

# Machine ability on Leather using CO<sub>2</sub> Laser and Power Diode Laser

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**Abstract:** *Leather is a versatile, robust and trendy material and therefore its applications are nearly endless. The conventional method of leather cutting takes a lot of man power. Power diode-based Laser technology has grown significantly during recent years due to numerous advantages over conventional cutting methods. The conventional Lasers also have some drawbacks in cutting such as Geometrical inaccuracies, Carbonization, Overcut etc. This can be reduced by the use of Laser diodes. The main purpose of using Laser diode is to reduce power consumption. In the present study, an attempt has been made to develop laser diode-based Laser beam machining (LBM) and CO<sub>2</sub> based LBM, to compare the performance measures of Carbonization and Geometrical inaccuracy. The main objective of this work is to enhance the machining process using Laser diode, to make it eco-friendly through the different duty cycles of Pulse Width Modulation (PWM) which can be used to control the intensity of the Laser beam.*

**Keywords** —Laser Beam Machining (LBM), Pulse Width Modulation (PWM), Geometrical Inaccuracies, Carbonization.

## I. INTRODUCTION

Diode lasers are widely used in laser cutting, Fiber optic communications, Military applications, surgical procedures, etc. Laser diodes are smallest of all known lasers. A laser diode is an optoelectronic device which renovates electrical energy into light energy to produce high-intensity coherent light. The development of a laser power controller using PWM technique for the 3-axis computer numerically-controlled (CNC) laser Machines [1]. The ultimate goal is to design and develop the Laser cutting machine which is conveniently controlled by Arduino [2]. Lasers have been used for cutting purposes [3]. The leather manufacturing involves various processes which includes leather cutting [4]. LBM is a non-traditional machining process in which a controlled laser is directed towards the work piece for removing the material. This process utilizes the thermal energy to remove material from the work piece by the sequence of heating, melting or vaporization of the material. There are many different types of lasers including gas, solid states lasers, and excimer lasers [5]. LBM is a thermal machining process which uses Laser beam to produce heat to analyze the machinability of leather using CO<sub>2</sub> based LBM process [6]. Hence an attempt is made to

compare the machinability of leather using laser diode-based LBM setup and CO<sub>2</sub> laser based LBM in the present study.

## II. MECHANICAL DESIGN

### A. Cad Model

With the use of solidworks software, the part models of the 3-D setup are created. The T slots extrusion columns are made for the support of the system. Solid V wheel is created for the movement of X axis and Y axis with a conveyor belt. Flexible coupling is created for the movement of Z axis, through a lead screw for the precise movement. The parts are then assembled using assembly option in solidworks. The Figure 1 shows the CAD model of a LBM setup.

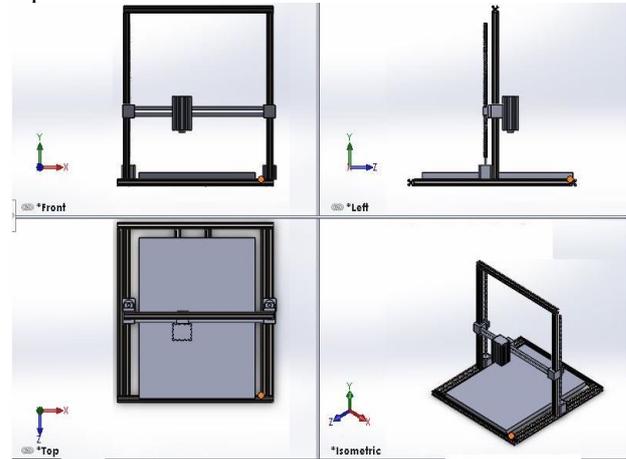


Figure 1.CAD Model

The setup is of gantry type where the X axis moves from left to right. Y axis (table) moves along with the workpiece front and back. Z axis moves from top to bottom. A separate Laser module holder is made in the center to hold the Laser diode rigidly.

### B. X-Axis Reference

The X axis stepper motor and V-belt are used to actuate the Laser and it can move up to 290 mm.

### C. Y-Axis Reference

The work table is moved with the help of Y axis stepper motor and V-belt. The table has about 260 mm in area and it can move up to 460 mm.

### D. Z-Axis Reference

The Lead screw is actuated up and down using the Z axis stepper motor. The lead screw is used instead of V belt because of firm grip for focusing Laser and it can be maintained at constant distance for any number of runs and it can move up to 360 mm.

