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Mini CNC Engraver Machine

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Abstract— **A Computer numerical control (CNC) is a computerized machine which is related to engraver used for milling, cutting, engraving various hard materials such as steel, wood, plastic and aluminum. It creates efficiency in many industries. Machining and accuracy are the main benefits of CNC engraver. The aim of this work is to reduce cost and complexity of CNC machine. For this the mechanical setup is constructed in wood. The design and development CNC comprises with the Arduino as the central element in controlling the motion in X, Y and Z (Three axis) direction of the CNC machine. The engraved material is the result of the 3-axis stepper motor arrangement and precise construction of the machine. These include printed circuit board (PCB) drawing, wood engraving, aesthetic designing and glass etching.**

Index Terms— Arduino, CNC, Engraving, G-Code, GRBL.

I. INTRODUCTION

Due to lack of imagination and innovation many problem and uncertainty occurs. CNC engraver is a revolutionary machine which surpasses the old CNC machine. A CNC engraver is very similar concept of CNC milling machine. It reduces worksheet residue and frequency of errors. It plays a vital role and it has critical part in many industries. The numerical control (NC) machines were not controlled by the computer built in the 1940s and 1950s, based on the existing tools that were modified with motors that moved with the control to follow points fed into the system on punched tape. In numerical control systems, the position of the tool is defined by a set of instructions called the part program. Later, CNC machine comes into the picture. CNC machining is a process used in the manufacturing sector that involves the use of computers to control machine tools. Tools that can be controlled in this manner include lathes, mills, machines and grinders (Yang et al. 2006; Kajal et al. 2016; Bhavani et al. 2016; Mohammed et al. 2016; Roshini and Sonali 2017). In this work, tool paths are controlled via computer numerical control. This work deals with design of automatic CNC machine for drilling, engraving and cutting. Three unipolar stepper motors are used for three axis movement. G-code is the heart of the CNC engraver machine. G-codes are used to command specific movements of the machine, such as machine movement or drilling functions. G-code is also known as RS-274 is the common name for the most widely used NC Programming language. G-code is interfaced with the Arduino CNC based Controller by GRBL module. It is used to convert the G - code into

conventional/convenient controller code (i.e) serial to USB converter. Hence, it acts like interfacing module between PC to controller. In modern CNC system, the design of a mechanical part and its manufacturing program is highly automated. CNC system used for the process that can be described as a series of movement and operations such as laser cutting, welding, stir welding, ultrasonic welding etc. Mini CNC Engravers are much smaller in size and available in affordable cost. Here it is tried to develop a CNC technology to make it more portable and up gradable to 3D Printer for smaller issues with much less power.

II. HARDWARE DESCRIPTION

Literature review related to the CNC engraver machine using GRBL, PLC, Fanuc open, G-code are presented here (Hong et al. 2005, Saputra et al. 2011, Sherring et al. 2012, Balasubramanyam et al. 2014).Zulkifli et al. (2010) proposed the CNC PCB drilling machine using novel natural approach. The system is to increase optimality machine usage and consequently give higher efficiency result by travelling salesman problem (TSP).The TSP naturally arises as a sub problem in many transportation, industries and logistics applications. They realized that TSP has caught much attention of mathematics and computer scientist specifically because it is easy to describe but difficult to solve. Traditionally, a traveling salesman wants to visit all cities without repeating any in while the edges are roads connecting the cities. Weight on the edges indicate the time or distance to travel between cities. Likewise the CNC is also implemented using TSP algorithm.

Pavel and Jaromir (2012) implemented the drilling of circuit boards using CNC controlled by programmable logic controller (PLC). The system is designed to automate the CNC machine and to monitor the overall process of the machine using EAGLE software. The system consists of three subdivisions namely controlling, monitoring and displaying. The entire process is controlled by PLC software. They identified that the visualization software used for monitoring and visualization of the laboratory task which is focused on CNC model machine positioning and CNC model movement was controlled via unification circuit by the PLC machine according to precise coordinates gained from the PC by OPC communication. This system improves the quality and reduces scraps.

