DESIGN AND FABRICATION OF LASER *ENGRAVING MACHINE*

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Abstract:

Engraving on different type of material is the most ancient and widely used technique. Since it is a 20th Century the demand of highly accurate and précised techniques are in demand. The use of Non-Conventional Machines has increased which helps in producing the best quality desired. In this paper the main aim is to design and fabricate the CNC operated Laser Engraving Machine. This machine is the alternate to the traditional conventional machines and it proves to have remarkable safety features as the whole work is carried out by the computers also the maintenance cost is very low. The prototype model of Laser Engraving Machine is designed, fabricated and analyzed. The model is portable, economical, simple to operate and best suitable for small and medium scale industries.

Key words: Engraving, CNC, Laser

1. INTRODUCTION

Laser means the amplification of light by stimulated of Radiation. Engraving is the practice in which the incising of the design in done on the surface of the material. Usually Engraving is done by creating grooves on the material by the help of Burin tool. Engraving can be done on all the materials which are having a flat surface. Engraving is one of the oldest and most used techniques for printmaking. Wood engraving is also quite popular. Engraving on the jewelry is very famous as the design is very complex and artistic. Engraving can be done by different methods such as Hand engraving, Etching, Aquatint engraving and Laser engraving. Out of all the engraving method the one which was most suitable with the least disadvantages was found to be Laser engraving.

Laser engraving is one of the most preferred technologies specially used for wood engraving operation. In this method a laser beam is being penetrated on the solid material. The advantage of this laser is non-contact working, high scanning speed, high flexibility and high automation.

2. DESIGN AND ANALYSIS

2.1 Extrusion bars:

The T-slotted Extrusion bars of size 45 x 90mm were used in the model. The material of the extrusion bar is Aluminum. This extrusion bars were selected because of the slot provided in which the column plate and wheel assembly will be mounted. The wheel assembly will move on the slots of the extrusion bar for giving the direction to laser module. Extrusion bars acts as the support for the column plate and wheel assembly

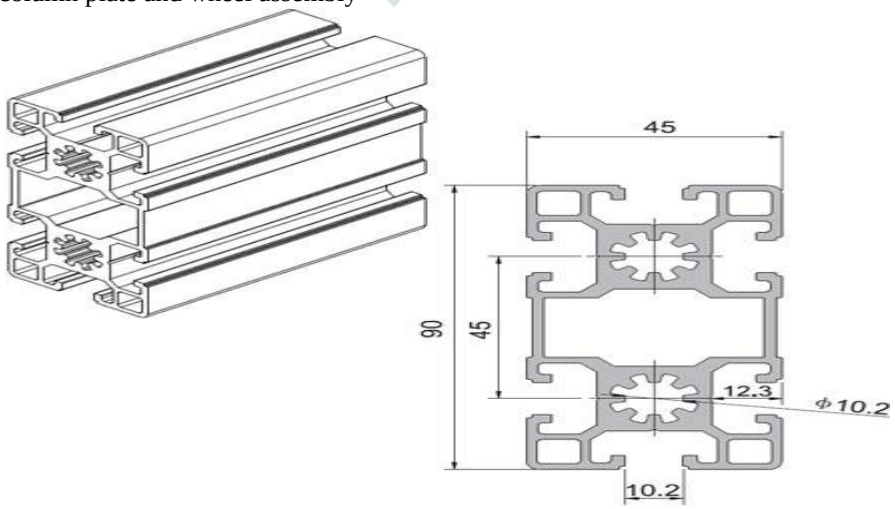

Fig.1 Aluminum Extrusion bar

Moment of Inertia: -	**Section Module:**
$\mathbf{I_{xx}} = \frac{bd^3}{12}$ $= \frac{9\times4.5^3}{12}$ $= \mathbf{68.3cm^4}$ $\mathbf{I_{yy}} = \frac{db^3}{12}$ $= \frac{4.5\times9^3}{12}$ $= \mathbf{273.3\ cm^4}$	$\mathbf{Zx} = \frac{I_{xx}}{y_{max}}$ $= \frac{\frac{bd^3}{12}}{\frac{d}{2}}$ $= \frac{bd^2}{6}$ $= \frac{9\times4.5^2}{6}$ $\mathbf{Zx = 30.3\ cm^2}$ $\mathbf{Zy} = \frac{I_{yy}}{y_{max}}$ $= \frac{\frac{db^3}{12}}{\frac{d}{2}}$ $= \frac{b^3}{6}$ $= \frac{9^3}{6}$ $\mathbf{Z_y = 121.5\ cm^3}$

2.2 Column plate:

Column plate of derlin material is used because of its light weight and good properties such as high tensile strength, creep resistance and toughness. This material also exhibits low moisture absorption. Column plates are used for the mounting of stepper motor and pulley which will guide the wheels according to the requirement. The material of the column plate should be carefully selected because if the heavy material is taken then the wheels have to carry a lot of load and stepper motor of high specification would be required which will increase the cost.

