MSA
October University for Modern Science & Arts Faculty of Engineering
Department of Industrial Systems Engineering

Design and Manufacturing of a Laser Engraving Machine

A Graduation Project
Submitted in Partial Fulfillment of B.Sc. Degree Requirements in Industrial & Systems Engineering

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Abstract

In laser engraving, the laser beam burns the top layer of the surface to be engraved. The burned region stands out from the surrounding surface because it is uncolored. When engraving with a laser, the laser beam must penetrate the surface. This could be accomplished by focusing the beam on a specific location for an extended period. Gather the information required to learn more about this subject in depth, depending on the cutting material’s strength. A working model of a laser engraving machine will be created as part of the project. This equipment is very useful in our division because it functions as a sort of rapid prototyping device. It may engrave thermoplastic sheets and paper to create the desired shape.

It may engrave thermoplastic sheets and paper designs patterns to create the desired shape. We have gathered information on laser, and what engraving is up to this point. Laser engraving differs from laser cutting in that it uses a very low intensity, whereas laser cutting uses laser torches. We were given a quick overview of the laser, including how it works, what characteristics it has, how to produce it, and how to control its intensity. The machine is built with a 200mW red laser. It may be incapable of cutting through wood.

The software "Solid Work" is used to run simulation analyses on each component of the machine. It was useful if necessary.

Keywords: Laser, Solid Work, Engraving, Portable, Low Intensity.
Acknowledgement

In the name of Allah, the most gracious, the most merciful. Firstly, we would like to thank the following people without whom this study would never have eventuated. The participants, to whom we were unknown and yet they were prepared to share their world with us, their energy and hope in the future was vital to this study. Dean Prof. Dr. Nahid Sobhi (Dean of faculty of engineering) for her constant belief in us. Dr. Tarek Elhossainy, our supervisor, assisted with sharing ideas and contribution to the final product.
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# Activity Work Contribution

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Project Supervisor: Dr. Tarek Elhossainy

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Project Supervisor: Dr. Tarek Elhosseiny

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Chapter I

Introduction

1.1 Introduction

Light Amplification by Stimulated Emission of Radiation, or laser, was first identified in 1960. Laser light is distinct from other light because of its high temporal and constrained spectral bandwidth. In this instance, the light is amplified by a laser active material (gain medium). This medium is produced by promoting the emission of photons from a lower energy level to a higher energy level than was previously occupied by a pump source. For leasing activity to start in the medium, a non-thermal energy distribution called the population inversion is required. The needs of the active media influence the variation in photon wavelength. The wavelength is a representation of both the color and the energy held. The produced photon must be sent back into a resonator, which is essential. The produced photon must be sent back into the active medium via a resonator for many similar photons to collect for further stimulated emission. Pumping action is required for the laser active medium to receive energy constantly. This contributes to the continued production of sufficient emission. Lasers may be grouped in a few ways depending on their method of operation or the kind of laser-active material they use.

The first diode application for material processing passed long ago after connecting a 15W medical diode laser. Compared to earlier, it has substantially expanded currently. The advantages of high-power diodes are their compact size, durability, energy efficiency, and low cost of operation. Currently, CO2 and Nd:YAG lasers are used in the hardening and welding operations. High-power diode lasers may be distinguished from other types of lasers thanks to their wavelength, laser power, energy efficiency, beam creation, beam divergence, and asymmetry.

In its simplest form, engraving is the process of transferring a pattern to a hard, flat surface by making grooves in it perpendicular to the processing beam axis. For printing, generating maps, as well as for books and periodicals, engraving was an essential method of putting pictures on paper. Etching and other techniques have replaced the procedure because it is difficult to master. Modern engraving methods like laser engraving and three-photoengraving have a wide range of important uses. Laser engraving is one of the greatest technologies for use in wood engraving procedures. In this method, a laser beam pierces the solid material. Non-contact
operation, rapid scanning, high flexibility, and excellent automation are all advantages of this laser.

1.2 Problem Definition
The basis for the innovative design development in this project is the industrial laser cutting and welding equipment. This technique employs a movable platform with a laser nozzle mounted on top to provide the required manipulation capability (for proper laser cutting and engraving). a scaled-down version of the industrial cutting system, a cooling system, and a flexible bed design. With the help of an external power supply and an Arduino, the stepper motor that moves the bed is controlled.