Dong and Zhuang (2014) implemented the machine tools supervisory system based on the information model. The system is to design CNC to manufacture products with faster, smoother and laser machining of curves, complex 3D dimensioned profile to improve the productivity and quality of the product. They implemented process monitoring and analytical technology, which analyze the data of continuous feedback during the manufacturing process with analytical tools and encourage industry to adopt innovation technologies to increase quality. They have monitored the different CNC status using software like FANUC open CNC. This system improves the machine health maintenance.

Mohammed and Ahmed (2016) proposed controlling the CNC machine using microcontroller to manufacture PCB. The system is designed to produce robust and cost effective method of controlling a CNC to manufacture the printed circuit board (PCB) to make electronic projects easier, more flexible and faster to implement through simplifying the complex circuit topology. The entire process is controlled by microcontroller in which the machine code was converted through G-Code and transferred to microcontroller through serial communication port. They identified that the dimension limits the sensor to stop the drill from going out of the machine table.

Kajal and Kranti (2016) implemented the automatic mini CNC machine for PCB drawing and drilling. The system is designed to fabricate the low cost CNC to drill and increase the flexibility of the machine. The entire process is used by G-code. They identified that the movement of stepper motor can be done by converting the machine code into pulses. This can be done by using G-code is interfaced with ATMEGA 328. The G-code with the hardware setup gave better accuracy and reduces the work load.

Bavani and Jerome (2017) implemented a CNC router using Arduino. They have illustrated the design of automated CNC machine with the low cost and with small size to increase the flexibility and cost of the machine. They identified the system which meets the demands of miniaturization with least mechanism requirements. The process consists of three axis such as X-axis, Y-axis, and Z-axis which are controlled by an Arduino for reduction in operating costs as compare to the other process. The system is used in wood working and manufacturing industries.

Martheyn et al. (2017) analyzed a parallel control firmware for CNC milling machine based by using Arduino. The system is framed using master slave algorithm. They observed that there are more industries implementing these machines to produce their own products with low cost, high quality and less environmental impact such as 3D printers, a CNC machine branch which has evolved allowing faster and cheaper prototyping with acceptable percentages of error, for industries and designers such as Formula1 cars parts development. They achieved parallel control of CNC machine by WiFi or Bluetooth.

From the literature review, it is observed that GRBL software is used mainly to send G-code to Arduino. Arduino-uno is used for controlling the system process to coordinate the stepper motor in three axis. In this work, the CNC Engraver is constructed with low cost and high accuracy. The mechanical setup of the CNC Engraver machine is constructed with wood. Stepper motors used can be either unipolar or bipolar which can be controlled by stepper motor drivers. Limit switch is used to prevent ramming of Z-axis housing compartment with side vertical beam which gives better mechanical stability.

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III. EXPERIMENTAL DETAILS

The following section deals with the components and tools used in the CNC Engraver machine Stepper motor (Model: NEMA 17, Make: Minebea Co. LTD) is used to control the X, Y, Z axis of the CNC Engraver machine. Driver circuit (Model: V44A3967, Make: Absolute Native Electronics) is used to maintain the speed of motor and to control the voltage regulation of the motor. CNC shield (Model: V3) is used to convert the G-code into Arduino Code. Arduino-uno (Model: ATmega328) is used to control the motor with respect to the program, pulses to be given to the motor. DC spindle motor (Model: AD12V, Make: Themisto) is used to engrave the given design on the working plate. Drill bit, chuck, polish rod, screws and nuts are the other hardware parts used in mechanical structure of the CNC machine. Figure 1 shows the schematic diagram of the CNC Engraver machine which consist of three stepper motor and one DC motor. The stepper motor can be used for various axis such as X-axis, Y-axis, and Z-axis. X-axis is to move Z-axis housing whereas DC motor timing belt is used. Y-axis is to move the working plate. The DC motor is used to engrave given design on the moving plate. The stepper motors are connected to the CNC shield with Arduino-uno. The CNC shield is excited with the power supply of 12 V. For attaining 12 V, power adapter is used to lower the voltage from 230 V to 12V to run the motor. The design to be engraved can be designed through the Inkscape software. The Inkscape software is to convert the diagram into G-code. GRBL module is used to convert the G-code into Arduino code. The Arduino sends the appropriate driving signals to stepper motor driver to run the stepper motor in deterministic way.
Figure 2 shows the flowchart of the CNC Engraver machine.