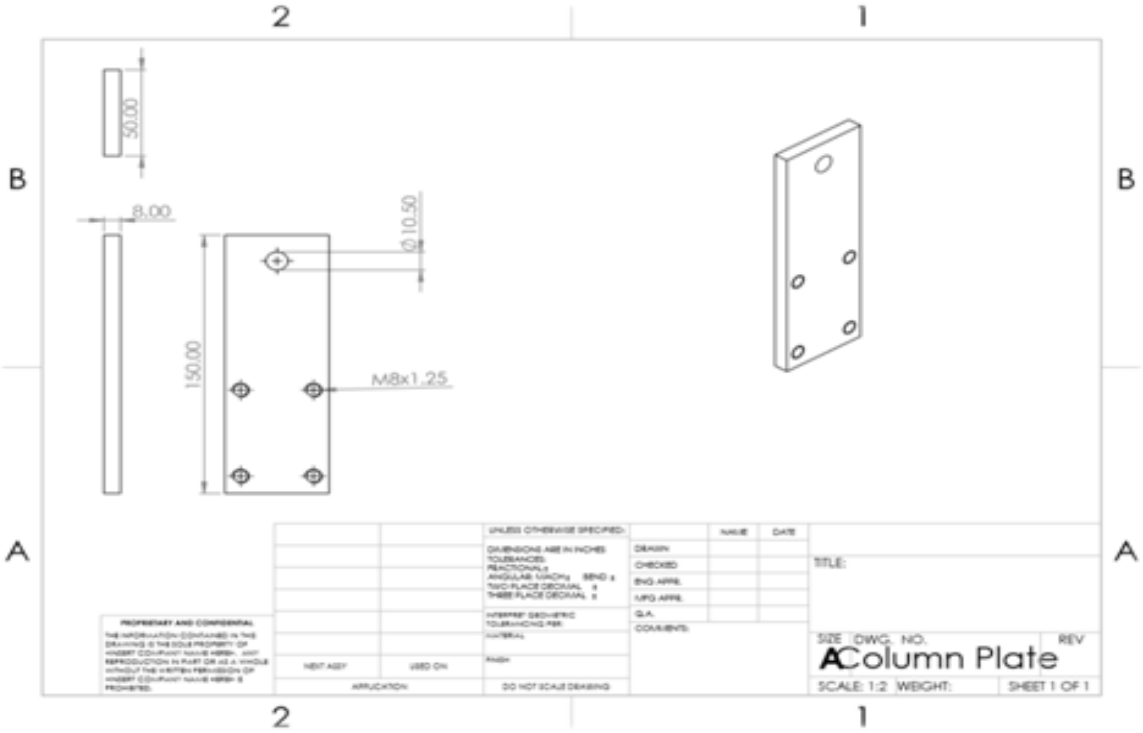

Fig. 2 modeling of column plate

2.3 Stepper motor:

NEMA 17of size 42.3mm x 48mm stepper motor is used for this working model. The stepper motor is joined with the column plates with the help of screws and its rotating part is joined to the pulley and wheels for the purpose of guiding the laser module for doing the engraving. The stepper motor runs on voltage of 12v and 400mA current. This stepper motor is the best suitable because of its light weight of 350g which the wheels have to absorb because if the weight of the stepper motor is heavy then there will be problem in co-ordination of the wheels which results in to bad engraving. The stepper motor has step angle of 1.8-degree full step and the shaft diameter is of 5mm.

