ISSN: 2583-3286(Online)

IPEC Journal of Science & Technology
Vol. 01 (01), Feb. 2022, pp. 26-30

Design and Fabrication of CNC Laser Engraver using Microcontroller: A Review

A.P. Singh, Aman Tripathi, Abhinav Nagar, Himanshu Choudhary

Department of Mechanical Engineering
Inderprastha Engineering College, Ghaziabad, India

Accepted on 20 February 2022

Abstract: At the present time with a digital control and simple coded software it's became more useful machine tool for engraving. Laser engraver machine is utilized to stain many images and codes on different materials. The laser engraver setup is lead due to its low operational power, lightweight, handiness and very easy-to-learn features. Various controllers and microcontrollers are connected together, further leading to the implementation of final engraving process. Machine's validity has been verified by performing dimensional, dependency and co-ordinate testing. Various types of industrial lasers like, CO_2 laser and fiber laser, semiconductor laser is available in market for laser engraving. Laser GRBL software is utilized for image showing and simulation purpose.

Keywords: **laser engraver, microcontroller, hatching, material removal**

I. INTRODUCTION

Laser means "Light Amplification by Stimulated Emission of Radiation" works in three main steps Light absorption, spontaneous emission, stimulated emission and is widely considered in current times due to development and stage progress, research and in laser technology advancement. It has been incorporated in industrial operations like Engraving, marking, cutting and in machining process of different materials. When we use laser for process of engraving no wear of tool along with more accuracy obtained. There are many advantages over using the conventional manufacturing because it always involves tool wear and less accuracy. The laser engraver is basically works on G-code and M-code programming because it is basically a Computer Numerical Control machine. There is basically three main parts in laser engraving, laser, microcontroller, body, motor controller. By using CNC (Computer Numerical Control), machining is a processes of manufacturing in which set of instruction of computer software directs the movement of path of tools and machinery, it is also known as subtractive manufacturing and CNC is an automatic machine works on G-code and M-code programming language.

II. RESEARCH METHODOLOGY

Restrepo et.al (2006) examined on brick of clay pavers cut in shape of squares with dimension 55 × 55 × 14 (in mm). Continuous type YAG laser producing 1.06 millimeter wave mode with a highest power o/p of 70 W with scan speed range of beam within 1 mm/s to 1200 mm/s and it was utilised to perform the bricks stamping test. The specimens were fixed on a position lift in process to find their surfaces on the lens focal distance. It was seen that the beam of laser was focused in a patch size of 300 mm diameter over the specimens face by a 160 millimeter focusing lens .

Bebghalem et.al (2008) explored the result of carbon dioxide (CO_2) laser variables on engraving the glass by utilising optical type and ordinary type glass to engrave cut a measurement scales for measuring device precisely about 1/10 µm of precision. A carbon dioxide used laser of maximum power 25 W used in experiment. The various parameters which has been considered in process is speed of scanning of laser (400, 600, 800 &1000 m/second), the power value range (25, 75 and 80% of 25 W) and the variable number of repeat passes (i.e. one, two and three passes). The beam was directed by galvanometric heads which utilised two fixed type mirrors. These two type mirrors guide the beam to the lens which anchors the beam at the workplace. They also made a calibration in between laser marked & reference sample and results showed good precision and a weak dispersion in value of obtained reading. The study showed some visible cracks in the stamped sample due to the many passes which creates a defect in this work .

Leone et.al (2009) investigated the impact of the process variables on the material removal rates by stamping image on panels made up of various types of wood. It was revealed that not all types of wood are fit to be engraved, it

Date of Submission: 15 Jan 2022
Corresponding Author: A.P Singh (e-mail: ap.singh@ ipec.org.in).

Published online : 25 February 2022

subjects on the structure of wood. The depth of engrave is robustly affected by the power, the frequency of pulse, the speed of beam and number of passes or repetitions .