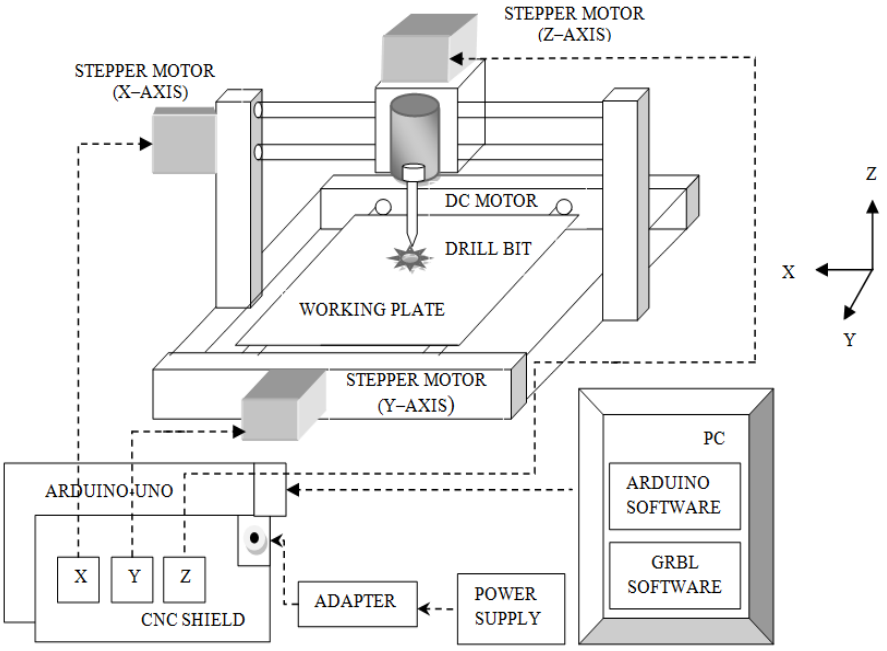

Fig. 1. Schematic diagram of CNC engraver machine

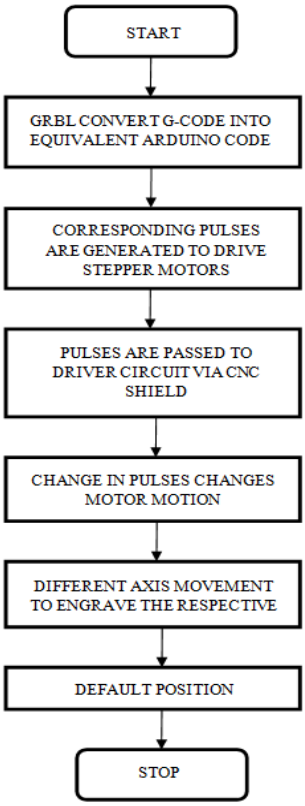

Fig. 2. Flowchart of the CNC Engraver machine

IV. MECHANICAL DESIGN

The mechanical design and programs for the CNC Engraver machine are briefly described.

A. CAD Model for the CNC Engraver Machine

Figure 3 shows the CAD design of the CNC Engraver machine using (Design spark). It is also one of the CAD software which is majorly concentrated for CNC machine designs. The design steps are traditional such as first the base is designed, then the working plate (green plate) is designed then the two side vertical beams are designed.

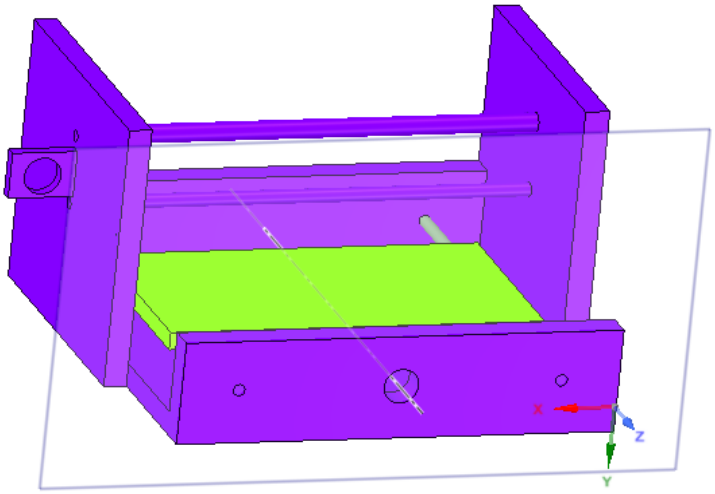

Fig. 3. Cad Design of CNC Engraver Machine Using Design Spark (AutoCAD)