1.3 Project Aim and Objectives
The project aims to develop a two axis CNC laser cutting and engraving machine to transform a large-scale industrial cutting machine into a compact portable lab equipment that can cut paper, polystyrene, and thin sheets through the following objectives:

- **Investigating** the reasons and impacts of switching to CNC laser cutting and engraving equipment from conventional equipment.
- **Literature reviewing** of earlier research on laser engraving equipment.
- **Reviewing** the concept of using the laser cutting and engraving machine.
- **Proposing** a plan of action that will make the machine transportable and reducing the cost of producing prototypes.
- **Collecting** the information needed to create a design.
- **Identifying** a method that would provide cutting with a high degree of accuracy and precision.
1.4 Report Organization

The Project is divided into five chapters:

Chapter I: Brief introduction that consists of background information, problem definition, project aims and objectives of the laser cutting and engraving machine.

Chapter II: The literature review, including all the previous studies related to the development of the laser cutting and engraving machine.

Chapter III: Design of the laser engraving machine.

Chapter IV: Manufacturing and Assembly.

Chapter V: Conclusions and Recommendations.
Chapter II
Literature Background

2.1 Introduction

According to Christian (2004), a laser cutting device has a chamber designed to provide a controlled environment when the laser beam is used to cut metals in order to restrict or eliminate heat energy and changes brought on by oxygen, also known as mechanical characteristics of the metal. Also described is how to consume gas and clean the cavity of particles. Gas is put up in a different configuration to be supplied to the cavity's regulated environment. A moving tool is used to create the flow of a shielding gas, which also offers a different way to disperse a laser beam before it harms the work piece.

To deliver a static laser shaft that is focused onto the sheet material as it passes through a tubular roller, the cutting tool is made consisting of a laser and a collimator that are placed in a fixed edge. An assistant head that is flexible longitudinally parallel to the material support suggestion and attaches reflecting and focusing devices controls the cutting sample. Under the direction of bi-directional material nutrition infers, this assistant head moves the internal motivation behind the longitudinal column of the material reinforce infers in synchronism with the improvement of the material.

In a desired modification, stamps on the sheet material are detected using an optical sensor mounted on the assistance head. An optical sensor's output is sent in yield and cut modes to a control PC. The yield technique for the PC has experts trigger the associate head and the bi-directional sustenance infers in synchronism while the laser is dead for the optical sensor to check the form or sample on the sheet material.

The computer handles the yield's delayed effects to generate a desirable cutting route in its memory that is specific to the sheet material's form or illustration. The computer's cut system also uses its expertise to activate the assistance head and the bi-directional alimentation.
2.2 Background

According to Ion (2005), in 1965, holes were drilled in diamond dies using the first industrial laser cutting device. The laser cutting device was created to cut metal and additional materials. The Western Electric Engineering Research Center, a British business that pioneered laser-assisted oxygen jet metal cutting in 1967, developed this gadget. This method was created in the early 1970s to cut titanium since CO2 lasers at the time were not strong enough to overcome the heat conductivity of metals. CO2 lasers were adapted to cut non-metals like fabrics and foam while they were used for aeronautical applications. To cut a metal work piece, a laser beam must contact its surface at a high enough intensity. To create beams with the right level of intensity, we use coherent laser sources that are devoid of outside disturbances. Modern high-tech laser cutting equipment is mostly used in industrial settings for mass manufacturing. The laser cutting machine is more accurate and precise than mechanical and plasma cutting. In the past, CO2 lasers were prohibitively costly, making them accessible to only a select few businesses.

2.3 Different Types Based on Laser Used in Cutting Mechanism

In general, three main types of lasers are used in laser cutting processes, according to Christian (2004). They are all explained below:

1. CO2 Laser

These lasers are often used for cutting, drilling, and engraving applications. To cut materials including wood, fabrics, stainless steel, titanium, plastic, aluminum, mild steel, and others, CO2 lasers are used in heavy industries. A high-speed gas combination composed of nitrogen, helium, and carbon dioxide is propelled by a blower. The laser generator and focus lens both require cooling. Air or coolant are frequently used for cooling. Water, which is widely used as a coolant, is circulated by a chiller or heat transfer system.

2. Laser micro-jet

A water-jet driven laser of this type shoots a pulsed laser beam and a low-pressure water jet at the surface of an object. Essentially, it is used when accurate cutting is required. The fact that this kind of water is cooled gives it an advantage over others since it stops chipping, micro-cracks, and heat impacted zones from developing. The cost of running a laser is minimal.
3. Fiber lasers

The market for fiber-type solid lasers for metal cutting is growing significantly. It makes use of a solid gain medium rather than a gas or a liquid. The laser beam produced is amplified by glass fiber. With a wavelength of 1.064 micrometer and a very tiny spot size, cutting reflective metal materials is feasible.