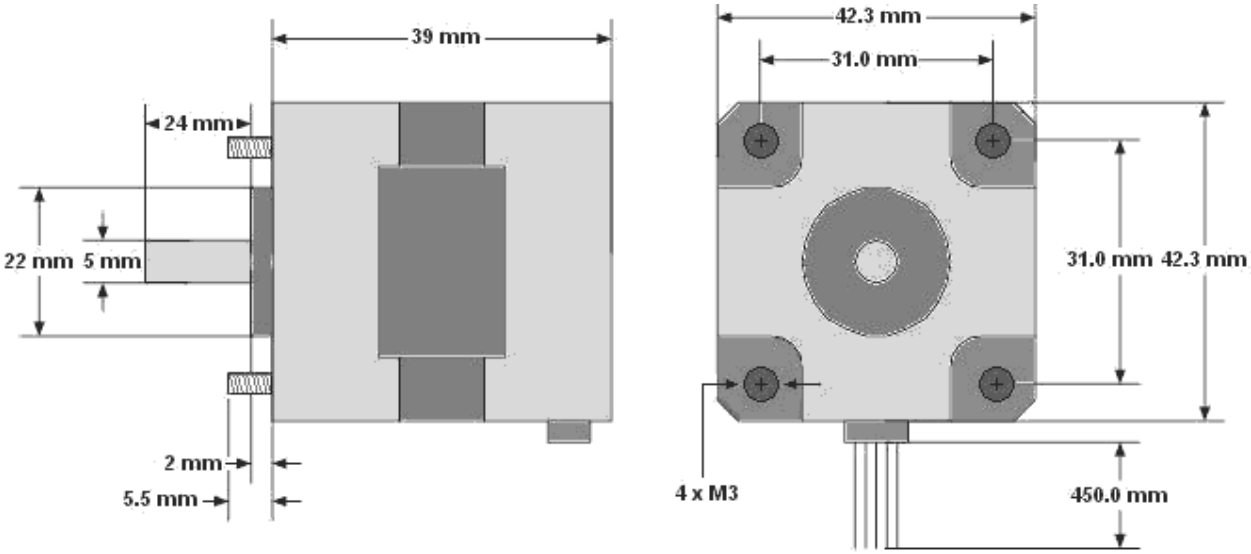

Fig. 3 Stepper Motor

2.4 Laser module:

Laser module of 3000mW is used because it is ideal for engraving. Its working voltage is DC 12V and its life is >10,000 hours. The beam shape is dot and focusable. The wavelength of laser is 445nm. Laser module is attached to column plate and with the help of stepper motor the wheels are guided and proper engraving is done. The luminous color of the laser is blue which is less harmful compared to others. The cooling fan is attached on the upper side of the laser module so it reduces over heating risk and ensures the service life. The section size is 33mm x 33mm. It consists of the adjustable focal length which is set according to the material which is to be engraved. It is equipped with constant current driver board which ensures the stable output optical power.

The laser module comes with the weak light mode button in which laser light emitting becomes weaker and it will not engrave the material which helps one for the positioning of the material to be engraved. The materials which can be engraved with the help of this module are MDF, Balsa, paper, wood, fabric, plastic, leather, plywood, foam paper and thin metal sheets of 10mm thickness. The laser module is not able to engrave reflective materials such as glass and ceramics

Laser Wavelength = $\frac{velocity/speed}{frequency\ of\ wave}$

($\therefore v = 17800$, F = 400)

