WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

AN APPROACH TO THE DEVELOPMENT OF ARDUINO BASED MULTI-PURPOSE COMPACT LOW-COST CNC LASER WOOD ENGRAVING AND PAPER CUTTING MACHINE

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A B S T R A C T

In the laser engraving process, the laser beam hitting the top layer of the surface to be engraved vaporizes the material into fumes to engrave permanent deep marks. While in laser cutting the laser beam has to penetrate through the surface resulting in a cut edge. This can be achieved by prolonging the laser beam on a particular area for a longer period duration decided based on the strength of the material to be cut. In the present study, an attempt was made to design and fabricate a Mini CNC Laser Wood engraving and Paper cutting machine that can engrave 2D & Gray scaled images or pictures with help of a high watt burning laser module on the paper and wood. This machine can also be used to cut out paper patterns and thermoplastic sheets to produce desired shapes and patterns.

Keywords*: CNC Laser Engraver, CNC Laser cutting, CNC Papercutting*

1. INTRODUCTION

Computer numerical control is an advanced automation technique used to control the motion and operation of machine tools. CNC Machines work on the program's commands written using computers in coded formats. Products manufactured by the CNC machines are precise in their dimensions. Inspired by the CNC technology and the advancements in the world of digital electronics and microcontrollers we are presenting in this paper an approach to the development of a mini laser wood engraving and paper cutting machine built on the principle of CNC technology controlled by the Arduino platform. The machine built represents a microcontroller-based intelligent system for laser engraving.

In the laser engraving process, a laser beam physically removes the surface of the material to expose a cavity that reveals an image when looked at it. During the engraving process, the laser beam creates high heat, which essentially causes the material to vaporize. This creates a cavity in the surface of the wood that is noticeable and used for cutting the papers as per the profile created by the laser beam movement. Several passes are to be done to get deeper marks during the engraving process. In the present work, a low-cost, mini CNC laser wood engraving and paper cutting machine was developed. Open source microcontroller platform Arduino is used for control of the motors, and open source software is used for executing the G codes for laser engraving.

2. COMPONENTS AND DESIGN

The Mini-CNC Laser wood engraving and paper cutting machine consist of three major functional systems. They are,

a) Mechanical frame,

b) Electric system and

c) Control and computing system.

Following are the important Electrical and Control system components of the machine:

a) Laser Gun with the driver circuit board

b) Stepper Motor

c) Arduino board

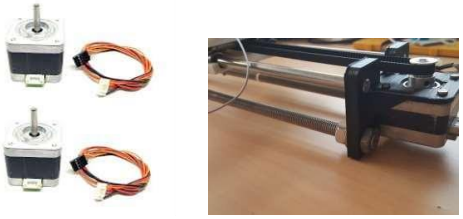
d) SMPS unit

As ultraviolet lasers have been widely used for applications in industrial laser engraving an ultraviolet 500mw power laser module with 405nm

wavelength was chosen for this machine shown in figure 2.1.

Fig. 2.1 – Ultraviolet Laser module with control panel

A stepper motor is used to achieve precise positioning via digital control. The motor operates by accurately synchronizing with the pulse signal output



from the controller to the driver. Stepper motors, with their ability to produce high torque at a low speed while minimizing vibration, are ideal for applications requiring quick positioning over a short distance. Stepper motors enable accurate positioning with ease. They are used in various types of equipment for accurate rotation angle and speed control using pulse signals. Stepper motors also hold their position at the stop, due to their mechanical design. A 12V DC stepper motor and sliding rod unit used in this machine are shown in figure 2.2.

Fig. 2.2 – Stepper motor with sliding rod unit

The main component of the machine, an Arduino Uno R3 which only runs on G-codes was selected for the machine. The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started the board features an Atmel ATmega328 microcontroller operating at 5 V with 2Kb of RAM, 32 Kb of ash memory for storing programs and 1 Kb of EEPROM for storing parameters. The clock speed is 16 MHz, which translates to executing about 300,000 lines of C source code per second. The board has 14 digital I/O pins and 6 analog input pins. There is a USB connector for talking to the host computer and a DC power jack for connecting an external 6-20 V power source. The Arduino board with the driver shield is shown in figure 2.3.