2.4 Different Type Based on Method of Cutting

There are five basic types depending on different cutting techniques or procedures, according to Ion (2005). They are all explained below:

2.4.1 Stealth dicing of silicon wafers

It takes use of a pulsed 1064 nm Nd:YAG laser, which is also well suited to the electrical bandgap of silicon. When converting silicon wafers into semiconductor devices, it is used.

2.4.2 Melt and blow

It is sometimes referred to as "fusion cutting" and uses high pressure gas to blast molten material away from the cutting location, which considerably decreases the amount of power required. Before being blasted away by a gas jet, the metal must first reach its melting point to cut. It is often used for metal cutting.

2.4.3 Reactive cutting

referred to as cutting using a laser gas or flame that has been stabilized. Cutting reactively, with a laser beam as the ignition source, is like cutting with an oxygen torch. Most commonly, this is utilized to cut carbon steel that is 1mm or thicker. With it, very thick steel plates may be cut into pieces.

2.4.4 Industrial laser cutting machine.

Schools, small businesses, and hobbyists are increasingly using laser cutting technology, which uses a laser to cut materials. It is mostly employed in manufacturing applications for industrial settings. The most common method of laser cutting includes utilizing opticsto concentrate the laser's energy. Utilizing laser optics and CNC, the manufactured material or laser beam is guided (computer numerical control). To follow a CNC or G- code of the material's planned
design, a motion control system is generally utilized with commercial laser cutters. A focused laser beam is used to target the substance, which causes it to melt, burn, evaporate, or be blasted away by a jet of gas, leaving behind an edge with a superior surface quality. Industrial laser cutters can cut structural and pipe materials as well as flat sheets of material. Figure 2.1 shows an industrial cutting machine.

![Figure 2.1: laser engraver machine](image)

### 2.5 Goal of Laser engraving machine

According to Ion (2005), engraving a specified picture or trademark onto a chosen material is the aim of laser engraving. This manufacturing method is subtractive. However, the machine needs a file before it can start the engraving process. The file is delivered from the computer to the machine controller, which then sets the laser. When the laser engraving process starts, the beam emits intense heat that burns or evaporates the surface in accordance with the file's picture. Line engraving and face engraving are the two varieties. While the second evaporates the material to produce an image within the material or to give the design a 3D-like sensation, the first employs a vector image to follow a route or line.

Which file types are necessary for laser engraving? 3D files like stl cannot be read by laser engraving devices. Therefore, we must employ 2D file formats like jpg, pdf, png, or ai. The depth of the sculpture is determined by the distance between the points that were converted
from the models in the file. Which file types are necessary for laser engraving? 3D files like STL cannot be read by laser engraving devices. Therefore, we must employ 2D file formats like jpg, pdf, png, or ai. The depth of the sculpture is determined by the distance between the points that were converted from the models in the file.

### 2.5.1 Laser Cutting vs Laser Engraving

According to Christian (2004), Laser cutting creates precise cuts in materials, as the name implies. This technique is used in many different industries, including aerospace, automotive, medicine, and electronics since it can cut through other materials and produce smooth surfaces. Even though they can laser cut and engrave, certain laser equipment still needs 2D data to function.

### 2.5.2 The difference between laser etching and laser engraving

An alternative term for laser engraving is laser etching. However, rather than vaporizing the substance, it functions as a tool that melts it. When a substance is etched, usually metal, it expands and creates a raised hollow. This alters the attribute. The material keeps its original form when laser engraving is used.

### 2.5.3 Laser Engraving vs Laser Marking

Because it doesn't vaporize any of the material, unlike laser engraving and laser etching, laser marking doesn't change the part's surface. Low intensity laser beams are used for laser marking, which oxidizes and darkens the substance as a result. Because of this, laser dark marking is another name for the practice. This process ultimately results in a high-contrast picture that is permanent. Usually, words or logos are imprinted on a piece of material using laser marking or laser etching.

### 2.5.4 Laser Engraving Applications

According to Li (2000), Due of the versatility of laser engraving, it is used in so many different sectors. To produce a clear engraving on the surface of medals or trophies, engraving is frequently utilized. However, letterhead or ornamental marks can also be engraved using a laser. Laser engraving technology is frequently used in manufacturing to etch barcodes on items. The benefit of engraving is that barcodes may still be scanned for commercial reasons even after being utilized in production or other tasks. Additionally, engraving techniques are
frequently utilized with other markers, including QR codes. Due to the laser's ability to perform accurate engraving work, the jewelry sector also employs this technology. They can speedily engrave items for consumers thanks to it. Parts must constantly be identifiable in both the electronics and medical industries. These parts are often laser engraved with identification marks for quick and accurate identification. There are several additional variations of applications. These illustrations, however, demonstrate how well laser engraving may be employed.