Genna et.al (2010) inspected the engraved design on carbon steel plate of C45, with dimension as 150 mm x150 mm x 25 mm, put through finishing processes. A square area 5x5mm^2 in plane aspect was found over the models by marking an order as linear parallel designs. The study exposed that the space between the linear designs was set at the 20 and 40 µm values. The speed of scanning was constant at 100 and 200 mm/s values. The frequency values were changes in range of 20-50 kHz. In the testing procedure the top performance in form of roughness Ra value and MRR can be found by considering a speed of scanning at 200 mm/s, linear pattern distance of 0.04 millimeter & range of frequencies value as 30-40 kHz.

Agalianos et.al (2011) explored the engraving tests by using a YAG laser, using fundamental wavelength λ equal to 1064 nm with 100 W power. The laser beam is stirred by two galvanometer mirrors through work piece and final concentrated beam with approximately 50 µm as diameter. The parameters inspected were pulse frequency rate, speed of scan and thickness of layer. Experimented results on Al-7075 displayed that roughness of surface governed by the frequency values and scanning speed. It has been exposed that roughness result depends not as much on thickness of layer. It was detected that the best roughness of surface was attained taking a frequency value as 20 kHz, a scan speed value of range 600 - 700 mm/s and layer thickness of 4 & 6 µm.

Linggarjati et.al (2012) designed and produced a low-cost Computer Numerical Control (CNC) machine fitted with a capability to change laser beam head. Their Computer Numerical Control (CNC) machine has flexible use, being capable to use carbon dioxide CO_2 laser and working capability with various types of materials. In machining trial, they apply plywood, cardboard, acrylic and type of PCBs of thickness of 5, 3, 5 mm, & 1 mm (in order). Precise accuracy of machining was about 0.1 millimeter. As standard they consider 40 W lasers.

Campanelli et.al (2013) probed an experiment using YAG laser on aluminum-magnesium alloy 5754 of 3 mm thick piece of rolled sheets using a complete full factorial experiments plan, specify on the basis of 3 parameters (scan speed, frequency of repetition as well as mode of hatching), with four level range of scanning speed (i.e. 400, 800, 1200 & 1600 mm per second), three levels of rate of repetition (i.e. 25, 30, 40 kHz) and two levels of scanning strategies (i.e. 0, 1). 0 scanning strategy denotes to parallel hatching & strategy 1 denotes to mix hatching for 24 total combinations of the parameters given table 1. It can be evaluated that for upper range of scan speeds (i.e. 1200 and 1600 mm per second), the lowest range of rate of repetition (25–32.5 kHz) and two strategies of scanning. The higher values of roughness can be discovered for lower 0% for each strategies of scanning. Furthermore, there is intermission of values 0%, in between 40% & 70%, in this roughness drops till values below than 5 millimetres. The lowest values of roughness were 2.6 millimetre corresponding to overlapping degree in between 40% & 60% .

Table 1 Evaluated input & output parameters in the process of machining

Specimen	Strategy of scanning	Scan Speed [mm/sec]	Repetition frequency [KHz]	Overlap Degree [%]
1	0	400	25	77
2	0	400	30	81
3	0	400	40	86
4	0	800	25	54
5	0	800	30	62
6	0	800	40	71
7	0	1200	25	31
8	0	1200	30	43
9	0	1200	40	57
10	0	1600	25	9
11	0	1600	30	24
12	0	1600	40	43
13	1	400	25	77
14	1	400	30	81
15	1	400	40	86
16	1	800	25	54
17	1	800	30	62
18	1	800	40	71
19	1	1200	25	31
20	1	1200	30	43
21	1	1200	40	57
22	1	1600	25	9
23	1	1600	30	24
24	1	1600	40	43

Kasman (2013) investigated an activity on powder metallurgy oriented cold worked tool. A concentrated power of laser as 50 W, Fibre Laser engraving equipment with wavelength value 1064 nm was utilised over the plane engraving procedure. The constant focal length, maintained in the test, i.e. 160 mm experiments was executed to decide a range of the parameters. The range values for power and speed of scanning was selected among the values which provide the best roughness and worst roughness of surface and engraving cut depth. If laser power considered lesser than 25 watt there will decrease in engraving so power range value was considered above 25 W up to 50 W. Frequency ranges are 20 KHz & 80 KHz .