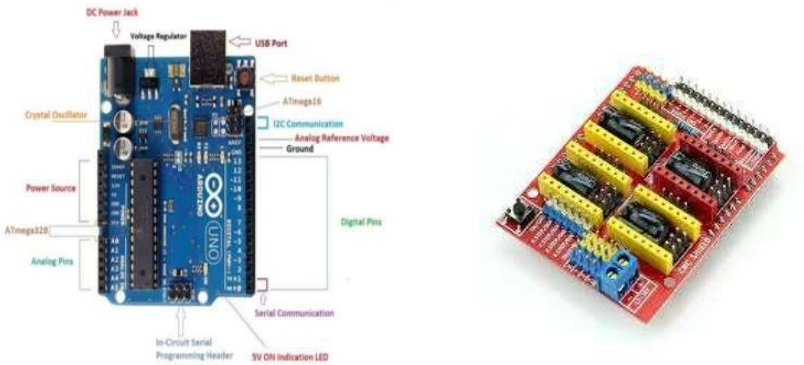


Fig. 2.3 – Arduino microcontroller with driver shield

The specifications of "Arduino Uno R3" is shown below in Table 1.1.

Parameters	Specifications
Micro-controller	ATmega328p
Operating Voltage	5 V
Input Voltage (Recommended)	7 – 12 V
Input Voltage (limits)	8 – 20 V
Digital I/O pins	14
DC Current per I/O pins	40 mA
Flash memory	32 kb (of which 0.5 kb is used by the boot-loader)
SRAM	2 kb
EEPROM	1 kb
Clock speed	16 MHz

Table 1.1 Arduino parameters & specifications

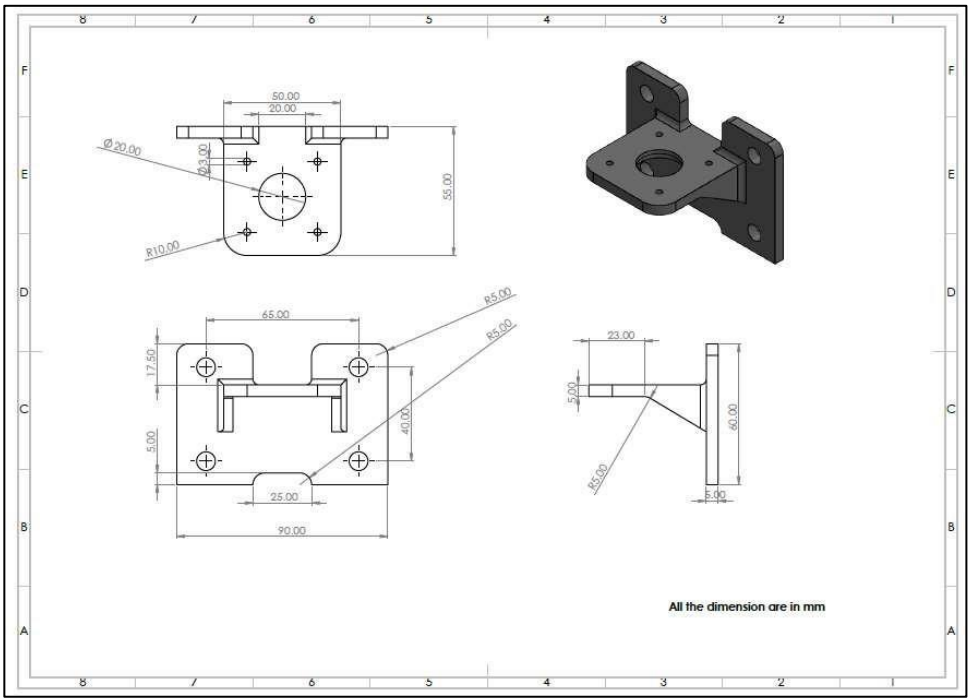
An SMPS (Switch Mode Power Supply) is used to step down 230V AC to 12V DC. The 12V DC supply used for supplying power to ARDUINO driver

shield V3 is shown in figure 2.4.

