Study and Design of Arduino Based CNC Laser Cutting Machine

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Abstract. For precise job manufacturing, system should possess good dimensional accuracy and surface finish. In applications like drilling, punching, marking, boring, tapping work piece is positioned firstly and then cutting tool performs its action while motion axes are kept stationary. In traditional approach for such applications, manufacturer uses highly expensive CNC machine for programming job cycle and executing the same. Big scale manufacturer can afford such highly expensive machines but for small scale mechanical job manufacturing industry we have to think of low-cost solution that can deliver high class output. In this project we are trying to propose low-cost design which gives similar functionality as that of high-cost CNC machine. By applying this machine in industry, it can acquire the multi generation brief time. In order to perform some operation which requires continuous cutting over a pre-defined curve, CNC machines are used as the traditional machines in the industry. Installation of a CNC machine requires a high financial investment and a skilled labour to perform the different operations on the machine. Apart from that the maintenance cost of such machine are also high. In small scale industries where the operations are performed on small job pieces, the installation of such high-cost CNC machine is very difficult; hence this project work is taken up in which a low-cost CNC laser cutting machine is designed using the Arduino. This CNC laser cutting machine will be quite useful for small scale industries where the job size is not very large. Also, the machine does not require a highly skilled labour to perform operations.

Keywords: CNC Laser cutting machine, Arduino, Proteus, design, modelling.

1. Introduction
A number of techniques have been developed by the researchers for optimizing multiple characteristics of the products. Kumar et.al. [1], design and fabricated a portable laser cutting and engraving machine and provides the fundamental goal to design and fabricate the laser cutting and engraving machine which is conveniently controlled by the Arduino CNC. It was made affordable than that of CO₂ laser cutters which is one of the precise and advantageous forms of cutting available today. CO₂ lasers are commonly pumped by passing a current through the gas mix or using radio frequency energy. They used the ELEKSMAKER Software to convert the graphical image into a G code language. Laser Diode Modules of 500mw power with 450nm wavelength are utilized as a part of an assortment of uses that require little sizes not withstanding low power utilization with long working life-time. All
design outlines were done on Solid works software. Stepper motor used in the model controlled by a microcontroller called Arduino CNC Shield Driver. The key point was proficient that was to produce a laboratory modeled Laser cutting and engraving machine. The result seems for the better quality cutting and engraving. Reza et.al. [2], described the design and fabrication of a microcontroller-based plotter and focused on the sketching aspect of the industry. The complex designs from the different industrial workshops can be obtained by the use of such types of machines. In this project three motors were used to obtain the range of motion across three translational axes X, Y, and Z. The Arduino IDE was used for the programming of the microcontroller while CAMotics software was used in order to generate the G-codes.

Madekar et.al. [3], fabricated the automatic mini CNC machine for PCB drawing and drilling operation. The main intention of this study was to design and drill PCBs at a low-cost CNC system. In order to achieve this low-cost goal, the machine incorporates features of a computer with the ATMEGA 328 controller in an Arduino. For the connection of the computer and the hardware, FTDI (Future Tech Devices International) module is used which is a serial to USB converter. All the modeling was initially done on the Solid works interface and later on fabrication was done. In addition, Firangi et.al. [4], developed the model of a CNC plotter machine which is able to draw a circuit layout on PCB or any other solid surface using the electronic component. In this project, Arduino Uno is used with the atmega328p microcontroller and is used as the control device. A servo motor is used along the Z-axis for positioning the pen which moves up and down. The stepper motors used in this project are bi-polar stepper motors whereas the servo motor used is the most common S90G servo motor particularly used in the low torque robotics applications. In another study by Joshi et.al. [5], a mini pen plotter machine that is capable of drawing difficult designs and write on paper or writable surfaces using G codes was fabricate. This small machine was portable and easily assembled as per requirement. For accurate functioning, they used two Stepper motors for precise movement in the X and Y axis respectively, and one servo motor for lifting up the pen in the Z direction. The author used drivers to supply the G codes in Sequence to the stepper motors and servo motor. The author used the Arduino UNO microcontroller board which controls the position of motors with help of a program. CNC shield mounted on Arduino which distributes the current in the command of the Arduino and converts the command of G codes in digital pulse by Stepper motor. The machine worked on input as G codes of design and converted it via the use of software further transferring to Arduino, CNC Shield, Stepper motors, Servo Motor.

Jayachandraiah et.al. [6], provided the idea to develop the low-cost Router system which is capable of 3 axes simultaneously interpolation. The low cost prototyping is achieved by incorporating the features of the standard PC interface with microcontroller base CNC system in an Arduino based embedded system. With a limited budget, the author concludes that small machine tools to fabricate small parts can provide flexibility and efficiency in the manufacturing approach and reduce the capital cost, which is beneficial for small business owners. In a review, Badoniya [7] examined the recent experimental investigations in laser cutting of various engineering materials concerned with cut quality analysis. The objective of this study was to identify the most common process parameters analyzed, cut quality characteristics. The results indicated that the quality of cut depends upon many control factors or parameters such as laser beam, material, assist gas and processing parameters. Therefore, the purpose of present work is to develop a methodology that would allow us to design and simulate the portable laser cutting machine.