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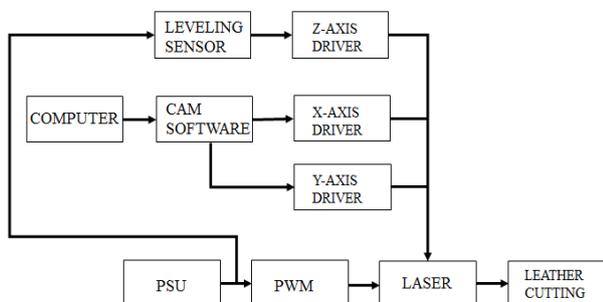
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### III. DESIGN OF CIRCUITS

#### A. Block Diagram

The block diagram of the LBM setup using computer control is given in Figure 2. The Power Supply Unit (PSU) is connected to each motor through Motor drivers. The PSU is also connected to the laser. The Pulse Width Modulation (PWM) is used to control power intensity of the laser beam.



**Figure 2. Block Diagram**

The leveling sensor is used to maintain the constant distance between the workpiece and the laser. The X, Y and Z axis is controlled by the actuation of the stepper motor. The CAD models are given as an input in dxf format, and then it is imported into the Arduino for the machining process.

#### B. Laser Diode

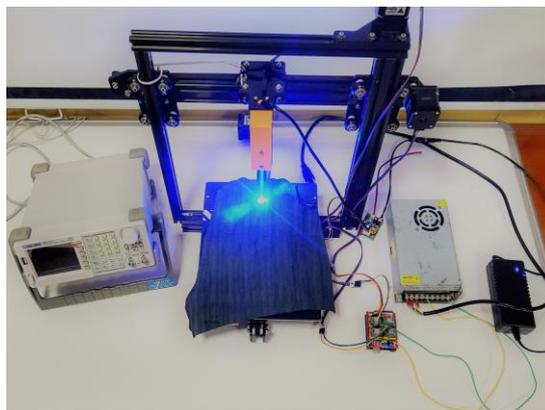
Laser Diode is of different wavelengths each distinguished by the color of the Laser. Among them three colors are frequently used because of their power Red, Green and Blue. The LBM setup used in the present work consists of Blue Colour Laser of 5.5 Watt and 450nm Wavelength. Laser diode can cut a maximum depth of 2 mm. Laser diode is used because of its advantage of high-quality cut at varying cutting speed.

#### C. CO<sub>2</sub> Laser

CO<sub>2</sub> lasers are the highest power which operates in continuous mode. In CO<sub>2</sub> lasers the light takes place within CO<sub>2</sub> molecules rather than within the atoms of a gas. Laser can cut a maximum of depth 3.5mm. CO<sub>2</sub> laser is used because of its varying power from 2 W to 20 kW. It has potential in overcoming nesting and cutting sequence problems.

#### D. Experimental Setup

The PC is connected with Arduino along with CNC Shield, which is fixed on top of the Arduino. CNC Shield firmware which is used to convert the G-Codes into embedded language. The motor drivers and the heat sinks are fixed in CNC Shield to reduce the heat. The stepper motor pins are connected to CNC Shield. The control parameters of the system consist of mechanical and electrical parameters. An arbitrary Waveform Generator which is used to control the electrical parameters of the laser. The electrical parameters are Duty cycle, Amplitude and Frequency. The mechanical parameters are standoff distance and cutting speed. The mechanical parameters are controlled by stepper motors using program codes. The Figure 3 shows the experimental LBM setup.



**Figure 3. Experiment setup**

The straight line of specified length is drawn using the CAD software and then they are imported from PC to the LBM setup. The parameters values are predefined and the cut is observed for carbonization and geometrical inaccuracy.

#### E. Controlling Parameters

##### a. Cutting Speed

The cutting speed is the moving speed of the laser module at desired direction to cut the leather. The slower the cutting speed the power density on the surface of the leather will be high therefore the leather is burned. The faster the cutting speed then power density on the surface of the leather is less therefore the leather is uncut.

##### b. Standoff Distance

The standoff distance is the height of distance between the laser and the workpiece. It is always kept at constant and it is calibrated before the machining process begins. The amount of thickness to be cut that is the penetration of laser beam on leather is decided by standoff distance.

##### c. Amplitude and Frequency

The Amplitude is a power modulator which enhances the power of the laser. The frequency decides the repetition of the signal over time. The frequency is directly proportional to the repetition of the signal.

##### d. Duty Cycle

The pulse width of a signal is decided by duty cycle. Duty cycle is defined as the cycle of operation of a device which operates in pulse mode. Lasers are used at non-continuous mode because continuous heat from laser damages the laser module as well as the setup.



**Figure 4. Duty cycle of 60% using arbitrary Waveform generator**

Duty cycle is always expressed in terms of percentage. The Figure 4 shows 60% duty cycle which means that the signal is ON for 60% of the time period and OFF for the rest 40% of the time period. Duty cycle operates fine from 40% to 70% for leather. The lesser the duty cycle the higher will be the carbonization. As the duty cycle keeps on increasing the intensity of the laser beam increases, which results in enormous heat. The leather gets ablated on such heat and fuses again.