Khan et.al (2015) investigated the outcome of the Laser Power, Frequency of laser & scanning speed over surface roughness and marking time by use of Taguchi approach. A Laser beam of 5000 UV was considered in laser cut marking activity of Steel AISI 316L. A convex type lens with 163 millimetre focal distance was utilised to spot the beam over work piece with I/P voltage of 230 volts. In experimentation procedure it was examined that main contributor of marking time was number of layers removed followed by speed of scanning. Surface frequency, speed of scanning and laser power indicates that the heat i/p directly influence the value of cut depth .

Martinov et.al (2016) examined a dedicated Computer Numerical Control system for the procedure of laser engraving. It was revealed that use of algorithms, which is developed; indicate a drop in time of processing by 30% to 50% with laser pulses. The look-ahead algorithm efficiency of NC blocks is considerably improved when relating the process of conversion to the environment of the speed profile constraints on the pulse repetition frequency rate. The study also revealed that the processing variables, such as laser frequency, allowable inaccuracy of frequency, the extreme acceleration in axes can be modified through the system operative. It permits to determine the best possible balance between performance and experiment processing quality .

Jiang et.al (2016) made a textile design technique joining laser marking method and lamination of foil method with the surface of fabric which displays shinning effect. The laminated foil denim model sample were cured with laser stamping through modifying the various parameters, containing resolution on 20, 30, 40 & 50 dpi and time of pixel on 120 & 180 microseconds for melting and dissolve the foil aluminum & some surface fibers. The properties of the beam marked fabric, include strength of tearing, air resistance, weight, colour presence, colour fastness, stress related mechanical properties and resistance to abrasion, were examined. The test outcome exposed that the fluctuations in these attributes are connected to the evaporated & melted laminated aluminum foil and various cracks area, wrinkles form, and vents created over the surface of fiber when the raise of laser beam applied .

Nikolidakis et.al (2018) investigated the laser beam process variables which influence the removal of material layers in form of thickness & MRR in the process of laser marking SAE 304 steel. Assessments of machining were performed in 4 × 4 mm size square shape samples shown in fig 1 with a fixed count of removed layers of fifty with combinations of 126 for 3 process variables power, rate of repetition and scan speed. The process variables are of 6 levels of speed of scanning (200, 300, 400, 500, 600, 700 mm per second), 7 stage rate of repetition F (i.e. 20, 30, 40, 50, 60, 70 and 80 kHz), & 3 values of the average power (8, 12, 16 W). Conclusions can be drawn scanning speed = 200 mm/s, repetition rate = 40 kHz and average power = 16 W .

Wangui et.al (2018) examined the beam orientation effect in engraving process using carbon dioxide beam laser. In this study a carbon dioxide continuous laser of 60 W was used & movable type mirrors and lends which work as delivery systems that instruct the laser waves over the workpieces.

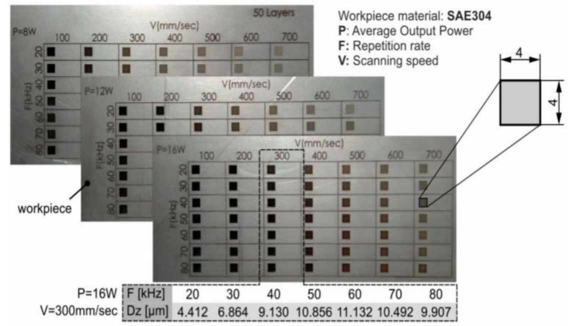

Figure 1: Sample work pieces with the various used process parameters.

The process was finished over perspex and soda lime glass. Variable speed and various angle of the incident was utilized for engraving the material. A projector analyzer was used for measurement of depth and width, also engraving roughness of was determined by the profilometer. From result it found that by raising the angle of incident the kerf width increases and engraving deepness decrease. The kerf width and engraving cut depth becomes larger in engrave cutting at low speed than in engraving at high-speed. This process provides several profits including high quality, engraving various materials and small marks .