$$\lambda = \frac{17800}{400}$$

$$\lambda = 445N.m$$

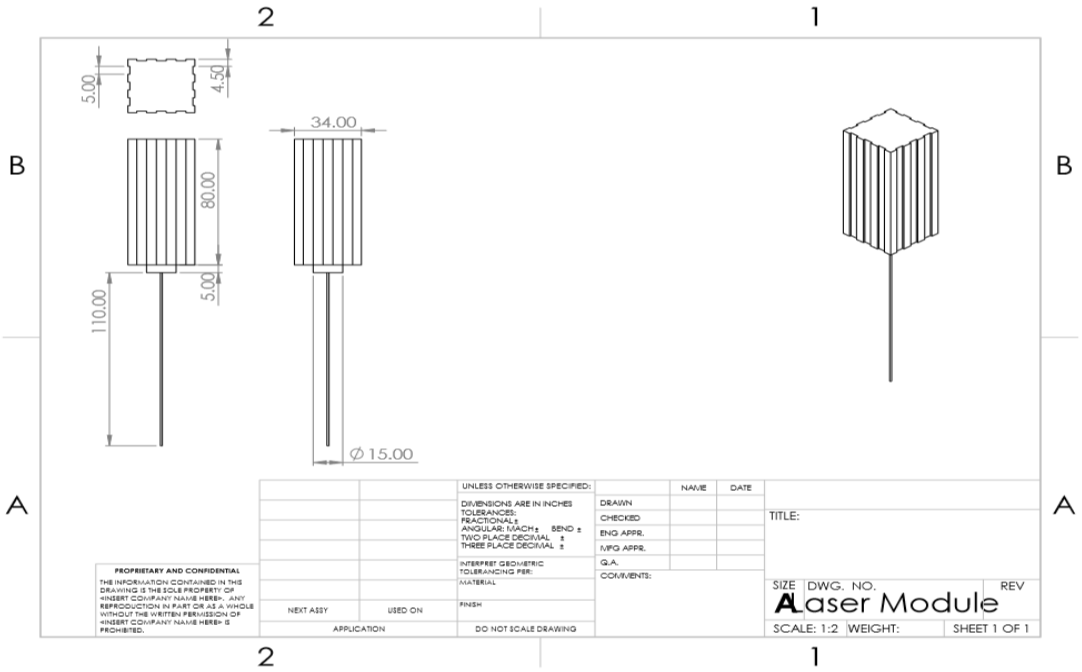

Fig.4 modeling of laser module

2.5 Final assembly:

The image shows the final assembly of all the parts assembled together. The working area of this model is 500mm x 500mm. Number of stepper motor used in the model is two. First stepper motor is used to give the direction in x- direction and another in y-direction. The material of the base is mild steel. M6 screws were used for joining the different parts which had 1mm pitch and 30mm length. Adapter of 12V is used to run the microcontroller chip. Benbox software is open source software which is used for giving the commands to engrave either in text, image or by using G & M-codes. The software is very easy to operate and it even shows the time taken to engrave anything on the computer screen.

The software lets you set the laser intensity and speed for engraving of different materials. It also shows the ideal laser intensity for each different material. The speed has its effect on the engraving quality more the time taken the better engraving results with good surface finish. Benbox software can even convert any image in to G&M-codes and performs the engraving.