Fig. 2.4 Power supply

The open-source Arduino Software (IDE) is used to write code and upload it to the board. The Benbox Laser engraver software is used as a CNC platform for laser wood engraving and paper cutting machines.

For designing the Mechanical framework of the mini CNC Engraver machine SOLIDWORKS software was used. The part modeling and assembly of



the machine were done in the software before fabricating the machine. The Part models and assembly are shown in figures 2.5 to 2.9.

Figure 2.5 Motor clamp

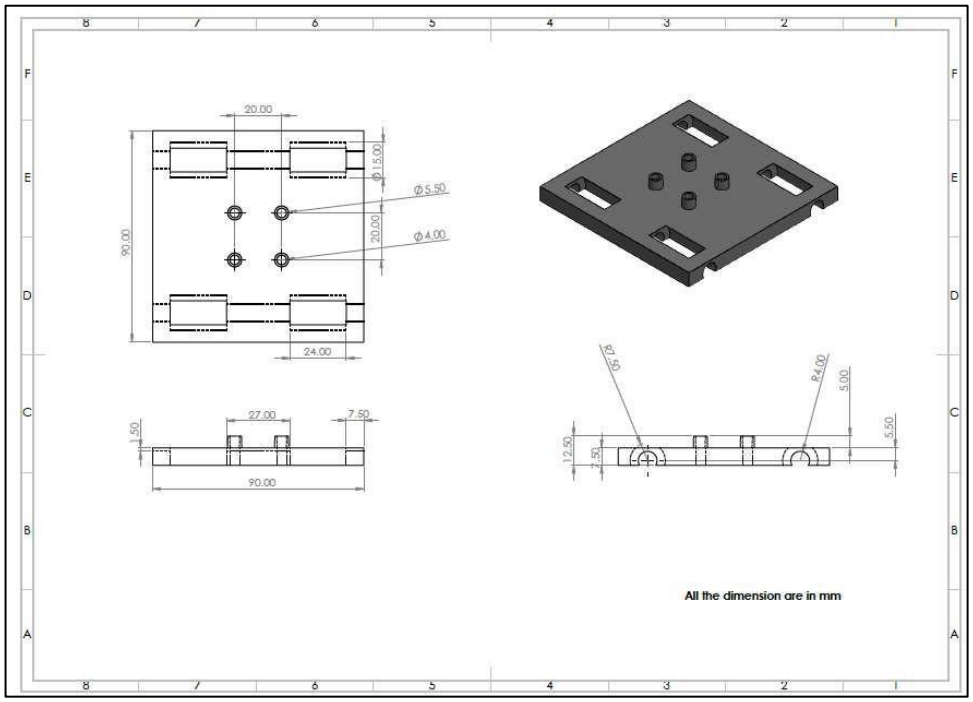


Figure 2.6 Top & Bottom carriage

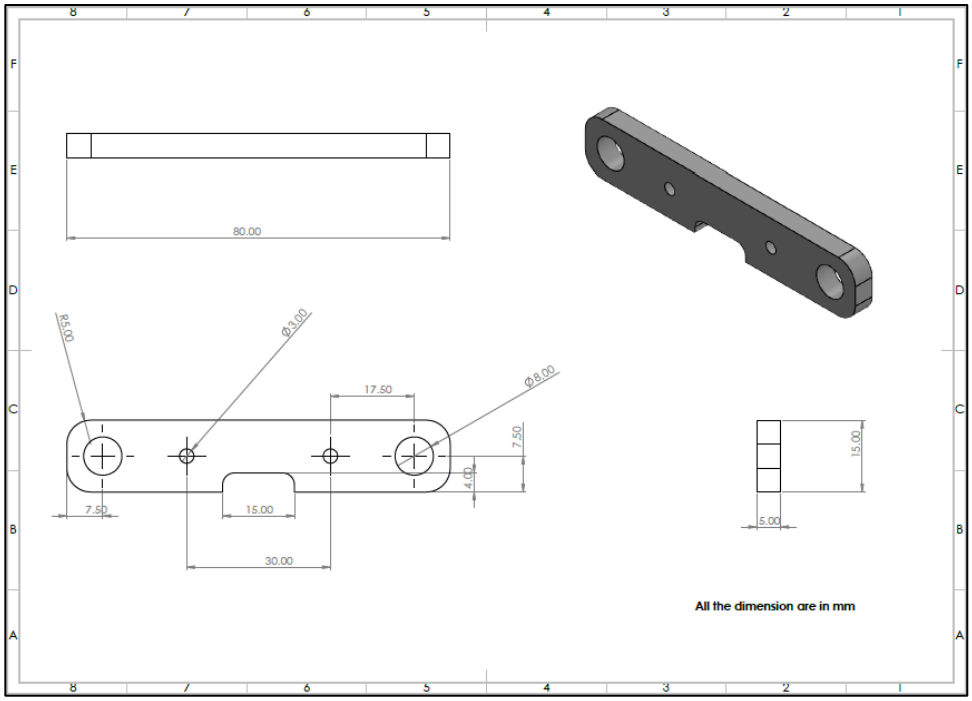


Figure 2.7 Side rod holding plate

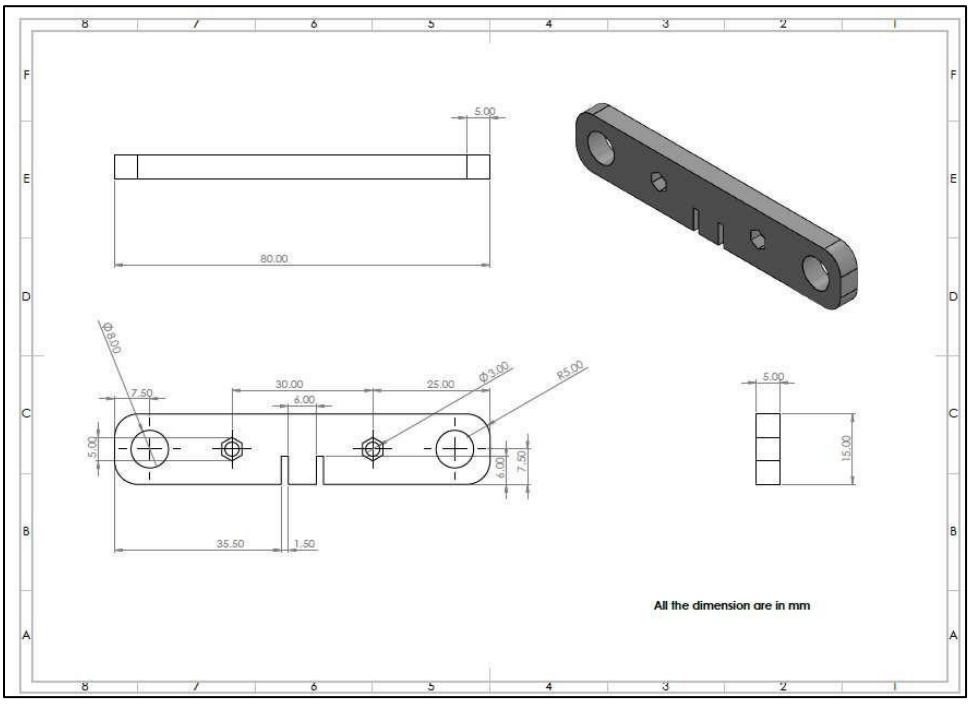
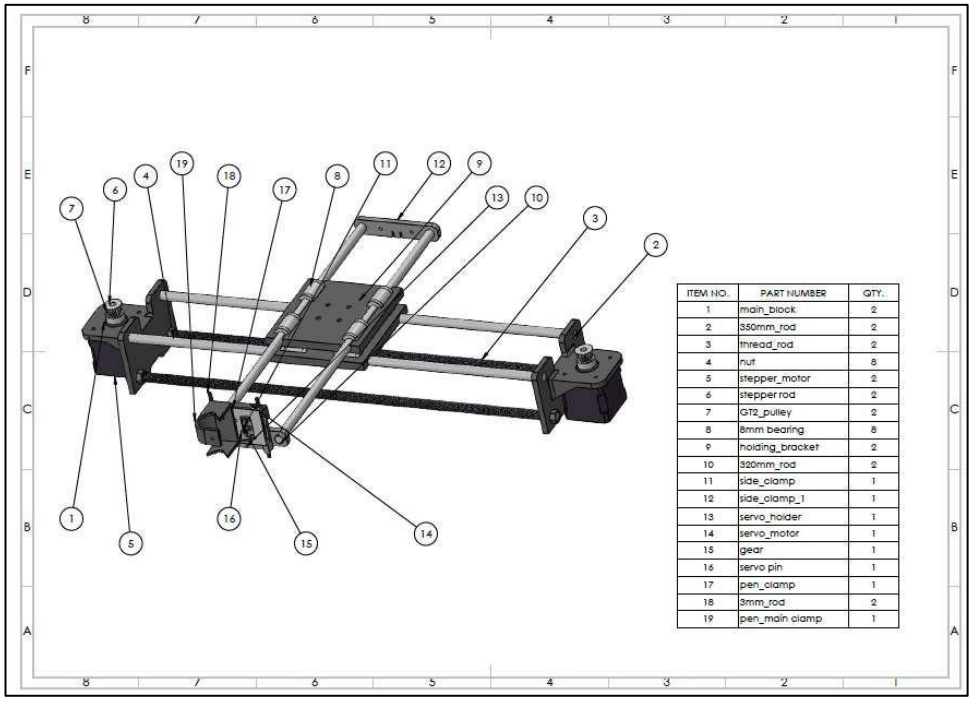