Patel et.al (2019) explored the assimilation of Laser Engraver & 3D Printer. To enhance the cut depth with low power, one can trim down its speed and raise the repeat number of repeat passes required. The study publicized that the printing quality depends upon the nozzle height for printing process. If the height is very high, the printed part incapable to stick to the bed. If the height is very low, the plastic melts stops flow from the nozzle. The study describes the procedure needed to merge these methods into one machine. Through the study it was establish that the laser is properly perform working on a wooden material work piece and capable of engraving wood as per design .

Kúdela et.al (2020) performed an experiment with CO_2 laser. The sizes of the irradiated beech wood sample were 100 mm × 50 mm × 15 mm as shown in fig 2. Specimens sample were placed at 17 mm which is focal distance of lens. The head of beam was travelling on the surface of specimen, taking the path as direction of fiber, with a fixed speed (i.e. 350 mm/s. The beam intensity changed with changing raster density & laser power. The 30 piece specimen series was imprinted at 4 percent, another (30 pieces) was stamped at 8 percent of the highest laser power. The impression was performed in perpendicular direction of grain, with densities of raster 1, 2, 5, 10, & 20 paths for each one millimeter over the sample width. The overall specimen's quantity was more than 30. The effective powers Pe values provide through the laser beam over the surface of specimen i.e. 5.5 W & 11 W. The equivalent irradiation doses connected to 1 beam path across the sample were 11.2 J cm^{-2} & 22.4 J cm^{-2} .

Published online : 25 February 2022

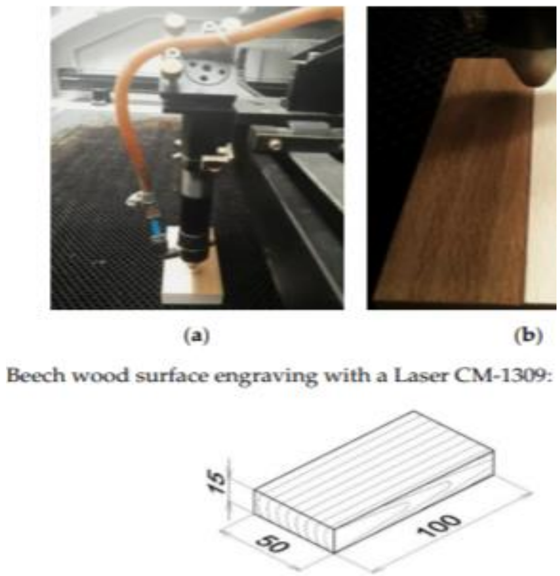

Figure 2: Beech type wood plane surface impression with a Laser beam CM-1309 a. General analysis b. Detailed analysis.