B. Grille Software for Engraving Process

Figure 4 shows the GRBL software for engraving process. GRBL software is used to interface the G-code with the Arduino. This software is used to change the codes into the required arduino code which is used to get engraved.

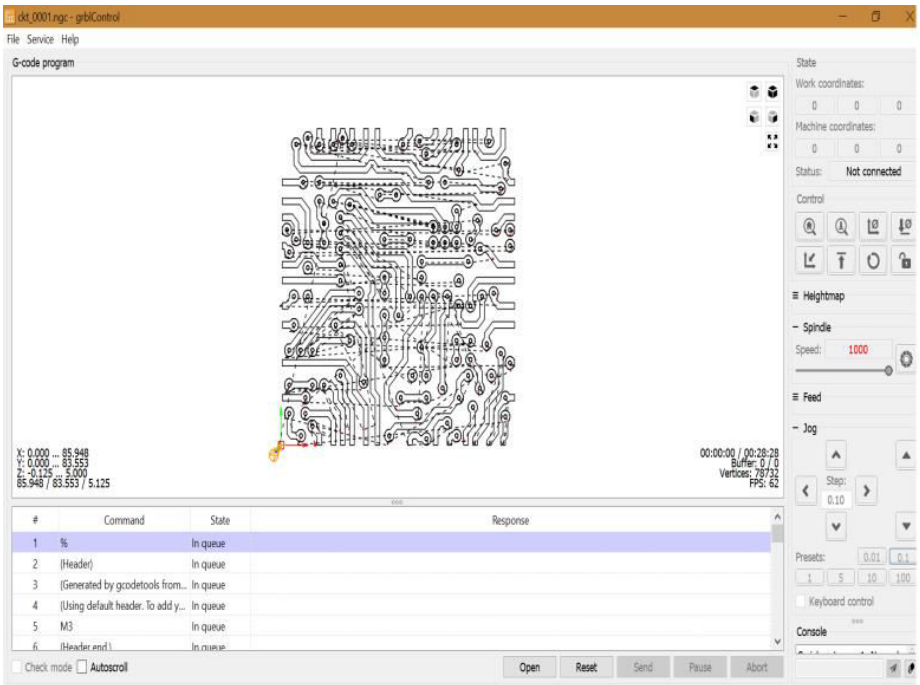

Fig. 4. GRBL Software for the CNC Engraver machine

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V. HARDWARE DESCRIPTION

The whole CNC engraver is constructed in Plywood namely 7 layer plywood. Figure 5 and 6 shows the photograph of CNC Engraver machine front view and top view respectively. The base area of the CNC machine is 420 mm x 380 mm. The stepper motor is mounted on the base plate for Y axis. The area of the motor is to be mounted on Y axis is 40 mm x 40 mm. The stopping plate is constructed on both side of base plate with the area of 400 mm x 150 mm. The two holes of diameter 10 mm is drilled on stopping plate for the insertion of stainless steel rod. The stainless steel rod of diameter 10 mm is used for the movement of working platform. The working platform of area 230 mm x 290 mm is mounted on the stainless steel plate with the help of linear bearing. The linear bearing of diameter 12 mm is used for the better movement of the working platform. For the movement of X and Y axis, timing belts are used. The centre of stopping plate is drilled with diameter of 50 mm which is to mount pulley for rotation of timing belt. The height of two side beams is 380 mm. The X axis has two stainless steel rod of length 460 mm. Another stepper motor is mounted on the x axis with 4 mm x 4 mm area. The timing belt is used of length 400 mm. At the centre of two side beams with the diameter of 50 mm is drilled. The pulley is inserted at one of the side beams with the help of screws and nuts. Two stainless steel rods are inserted on side beams. The timing belt is connected with the Z axis housing and linear bearing is inserted into the steel rods for balance of the housing. The Z axis arrangement is a quite complicated. Z axis is used for the up and down movement with housing is of area 180 mm x 95mm. For Z axis movement thread rod is used. Another motor is mounted at the top of the housing. The threaded rod is inserted into the shaft of the motor. This tends to move threaded rod at the time of motor running. The 3 layer plate is mounted with the help of screw for DC spindle motor arrangement. The linear bearing of diameter 12 mm is used. Finally, a DC motor is mounted on the Z axis housing to start drilling process.