Figure 2.8 Right end plate



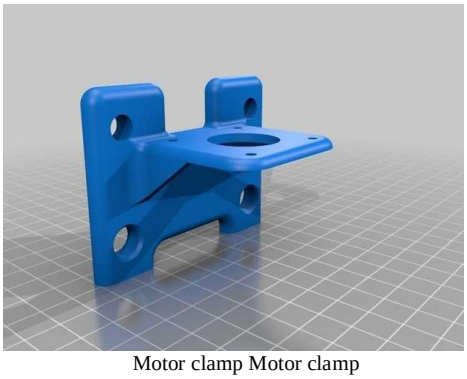
ITEM NO.	PART NUMBER	QTY.
1	main_block	2
2	350mm_rod	2
3	thread_rod	2
4	nut	8
5	stepper_motor	2
6	stepper rod	2
7	GT2_pulley	2
8	8mm bearing	8
9	holding_bracket	2
10	320mm_rod	2
11	side_clamp	1
12	side_clamp_1	1
13	servo_holder	1
14	servo_motor	1
15	gear	1
16	servo pin	1
17	pen_clamp	1
18	3mm_rod	2
19	pen_main clamp	1

Figure 2.9 Assembled View (3D) of the Mechanical frame of the Machine

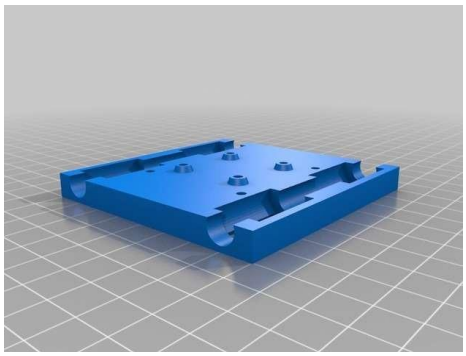
3. FABRICATION AND ASSEMBLY

The metal parts of the assembly were manufactured from a Mild Steel rod as per the designed dimensions. Motor clamps, Top & Bottom cartridges, holding plates & End plates were manufactured using 3D printing as per the designed dimensions. These parts were modeled in the 3D modeling software and converted into STL file format. Once completed, the STL file needs to be processed by a piece of software called a "slicer," which converts the model into a series of thin layers and produces a G-code file containing instructions tailored to the 3D printer (FDM printers). This G-code file can then be printed with 3D printing client software (which loads the G-code and uses it to instruct the 3D printer during the 3D printing process). The 3D models sliced in the slicer software and printed in the 3D Printer are shown in Figure 3.1.

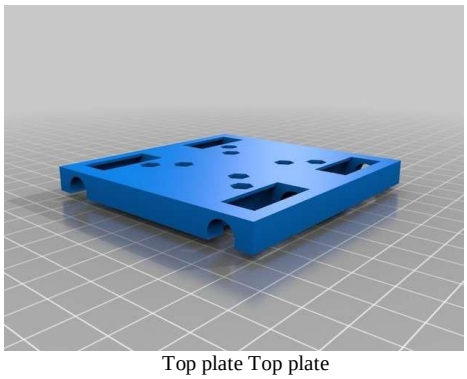
Assembly of the mini CNC Laser wood engraving and the paper cutting machine started by fitting 2 linear bearings in the 400mm length rod. Fit the motor clamp in both ends of the rod to support stepper motors. Insert the M10 threaded rod on the motor clamp and tighten it with nuts. Fix the stepper motor at both ends and tighten it with screws and washers. Fix the bearing holding block plate using nuts on the rod. Again, insert 2 linear bearings on 320mm length rod on each of the 2 rods. Fix side rod holding plate at one end and right end plate on the other end. Again, fix the top plate on the rod and tighten it with screws. Insert pulleys on each of the screws and fix the top carriage on the bottom carriage and tighten it with screws. Fix the pulleys on the 2 stepper motors and then fix the timer belt. Finally, fix the laser on the one end and give connections through the Arduino microcontroller and stepper motors. The assembled mechanical frame of the machine is shown in figure 3.2.



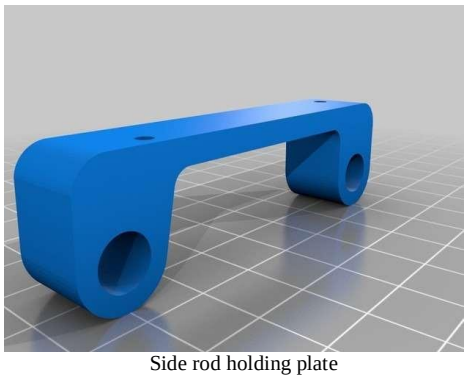
Motor clamp Motor clamp



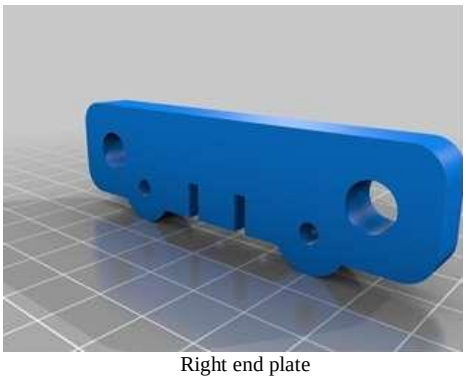
Bearing holding block unit Bearing holding block unit