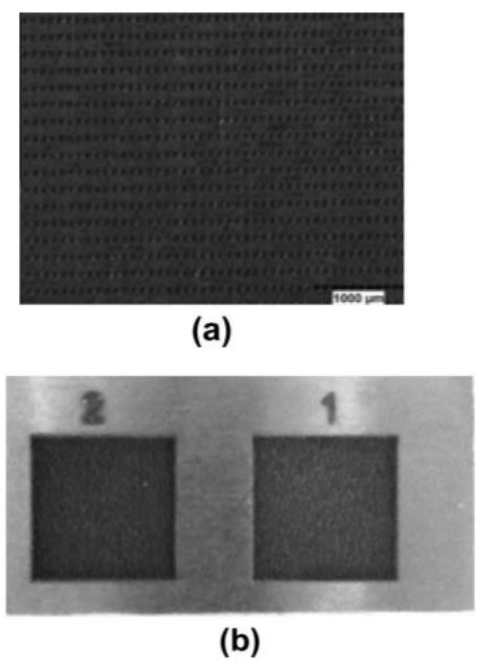

Figure 3 (a) Laser beam scan direction (b) Machined surface

IV. CONCLUSIONS

The main objective of the papers communicates the option of making a prototype of laser cut engraver CNC at low-cost that would capable to trace engrave on a 210 x 290 millimeters sample size. The prototype machine with low power consumption and operate in high accuracy by use of accurate stepper motors. It was designed to be portable, simple so that could be reached easily at any location over work piece. Automation through programming for the machine can be grasp very fast and very easy approach by adopting the suitable methodology by utilizing software like Grbl v0.9 software which converts G-code into certain commands that easily drive the stepper motor. The Taguchi approach was applied for the favorable process setting & the ANOVA was executed to establish the numerical importance of each variable on the performance features. In the process of investigation it was observed that scanning speed seemed to be the main effective variable for surface roughness and cut depth. Finally, it was observed that we can made low-cost CNC laser engraver for different material with different dimension we can find scan speed, power, wavelength of different material like wood, steel, sheets, plastic and much more.

REFERENCES

[1] J.W. Restrepo, J.M. Ferna´ndez-Pradas , M.A. Go´mez, P. Serra, J.L. Morenza Influence of preheating and hematite content of clay brick pavers on the characteristics of lines marked with a Nd:YAG laser (2006).

[2] Khanafi-Benghalem N, et al. Effect of Laser CO2 Parameters In Marking Of Glass. AIP Conf Proc. (2008).

[3] C. Leone, V. Lopresto , I. De Iorio, "Wood engraving by Q-switched diode-pumped frequency-doubled Nd:YAG green laser" , Optics and Lasers in Engineering (2009).

[4] S. Genna, C. Leone, V. Lopresto, L.Santo, and F. Trovalusci, "Study of fibre laser machining on C45 steel: influences of process parameters on material removal rate and roughness" (2010).

[5] F.Agalianos, S.Patelis , P. Kyratsis, E. Maravelakis, E.Vasarmidis, A.Antoniadis Industrial Applications of Laser Engraving: Influence of the Process Parameters on Machined Surface Quality world acadmy of science engineering and technology (2011).

[6] Linggarjati, J., & Hedwig, R. Manually interchangeable heads of homemade computer numerical control (CNC) machine. Internetworking Indonesia Journal (2012).

[7] Campanelli n, G. Casalino, N. Contuzzi Multi-objective optimization of laser milling of 5754 aluminum alloy (2013).

[8] Sefika Kasman Impact of parameters on the process response: A Taguchi orthogonal analysis for laser engraving (2013).

[9] A. R. Khan, M. Q. Saleem, A. Ikram, "Parametric Optimization for Laser Marking Performance via Taguchi Approach", Technical Journal, University of Engineering and Technology (UET) Taxila, Pakistan, 20 (2015) 50-55.

[10] Georgi M. Martinov, Aleksandr I. Obuhov, Lilija I. Mantinova, Anton S. Grigoriev "An Approach to Building a Specilised CNC System for Laser

Engraving Machining" , Moscow State Technological University" "STANKIN", Procedia CIRP 41 (2016).

[11] Shou Xiang Jiang, Guoxiang Yuan, Jingjing Huang, Qingxin Peng and Yan Liu " The effect of laser engraving on aluminum foil-laminated denim fabric" Textile Research Journal 0(00) 1–14, (2016).

[12] Evangelos Nikolidakis, Ioannis Choreftakis and Aristomenis Antoniadis Experimental Investigation of Stainless Steel SAE304 Laser Engraving Cutting Conditions (2018).

[13] Wangui E, A Study on Influence of Beam Orientation in Engraving Using CO2 Laser. Proceedings the 2012 Mechanical Engineering Conference on Sustainable Research and Innovation (2018).

[14] Jeet Patel, Bhavantik Gondaliya, Nairutya Patel, Dr. Ajay M. Patel "A Novel Integration of Laser Engraver and 3D Printer", G H Patel College of Engineering & Technology, Volume: 06 Issue: 12, Dec (2019).

[15] Jozef Kúdela, Ivan Kubovský * and Michal Andrejko Surface Properties of Beech Wood after CO2 Laser Engraving (2020).

Published online : 25 February 2022