingwere created employing a ball screw mechanism and stepper motors that act as actuators for the linear slide ways. Because the ball screw mechanisms are more reliable, dependable, and have great mechanical efficiency at low maintenance cost, the machine's total efficiency increases. Moreover, steppermo- tors offer such accuracy without sacrificing torque and have accurate rotation. The research paper by Kajal J. Madekar, Kranti R. Nanaware, and Pooja presents the development of anautomatic mini-CNC machine for PCB drilling and drawing.

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II. DESIGN CONSIDERATIONS

Four things are considered while choosing alu- minium profiles: alloying components, aluminum smeltingfurnace, alloy casting, and profile extrusion [4]. The three axes of a 3-axis CNC machine must be properly aligned.Cylindrical rods are chosen because they allow for the smoothmovement of machine parts [5]. The screw's rotation is greatlysupported by the flange bearing, which also steps the print head or cutter in perfect alignment [6]. In addition to keeping threaded screws from accidentally opening, brass nuts offer accurate alignment for securing them. The following variablesare the most crucial to consider when choosing alead screw for a particular application: load capacity, pressure velocity factor, efficiency, speed, duty cycle, backlash, life, lubrication, and online selection and sizing [7].

TABLE I

TABLE OF LINEAR FORCES

Fzr	32.137N
Fzc	77.07N
Fyr	25.64N
Fyc	32.137N
Fxr	33.90N
Fxc	133.9N

The Table.1 indicates the forces acting on the respective guideways which are necessary for the selection of stepper motors. The forces obtained act linearly across the axis which are under constant load.

TABLE II

TABLE OF PEAK MOTOR TORQUE REQUIREMENT

Z-axis	Zt	0.136N
Y-axis	Yt	0.22N
X-axis	Xt	0.236N

Based on the calculations and results obtained, the torque requirement of all the axis falls in the range of NEMA 17 Stepper motor which has torque holding capacity of 0.4118793N [1]. The required power to run the spindle motor is 7.54W at 6000RPM which falls under the range of standard power output limit (i.e,7.68W).Fig.1 is the 3D Design of CNCMachine.

III. MODELLING

The modelling was done using Creo software.

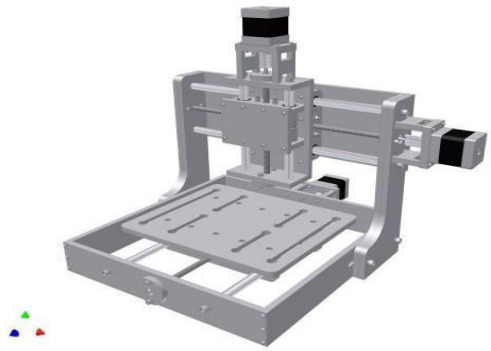

Fig. 1. 3D Design of 3 axis CNC machine

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InFig.1. 3D Design of 3 axis CNC machine made using CREO Software.

IV. SYSTEM ARCHITECTURE

In Fig.2, First the part program is inserted into the MCUof the CNC.In MCU all the data process takes place and according to the program prepared; it prepares all the motion commands and sends it to the driving system. The drive system works as the motion commands are sending by MCU. Drive

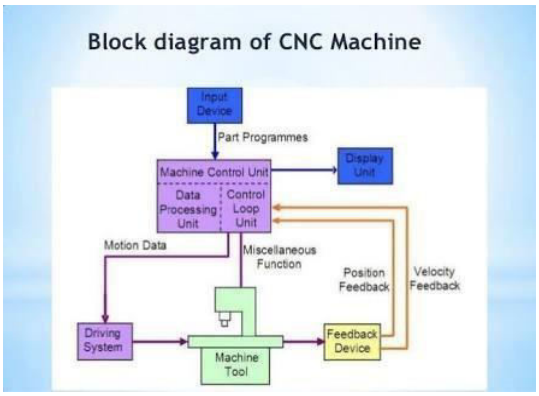

Fig. 2. Block diagram of system architecture

system controls the motion and velocity of the machine tool. Feedback system, records the position and velocity measurement of the machine tool and sends a feedback signal to the MCU. In MCU, the feedback signals are compared with the reference signals and if there are errors, it corrects it andsends new signals to the machine tool for the right operation to happen. A display unit is used to see all the commands, programs, and other important data. It acts as the eye of the machine.