Top plate Top plate



Side rod holding plate



Right end plate

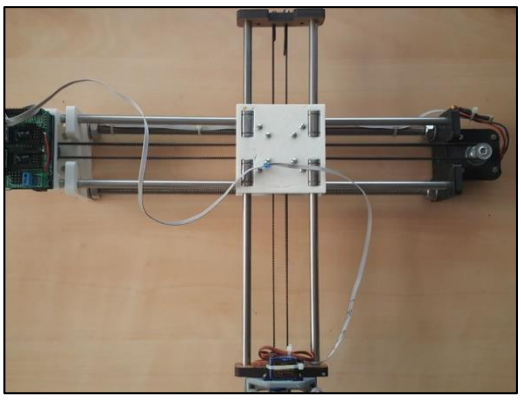


Figure 3.1 Models (3D) in the slicer software

Figure 3.2 Assembled Mechanical frame of the machine

4. WORKING

The mechanical system gets necessary control signals from the electronics system which ultimately results in the desired actuation of motors. The electronic system gets a command or a set of commands from the software system and generates controls for the mechanical system. The X and Y Sliding mechanism is connected by a DC stepper motor. These DC stepper motor and laser guns are controlled by the ARDUINO microcontroller.

To operate a CNC laser engraving machine, 2 axes are required (X-axis, and Y-axis). In this Mini CNC Engraving machine, we are using two stepper motors to control two axes, hence we require two stepper drivers for operating the stepper motors. One is for X-axis and the second for Y-axis. The laser module is fitted at the Y-axis. The X-axis and Y-axis work in unity to create a 2D image on plain paper. These X and Y axes are placed 90 degrees to each other such that any point on the plain surface is defined by a given value of X and Y. The movements in the X and Y axes are schematically shown in figure 4.1.

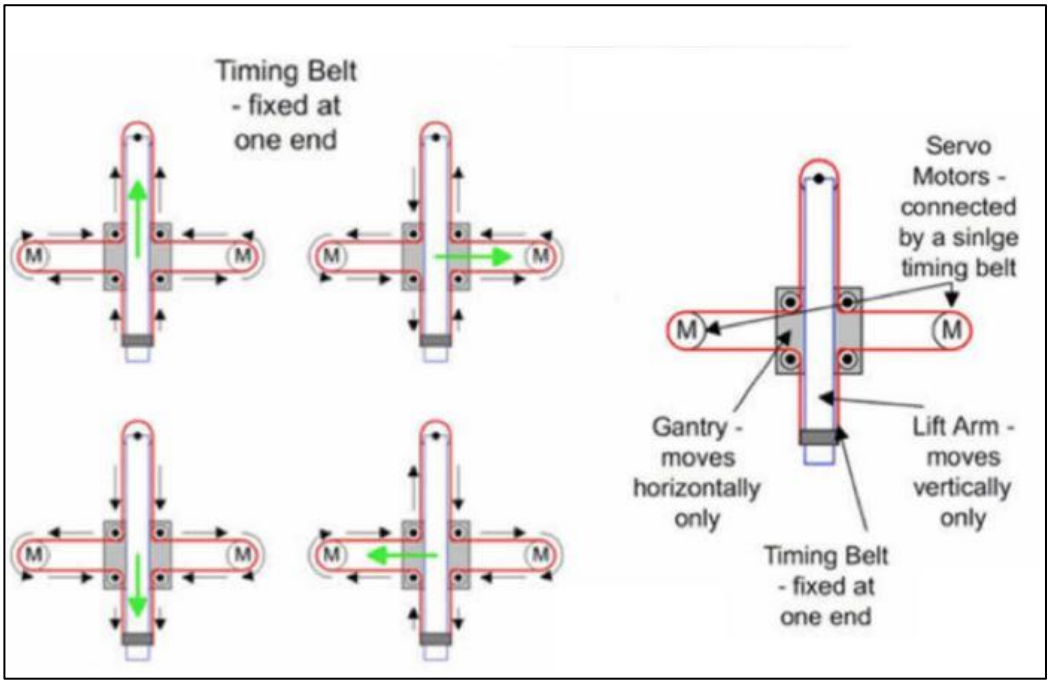


Figure 4.1 Engraver Movements

Depending on the image to be engraved, the **BENBOX software** generates the appropriate coordinates and sends them to the Arduino microcontroller which controls the X and Y axis drive through Arduino driver shield V3. The microcontroller interprets these coordinates and then controls the positions of the motors to create the image. Here we have used Arduino as the Microcontroller to build this CNC Machine. The GUI screenshots of the Benbox software are shown in figure 4.2. The assembled machine with all functional systems in action is shown in figure 4.3.