2.5.5 Used Materials in Laser engraved.

According to Li (2000), The vast range of materials that may be utilized for laser engraving is one of its key benefits. Laser engraving is feasible on a variety of materials, including acrylic, plywood, MDF, cardboard, glass, metal, leather, and POM. Let's examine each material's use of the technology in more detail:

1. Acrylic fiber
   The material acrylic is versatile. It is sturdy, significantly resistant to scratches, resistant to shrinkage, and shrink stable. This material offers good results and responds well to laser manipulation. It is a fantastic addition to the kitchen or bathroom due to its waterproof features. Acrylic is already used in many different sectors, including electronics and medicines. Cast acrylic (GS) and extruded acrylic are the two varieties of acrylic (XT). However, it is advised to only use cast acrylic for laser engraving since it produces superior results. Over 15 different acrylic paints are available in Sculpted.

2. Plywood
   Another substance that may be laser etched is plywood, but what is plywood exactly? Several pieces of wood are glued together to create this substance. The amazing qualities of plywood, such as flexibility, water resistance, mechanical strength, lightness, and beauty, are frequently used by cabin builders, builders, or industrial designers. Additionally, this material has a clear, brilliant surface that makes it perfect for laser engraving tasks. It is an excellent option for assembly projects since it is a lightweight material with minimal danger of breaking. Plywood is frequently utilized to give designs a distinctive but organic appearance. As a result, it makes a great finishing material.
3. **MDF**

MDF, or medium density fiberboard, is yet another type of usable wood. Remaining hardwood or softwood fibers are used to create this engineered wood, which is then mixed with resin binders and waxes. MDF boards are created by subjecting the fibers to extreme heat and pressure. MDF is a good material for sculpting since it lets you add depth to the piece. Like the material before it, MDF is strong and reasonably priced. Additionally, it is easy to produce and is waterproof, fireproof, malleable, bendable, paintable, dyeable, and colorable. MDF has a delicate texture and a light beige tint that defines it.

4. **Cardboard**

Like normal paper in origin, cardboard is a sturdy yet light-weight substance. Flat, embossed, or corrugated cardboard is laminated into pieces of various thicknesses during the manufacture of cartons. Cardboard is not only cheap, lightweight, and recyclable; it is also biodegradable. It is falsely believed that cardboard is solely used for packing as it is a great material for prototyping and displaying a model's architecture. The fact that card stock is so simple to work with is another advantage. It may be sliced, folded, and utilized with different installation techniques like glue or staples.

5. **POM**

POM, or polyoxymethylene, is a thermoplastic used in engineering. It is also known as polyoxymethylene or acetal. Popularity is attributed to its superior mechanical capabilities, superior dimensional stability, and high resilience. POM has a glass-like surface that is smooth. This substance has a wide range of characteristics. It is resistant to water, weather, and solvents in addition to being lightweight, sturdy, and long-lasting. Industrial tools, replacement parts, gears, hinges, and locks frequently use it.

6. **Glass**

Glass of almost any kind may be etched. Amazing effects may be produced with cups, wine glasses, bottles, and other items with this technology. Laser engraving is frequently used to give goods a more customized aspect, particularly in the wine business. There are several considerations to make, though: Choosing the right glass is crucial. Testing the glass type before beginning the engraving process is therefore usually beneficial.
7. **Metal**

Like glass, practically any metal may be engraved; the most popular metals are steel, iron, silver, aluminum, gold, and silver. Metal engraving is utilized for industrial and promotional applications, whereas glass engraving is most frequently employed for advertising. To improve aerodynamics, aircraft and vehicle makers will engrave their wings, while other manufacturers will utilize laser engraving to create sections with barcodes or QR codes.

8. **Leather**

Leather may also be laser-engraved in addition to metal, glass, plastic, and wood. Looks distinctive and unique. The most popular types of leather include suede, Alcantra, natural, synthetic, and nubuck. Because leather is frequently quite rigid, laser engraving is more desirable because it is challenging to produce aesthetically pleasing designs with other equipment.

2.6 **Types of laser engraving machines**

According to Leone C. Lopper and Iorio (2009), there are two types of machines for laser engraving - diode lasers and CO2 lasers.

2.6.1 **Diode laser machines**

Diode lasers and LED lights are frequently contrasted. Electricity is used to ignite electrons in negative/positive transitions, ejecting photons as a result. Before striking the substance, the beam goes through a lens to concentrate the photons. For instance, supermarket checkout counters employ diode lasers to read barcodes. Although more robust than those available in supermarkets, diode lasers used for engraving should nevertheless be handled carefully.