2. Objective
The present investigation was carried out to study and design the portable CNC laser cutting machine using Arduino and also to simulate the machine on a virtual platform and make it usable for cutting purpose for small scale industries.

2.1. Initial Design
The structure of laser cutting machine has been designed and modelling in Siemens NX 12.0 software with desired dimensions (Figure 1). All parts of the machine will be achieved before implementation of
the hardware of the actual laser cutting machine. This design will be further modified by some iteration and simulation. Some iterations will be done in order to achieve a final design to make it more stable and realistic.

Figure 1 Isometric and Front view of the Assembly

2.2. Final Design
After some iteration and motion simulation, the final design is achieved based on the interaction between the different components of the assembly (Figure 2). The final positioning of the different components like motors, lead screws and mounting plates is decided by considering the minimum tolerance and desired stability.

Figure 2 Isometric and Front view of the final rendered Assembly

3. Results and Discussion

3.1. Implementation of the process
Step 1 - Firstly programming of Arduino has been done.
Step 2 - Now in the Inkscape software, the design imported or the shapes to be cut sketched on the interface.
Step 3 - In the third step the design traced by the feature called bitmap tracing and after this, objects converted to paths.
Step 4 - Now the G-code file generated.
Step 5 - The G-code file opened by using GRBL controller/ Universal G-code sender.
Step 6 - The home of the machine set and the file sent to the hardware to start the cutting operations.
Step 7 – The electronic simulation is done on the Proteus software in order to validate the Arduino and stepper motor circuit.

Step 8 - In the last, motion study of the final CAD model is done to check any type of clearances between the machine parts on Solid works.

Flowchart representing the implementation of the process

3.2. Arduino Coding

For controlling the machine, Arduino UNO is used as the microcontroller. For the processing of the G-code and sending the signals to the individual driver is done by an Arduino coding using grbl library. In case of controlling the machine axis using different buttons, Arduino code was developed in the platform Arduino IDE.

3.3. Simulation of Arduino based CNC by Proteus and GRBL firmware.

In order to simulate the Arduino, stepper motor and CNC code, Proteus software is used with GRBL firmware. The Proteus Design Suite is a proprietary software tool suite developed by Labcenter Electronics used primarily for electronic design automation, schematic capture and PCB design. Its simplicity and user friendly design made it popular among electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards. Arduino can't operate NC by its own. Some firmware is used for doing that job. GRBL is one of popular and open source firmware. For virtual simulation, there is a need of virtual port driver. Virtual Serial Port Emulator named software application is used that replicates physical COM ports and are treated in the same way as a real port. G-code file is needed for the simulation that was generated previously from the Inkscape software. The main focus was to run the stepper motors through Arduino. After the code was executed. The designed circuit was simulated in Proteus software. Simpler layout of the circuit is shown in figure 3.

In order to connect the GRBL firmware with the Proteus software, there are several components used in the Proteus software like ARDUINO UNO R3, LEDBIBY, LOGICSTATE, MOTO-BISTEPER, DRV8825,COMPIN, VIRTUAL TERMINAL. The virtual COM pin from the Virtual Serial Port Emulator pinned in Proteus to work as a real physical port. The Hex file of GRBL to Arduino is introduce in Proteus software.
3.4. Design Motion study
The design motion study has been carried out on the solid works software. Motion studies are graphical simulations of motion for assembly models (Figure 4). They simulate and animate the motion of a prescribed model. The main objective of the motion simulation is to see how components visibly interact with each other.

4. Conclusion
We can see that all the production-based industries wanted low production cost and high work rate which is possible through the utilization of multi-function operating machines which will consume less power as well as less time, since this machine provides working at different environments it really reduced the time consumption up to appreciable limit. This project is a combined effort and the goal of this project
is to design a cost-effective CNC laser cutting machine which would help the small-scale industry. It would help laser cutting easily at certain desired depth. Using small machine tools to fabricate small scale parts can provide both flexibility and efficiency in manufacturing approaches and reduce capital cost, which is beneficial for small business. Arduino based CNC laser cutting machine is designed and implemented under very limited budget. From this paper, we can get a machine which has high accuracy and low cost as compared to large traditional CNC machines.

5. Practical Implementation
1. Can be used very efficiently in small scale Industries.
2. Affordable and can be manufactured very easily.
3. Reduces labour cost as single computer can be used to control many machines.
4. Increases product quality because human errors are eliminated.

6. Limitations
1. Cannot be used in large scale manufacturing system because of Arduino.
2. There will be the maximum size limit of the job because of the limited work area.

Conflict of interest
None.

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