#### IV. RESULTS AND DISCUSSION

The experiments were conducted on the laser diode and the CO<sub>2</sub> lasers. The influence of carbonization layer and geometric inaccuracies were observed with CO<sub>2</sub> laser and diode laser as shown in Figure 5. Even though the cutting process with CO<sub>2</sub> laser has been performed with the minimum power of 20Watts, a considerable amount of carbonization layer has been observed over the machined layer. This has been occurred owing to the high-power density as that of power diode.

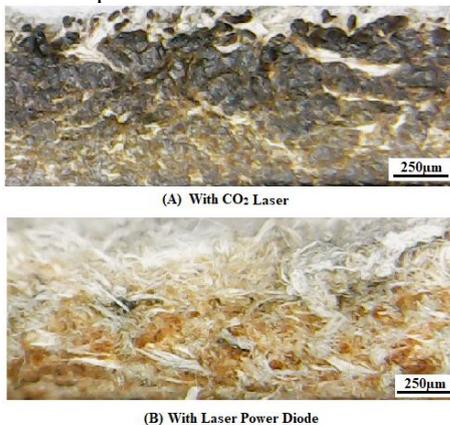


Figure 5. Carbonization layer on both lasers. Nevertheless, it has been observed lower carbonization zone over the machining zone using laser diode as shown in Figure 5. The carbonization layer has been drastically reduced due to the lower power density. However, the dross formation is still a drawback in case of laser diode. The further study will be focused to nullify the dross using laser diode.

The cross section of the carbon layer has also been investigated to analyze geometrical inaccuracies as shown in Figure 6.

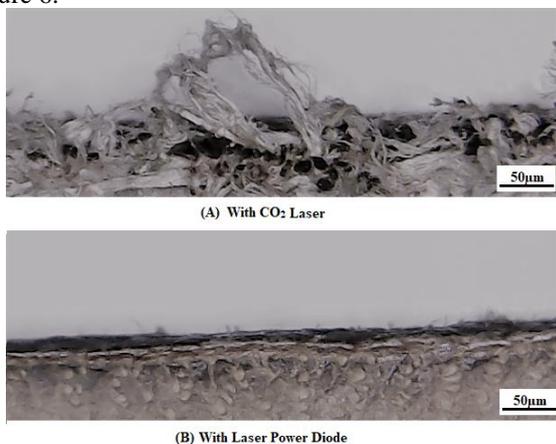


Figure 6. Geometrical Inaccuracies on both lasers. Power density of laser diode is less over the machined zone therefore the linear cut is achieved. However, the power

density is random and uncontrollable in case of CO<sub>2</sub> laser due to which the carbonization is high and the cut is nonlinear.

#### V. CONCLUSION

In the present study using CO<sub>2</sub> laser and diode laser the experiments were conducted to investigate the carbonization layer and geometrical inaccuracies. From the investigation the following conclusions were made.

1. Laser power diode can produce better geometrical accuracy over CO<sub>2</sub> laser.

2. Laser power diode produces less carbonization layer.

#### REFERENCES

1. Renann G. Baldovino, Jayson P. Rogelio, M.S., "A Pulse Width Modulation (PWM) LASER Power Controller for the 3-Axis Computer Numerically Controlled (CNC) LASER Machine", 7<sup>th</sup> IEEE International Conference Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM), 12-16 November, 2013.
2. P. Jammeswara kumar, A Siva Sai Tarun, M. Gowtham, P. Thamma Rao, G. Yaswanth, "Design and fabrication of portable Laser cutting and engraving machine", in International Journal of Engineering and Technology, 2018.
3. Nayanthara Bhatta, M.D., R. Rox Anderson, M.D., Keith Isaacson, M.D., Isaac Schiff, M.D., Krishna M Bhatta, M.D. in "Comparative study of different Laser systems", vol61, no.4, April 1994.
4. Anizah khalid, Irraivan Elamvazuthi, Susana, Kamaruddin, Mohd Shahrul Azmi and Mohd Nidzam, "Productivity Improvement Through Automation of Leather Cutting Process", Asia SENSE 2003.
5. Nasim, H., Jamil, Y.: Diode Lasers: From laboratory to industry. Opt. Laser. Technol. 56, 211-222 (2014).
6. Vasanth, S., Muthuramalingam, T., "A Study on Machinability of Leather Using CO<sub>2</sub> Based Laser Beam Machining Process". Advances in Manufacturing Processes, Lecture Notes in Mechanical Engineering, 239-244 (2019).

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