V. EXPERIMENTS AND RESULTS

Following tests were carried out on the machine which is shown in the Fig.3 and specific results were obtained.

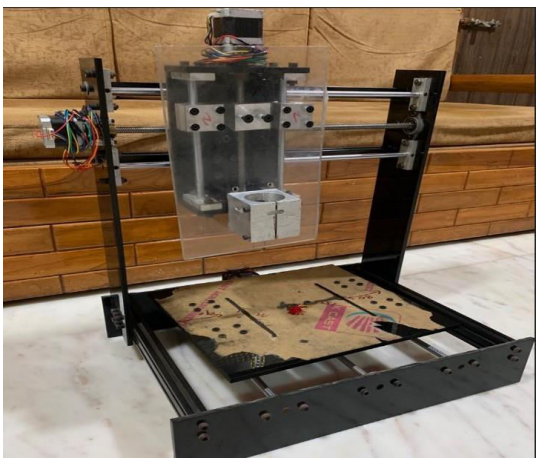

Fig. 3. CNC portable machine

A. Cutting system tests

The cutting system test was conducted on an acrylic sheet having 3mm thickness, using 3mm diameter end mill drill bit, 6000 rpm spindle speed and 20mm cutting depth. Image was designed using Artcam software.

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B. Engraving system tests

The engraving system was conducted on an acrylic sheet of 3mm thickness, using 3mm vbit60° drill bit, 6000 rpm spindle speed and 1mm engraving depth. Image was designed using Artcam software, design examples using writing combinedwith engraving pattern.

C. Marking system test

The marking system was tested on an acrylic sheet with 3mm thickness, using 3mm bit and end mill drill bit, 6000 rpm spindle speed and 1mm and 0.5mm marking depth.

D. Depth test

The measurement was conducted to check the level of precision on the depth of CNC machine while working. Testingis creating 6 lines each of which has 50mm length and 2mm depth using a 3mm end mill drill bit with a spindle speed of 6000 rpm. In Fig.4.

Fig.4. Depth Test.

E. Speed test

The speed test is conducted to determine the effect of angle on the speed in the object formation. The inputs for this testare various designs which will be formed to resemble some2D shape. With 1mm engraving depth on acrylic using 3mm end mill drill bit. Uploaded designs will be timed using a stopwatch to see how long it takes for each design to be made.

F. Accuracy test

This test is conducted to determine the precision level of CNC engraver. This test was about engraving 6 lines of different lengths and each of 1mm by using 3mm vbit60° drill bit with 6000rpm spindle speed.

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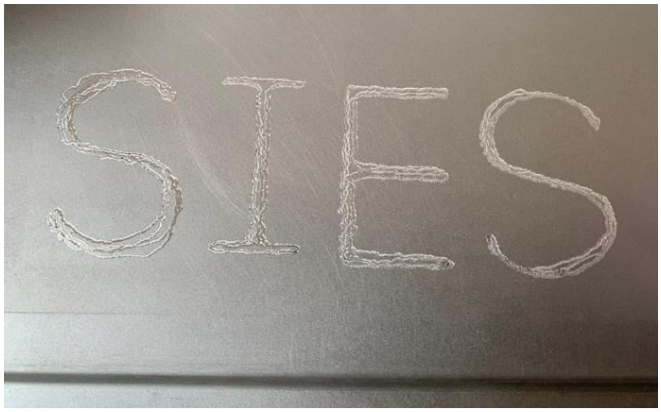

Fig.5. Final Output.

VI. CONCLUSION

The CNC router machine, with a 20x20cm cross-sectional area and a 30-Watt spindle motor, was successfully built utilizing ATmega328p and IC4988 microcontrollers in conjunction with three NEMA 17 stepper motors. The CNC machine has a 99.9 percent carving accuracy and 100 percent depth accuracy, allowing it to be used to cut, engrave, and mark the wood to construct 2D things. The GRBL library and Universal G-code Sender Software were used to control the process of synchronizing the three stepper motors.

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