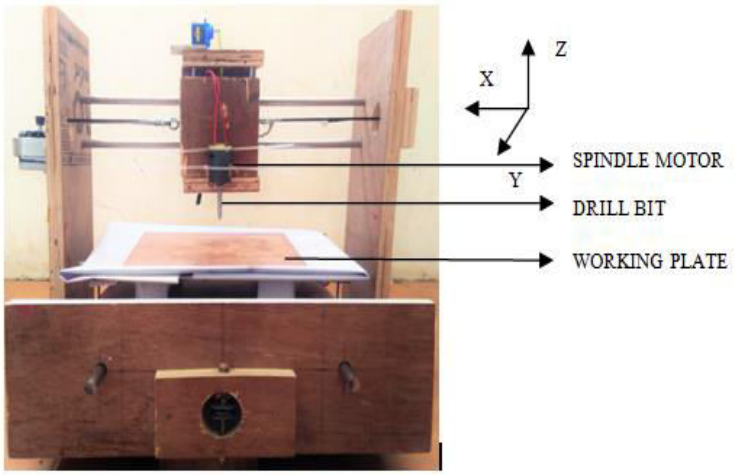

Fig. 5. Photograph of the CNC Engraver machine (Front view)

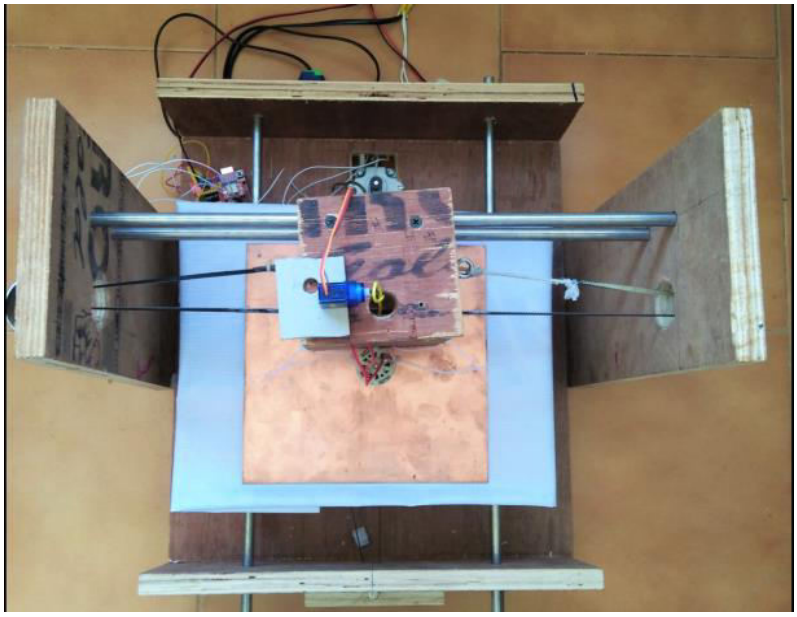

Fig. 6. Photograph of the CNC Engraver machine (Top view)

VI. CONCLUSION

In this work, a mechanical working model of a CNC which is able to draw a PCB layout and engrave wood and glass is constructed. The CNC PCB drilling machine is equipped with three dimensional movements and considered to produce good precision accuracy for a competitive development cost. This collaboration of hardware with G-code gives better productivity and reduces the work load. This design approach gives promising result to yield better output design. G code make easy to find the information of locations of all stepper motor moving, as the status of our moving motor are directly seen on computer hence we can start or stop the machine whenever we are needed. Making a small machine brings a flexibility to do work.

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