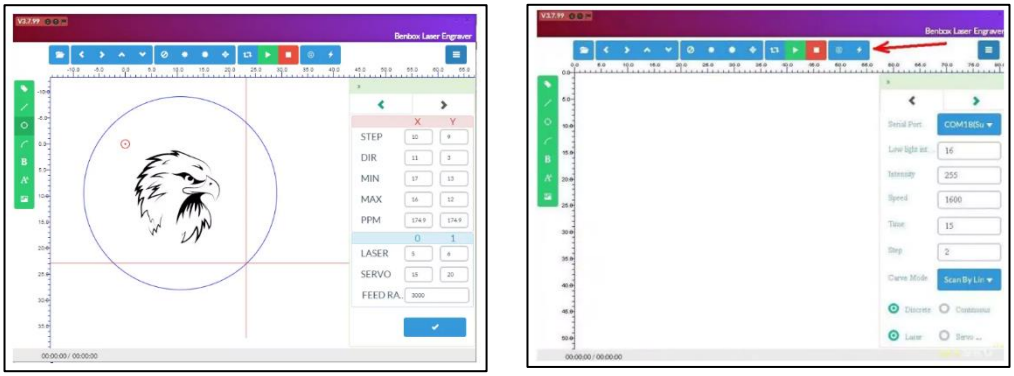


Figure 4.2 GUI Screenshots of the BENBOX software

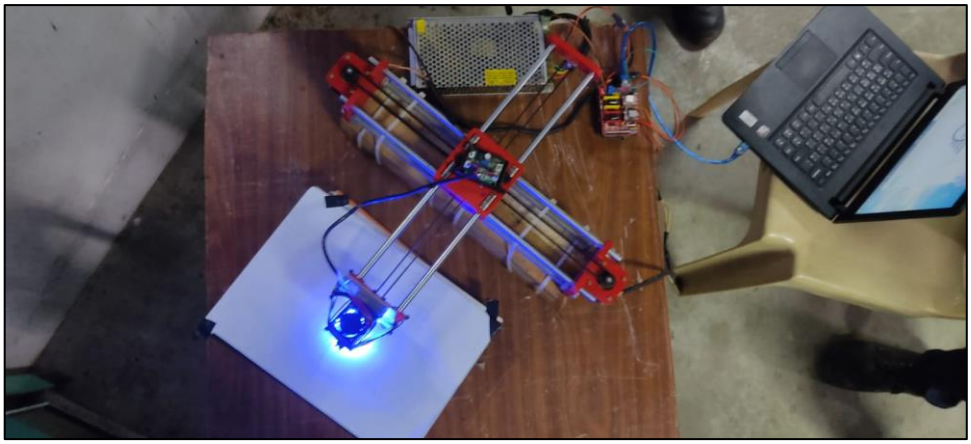


Figure 4.3 Mini Laser wood Engraver and paper cutting machine are in action

5. CONCLUSION

The demand for CNC machines with high accurate machining output for wood engraving and paper cutting at an affordable cost will be high. In the present work, a mini CNC laser wood engraving and paper cutting machine was designed and fabricated at a low cost. Customized 3D printed parts modeled in SOLIDWORKS software made the machine compact and helped in fabricating the machine sooner.

The testing conducted on the machine in paper cutting revealed that the use of CNC controllers increased the quality of the products manufactured with higher accuracy levels in the manufactured parts. It also increased productivity and reduced the lead time. The information of location coordinates of the laser beam can be easily traceable as the status can be directly seen on the computer. The compactness of the machine gives the flexibility to work and the machine can also be useable on different materials like wood, paper, plastics, and thin sheets.

In conclusion, the mini CNC Laser wood engraving and paper cutting machine parts manufactured by the 3D printing method have fulfilled the assembly requirements and the developed machine performed the intended function with higher accuracy and precision.

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