THINK INDIA (Quarterly Journal)

ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

Design and Fabrication of Wi-Fi Enabled Laser Engraver

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***Abstract*— The Laser Engraver is a simple cutting and carving instrument that has semi-conductor laser for performing the operations. Unlike professional laser machines, it uses a medium power laser for cutting thin materials like medium density fiberboard, balsa, paper, wood, fabric, plastic, leather, plywood, foam paper. The setup has Cartesian co-ordinate system with 3 degrees of freedom. It has optical lens for obtaining clear spotlight and minimum divergence. The movement of the Engraver works on the same principle of movement of a CNC machine. The CNC codes of an image will be generated by LaserGRBL software. The electronic data transfer and motor control is achieved using Arduino board, which in turn activates the electric motors to perform the operation.**

Keywords— Laser, Engraving, CNC, Semi conductor, LaserGRBL

I. INTRODUCTION

Laser Engraver is an instrument used to engrave or leave marks on the surface of objects. This is called laser marking. It does not involve the usage of inks or tool bits or any other contact type tools are carving the image, hence more preferred to other mechanical contact type tools that would wear out gradually and needs frequent replacements. Laser cutting is a technology that uses a laser to cut materials, and is typically used for industrial manufacturing applications. Laser cutting works by directing the output of a high-power laser most commonly through optics. A typical commercial laser for cutting materials involved a motion control system to follow a CNC or G-code of the pattern to be cut onto the material.

Shady et al. proposed that Polylactic acid is the most extensively used bio degradable aliphatic polyester. They degrade by hydrolysis after several months of exposure to moisture. Ivan proposed a result that the laser cutting process is responsible for the colour change and the other changes in the surface of the wood. The spectrometer is used for the identification of colour changes and the other methods for the chemical changes. Juan et al. states that the moisture content in wood modifies the yield and quality of the cuts made by laser. The direction of cut also affects the cutting process.Bursi explains that laser cutting

operations are more preferred for machining of steels than other processes. Laser cutting reduces the heat affected zones, reducing the material warpages or deformation of the materials on the surface. Dongk et al. experimented on printed circuit board and explains that during manufacturing of Printed Circuit Boards, mechanical cutting is used, it might damage the body of the PCB, hence laser spot cutting is preferred. Johan explains that electrons are being replaced by photon for laser beam machining. The Light moves in the atmosphere as a wave but when it encounters by the material it does not behave like a wave where as it behaves like an energy. Sanjay et al. researched about laser beam micro machining and explains that laser radiation has a number of unique properties like high intensity of electromagnetic energy flux, high monochromaticallyy and high spatial and temporal coherence. Laser can travel as a very narrow beam and it can be focused upon small areas with very high radiance. Yusoff et al. researched and concluded that there are two basic methods of marking Integrated Chip packages with Nd : YAG lasers, mask marking and stroke marking, pulsed lasers being usually used for that purpose. Seheyok et al. investigated the quality of cut in Carbon Fibre Reinforced Plastic made using the fibre laser. The research work also stated the recent wide application of the carbon fiber reinforced plastic (CFRP) that has been emerging to replace the existing materials used for the body of the aircraft, automotive, building, turbine, and high-grade sports goods, because of its superior mechanical properties. Romero et al. investigated the diode laser cutting of silicon by means of water assisted thermally driven mechanism. He also stated that crystalline silicon wafers are the dominant substrates for electronic, sensor and photovoltaic applications. Pratik et al. investigated the brightness of the beam and he believed that it would create a new perspective. He described brightness as the visual perception of light. The brightness of objects or a light source varies with change in the distance and the angle at which the object is visualized. John identified that a discontinuous jump of energy of electrons at the juncture between two semiconductors creates quantum wells and potential barrier for conduction of electrons.

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II. Design Diagrams

The 3D assembled isometric view of Wi-Fi enabled Laser Engraver is designed using SOLIDWORK and shown in figure 1. From the isometric view, the shaft connecting both X-axis panels, laser head and laser holder can be clearly visualized.

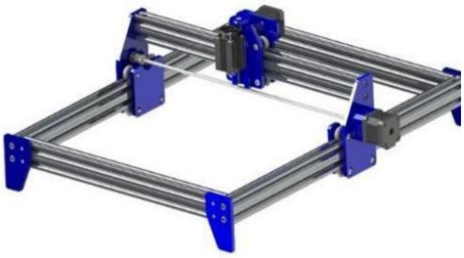

Fig. 1. Isometric View of Laser Engraver

III. Fabrication of Laser Engraver

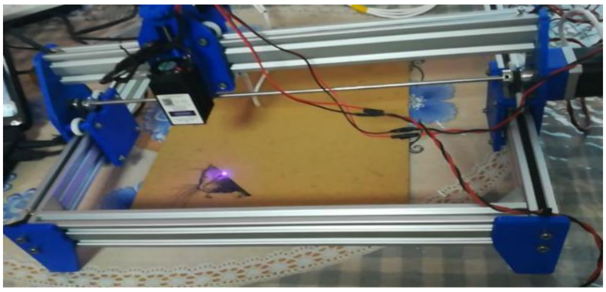

Fig. 2 Fabricated Laser Engraver

The required parts for the laser engraver are designed in solid works, printed using 3D printer and few materials like aluminium V-frame, nuts, bolts, stepper motors were purchased. The aluminium frame was cut down to required dimensions and fitted using purchased nuts and bolts. The bearings for the movement of laser head are attached to the Al frame. The timing V-Belts are fitted to frame using the printed 3D parts and this completes the motion of laser head. The electronic layout was prepared for the Arduino UNO board and CNC shield. The laser head is held between the laser holder and laser base. The electrical connections for the laser head, stepper motor are given accordingly with the Arduino board and CNC shield. The wire connections for this electrical circuit was soldered and braided for improved quality, sustainability and longer life. The fabricated laser engraver is shown in figure 2.