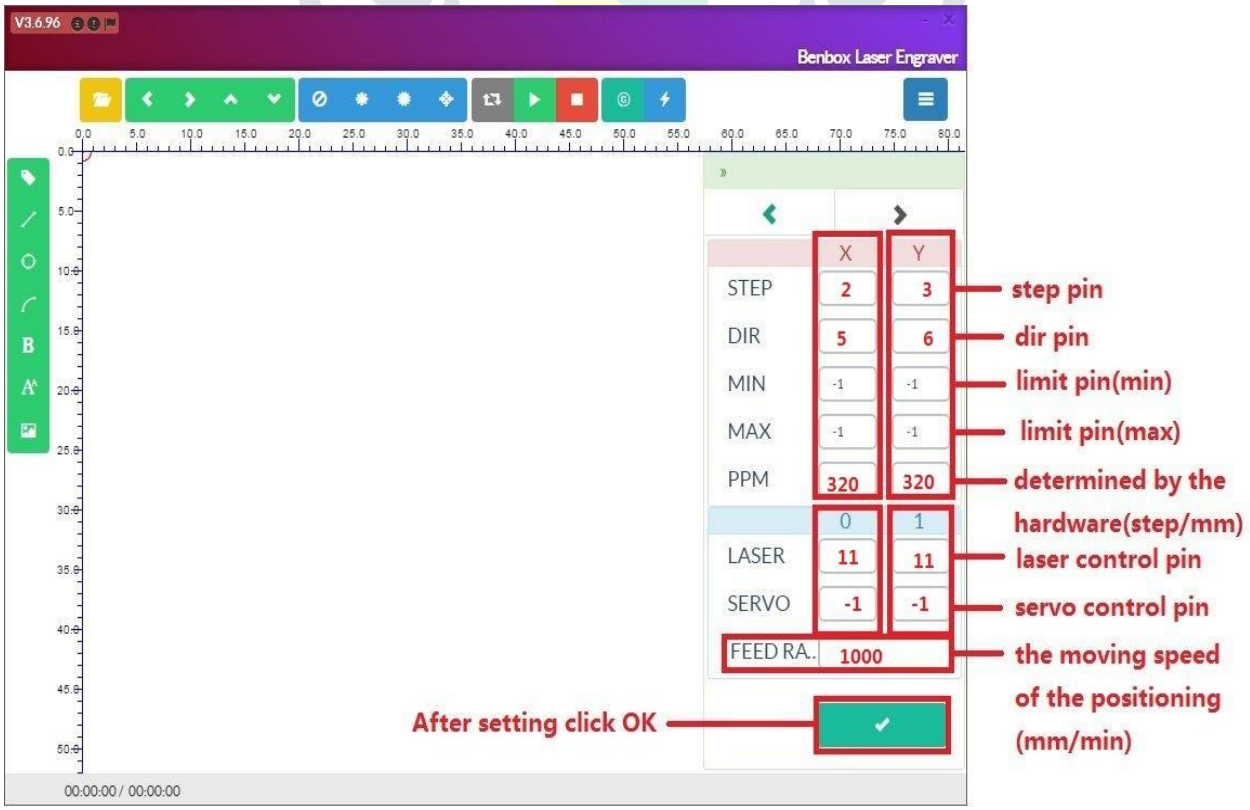

Fig.5 Preview of Benbox software

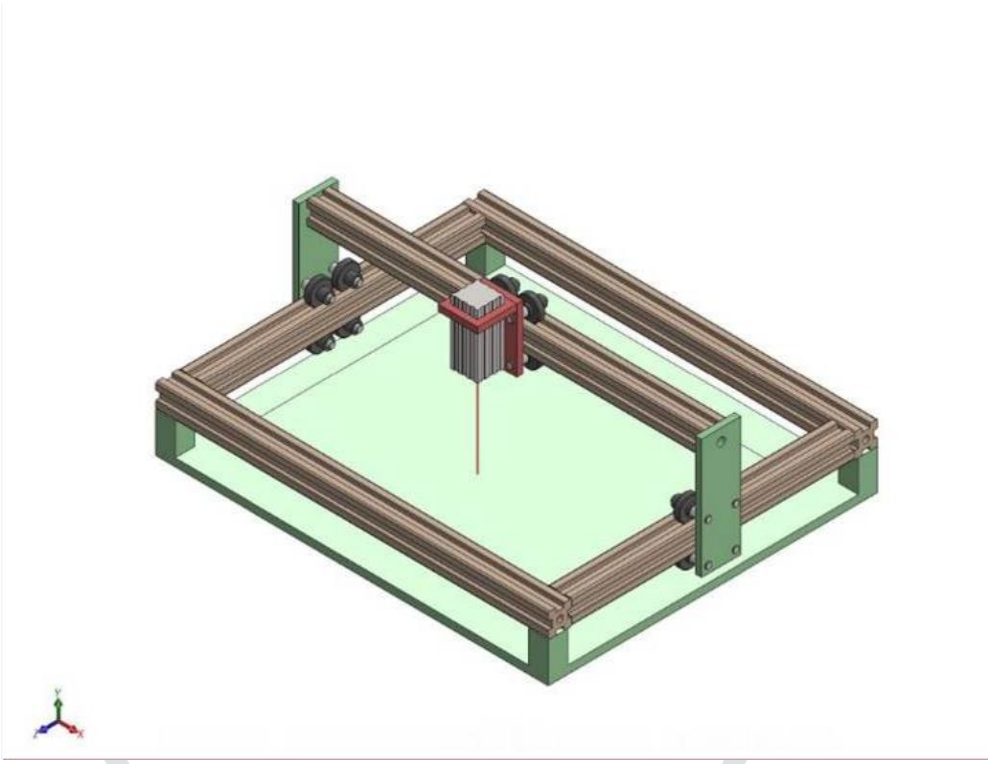

Fig.6 Final assembly

3. Procedure for experiment:

The three parameters which have been taken into consideration are the different types of materials to be engraved, intensity of laser for each of the materials and the ideal speed for each of the material for getting the desired quality surface finish. Other than this the size of the beam can be set manually by just rotating the knob on the laser module according to the requirement.

Detail procedure:

- Connect the adaptor to microcontroller chip and power supply
- Then connect the USB cable to microcontroller chip and computer
- Turn ON the microcontroller chip by pressing the button on the chip
- Open the BenBox software in computer and update the firmware
- Check through the BenBox software that the stepper motor and the laser module are working.
- Insert the Image/Text or G&M-codes in the command prompt in the BenBox software for engraving
- Define the reference point through the BenBox software and set the size of the Image or Text according to requirement.

4. Observation table:

SR. NO.	MATERIAL	INTENSITY(W/cm^2)	SPEED(RPM)
1	Wood	255	400
2	Paper	100	500
3	Cardboard	230	500
4	Plastic	150	350
5	Metal	255	120
6	Leather	400	200

Table shows the various observations taken on different materials

5. Conclusion:

The working model of the CNC operated laser engraving machine was designed, modeled and fabricated. The working model is functional and is able to successfully engrave all the materials except of the reflective materials. This technique is economically well and providing a significant simplified process compared to the machines available in the industry. As per the industrial feasibility we have optimized the cost of the laser engraving machine with the capacity of 3000mW, 445nm wavelength. The objective to make the machine portable and make it available as laboratory equipment was fulfilled

The Present design can be modified in many ways because there is no end to innovations. The one thing which can be worked upon is to create a model in which the use of the similar machines working in the x-Y direction such as milling machine and drilling machine can be equipped according to the requirement this way the same model can perform the multiple tasks.