IV. Working Principle

The image to be engraved is first uploaded in LaserGRBL software and corresponding G-Codes are generated. The codes are then transferred to Arduino board by wired connections. The CNC shield that is integrated with the arduino generates series of pulses for the movement of stepper motor. Preferred speed (rpm), feed, depth of cut, can be specified in the software itself. Once the process is started, all the movements are performed automatically. The intensity of the laser is self adjusted according to the contrast of the image uploaded.

The engraver is made wireless by integrating a wi-fi chip ESP8266 to the controller. A 5 GHz router is used for faster connection and the router's URL is entered to the LaserGRBL's memory address. Now the LaserGRBL can communicate with the engraver via the 5GHz router.

V. RESULTS AND DISCUSSIONS *A. Laser Engraving*

ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

Fig. 3 Laser Engraving of Bevel Gear

The image of the bevel gear to be engraved is uploaded into LaserGRBL software and following parameters are entered to obtain the output as figure 3. Rough and coarse surface is most suitable for engraving.

- Protocol - USB Serial
- Conversion tool - Line to Line Tracing
- Direction - Horizontal
- Quality - 7 lines/mm
- Engraving speed - 2500 mm/min
- S-Max - 255
- Size - 100mm x 133.33mm

B. Laser Cutting

Fig. 4 Laser Cutting of Peacock

The image of the peacock to be laser cut is uploaded into LaserGRBL software and following parameters are entered to get the output as figure 4. Thin paper is most
suitable for laser cutting. Quality of paper is checked to prevent from being burnt by laser.

- Protocol - USB Serial
- Conversion tool - Vectorise
- Spot removal - 2
- Engraving speed - 500 mm/min
- S-Max - 255
- Size - 80mm x 106.7mm

C. Laser Engraving using Wi-Fi Module

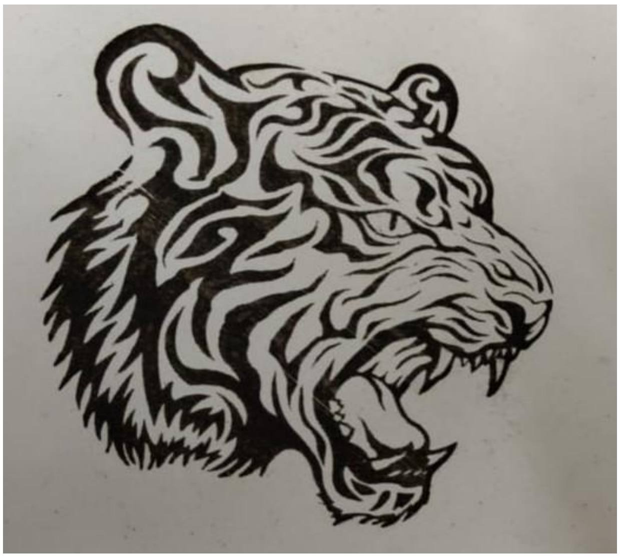

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Fig. 5 Laser Engraving of Complex Tiger's Face using Wi-Fi Module

The image of the tiger's face to be engraved is uploaded into LaserGRBL software and following parameters are entered to get output as figure 5. The 5 GHz Wi-Fi router is connected to laser engraver by ESP8266 chip.

- Protocol - Laser Web ESP8266
- Conversion tool - Line to Line Tracing
- Direction - Diagonal
- Quality - 7 lines/mm
- Engraving speed - 2500 mm/min
- S-Max - 255
- Size - 100mm x 133.33mm

D. Laser Cutting using Wi-Fi Module

Fig. 6 Laser Cutting of Welcome Sign Using Wi-Fi Module

ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

The image of welcome sign to be laser cut is uploaded into LaserGRBL software and following parameters are entered to get output as figure 6. 2.4 GHz Wi-Fi connection is enough for laser cutting as the cutting speed is much lesser than engraving. Connection speed is changed from 5 GHz to 2.4 GHz under Wi-Fi router webpage.

- Protocol - Laser Web ESP8266
- Conversion tool - Vectorise
- Spot removal - 2
- Optimize - 0.2
- Engraving speed - 500 mm/min
- S-Max - 255
- Size - 80mm x 106.7mm

In general, for laser engraving using wired connections, high quality image is obtained when engraving speed is set to 2500 mm/min at 7 lines/millimetre quality. Cardboard material provided an optimum quality output than other materials like paper, glass and wood. The engraving speed also plays an important role. When engraved at a speed less than 1800 mm/min, the laser burns the material surface as the laser is concentrated at a same point for a long time. But, when speed exceeds 2700 mm/min, the time taken to print the out is drastically reduced but it has a direct impact on quality of output. At this high speed, few lines were skipped without engraving. Hence an optimum speed of 2200-2500 mm/min is preferred. When glass is used to engrave, a part of the laser is reflected from the surface leading to poor quality images. In order to overcome this issue, a marker of black colour is first applied on the surface and then engraved. Size of the image also plays a major role in output quality. Smelled output sizes provide higher quality images. For laser cutting using wired connections, cutting speed is reduced to 500 mm/min. When speed is reduced under 500 mm/min, the laser intensity is focused on a particulate point for a long time leading to burning of material. At speeds greater than 700 mm/min, intensity is not enough to cut the paper. Thin materials like paper is best suited for laser cutting rather than thick materials like cardboard. For laser cutting and engraving using Wi-Fi connections, both 2.4 GHz and 5 GHz routers can be equipped for different engraving speeds. For highest possible speed of cut, 5 GHz router is used.

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