Despite being the most potent in their class, diode laser engravers cannot cut all materials. They are ideal for straightforward laser engraving applications, though, and are quite inexpensive.

2.6.2 **Choice of diode laser printers:**

- Ortur Laser Master 2
- Fox Alien LE-4040
- Atomstack A5 Pro
2.6.3 CO2 laser machines

In enclosed glass tubes filled with CO2 and other gases, lasers are created in CO2 machines. Because it aggravates the gas, electricity causes light to be produced. On its journey to the lens, the resultant light wipes away a number of mirrors. Before the beam leaves the laser and contacts the substance, the lens concentrates it where it needs to be. In general, CO2 lasers are more potent than diode lasers. They have the benefit of being able to penetrate materials that diode lasers cannot because of their power. Sadly, because of this machine's high sensitivity, if the glass tube or mirror is broken, the laser may not function correctly or at all. As a result, they need more upkeep than diode lasers. Wood, glass, ceramic, plastic, and leather are common materials for CO2 laser engraving. Despite this drawback, CO2 lasers can cut and engrave solid materials.

2.6.4 CO2 laser printer selection

- 40 W OMTech (DF0812-40BG)
- This Flux Beamo
- Laser Fusion Pro
- Muse Core Full Spectrum Laser
- The Glowforge Plus
- Laser Epilog Fusion Edge

2.7 Used Software

According to Leone C, Lopresto and Iorio (2009), for laser engraving to begin, laser equipment needs vector files. The laser engraver uses the file to determine where to focus the laser and what picture to produce. Such files can be produced by a wide variety of software applications. We concentrate on six key initiatives here as shown in figure 2.2:
2.7.1 Inkscape
Let’s begin with the Inkscape application. During the design phase, this open-source software is cost-free and provides a wide range of alternatives. You may use it to generatenew files from scratch or to fix or edit existing ones. Because it is simple to use yet still has excellent design tools, it is excellent for novices. The numerous channels for communication with other users offer the perfect environment for boosting and challenging the learning process. Mac OS X, Windows, and Linux distributions all supportInkscape.

2.7.2 Adobe Illustrator
It is not often known that Adobe Illustrator is a laser engraving program. Graphic design software may, however, also provide files for laser engraving. The program isn’t free compared to Inkscape. The program is available for a 7-day free trial, after which it costs €23.79 per month. While Illustrator functions well on its own, you may choose to purchase. An Adobe package to use additional programs like InDesign or Photoshop. The program has a steep learning curve, so beginners may need some instruction to become acclimated to it. File types for Adobe Illustrator include AI, PDF, DWG, SVG, DXF, andEPS. Both Microsoft and Mac users can utilize the program.

2.7.3 Lightburn
Another Lightburn is an additional piece of software that may be used to produce laser engraving files. This program was specifically made to create files for laser engraving. It supports vector graphics and image formats including PDF, AI, SVG, DXF, PLT, PNG, GIF, JPG, and BMP. You can make new vector shapes with the Lightburn editor and modify or rearrange them. We may also immediately transfer files to the laser cutter. Lightburn provides a 30-day trial to make sure the product is appropriate before needing a license purchase. Linux, Windows, and Mac OS users can use Lightburn.

2.7.4 DraftSight
DraftSight is a 2D laser cutting program with an emphasis on intricate 2D vector drawings. Its ability to convert PNG or jpg to vector lines and angles makes it special. After the first 30-day free trial, there are two price options for DraftSight: Professional is $200 per year and Premium is $499 per year. DraftSight is intended for specialists only because of its greater pricing. You
need a Mac or Windows computer to utilize DraftSight. DraftSight is a 2D laser cutting program with an emphasis on intricate 2D vector drawings. Its ability to convert png or jpg to vector lines and angles makes it special. After a 30-day free trial, DraftSight charges $200 per year for its Professional plan and $499 per year for its Enterprise plan.

2.7.5 On Shape

With On Shape, modifications can be done on the designs across a variety of platforms, including PCs, tablets, and smartphones. A 14-day free trial is available. Depending on the plan you select, the price might go as high as $2100 after the trial time. Since On Shape is a cloud-based service, it may be viewed using any web browser, including Firefox, Safari, Chrome, and Edge.

2.7.6 Laser Web

A totally free and open-source laser-cutting tool is Laser Web software. This tool’s capability to import several files in various formats into a project is one of its benefits. This broadens your options and makes collaboration easier. You have access to a wealth of advice through the extensive Laser Web community that can assist you develop your vector files. Both Mac and Windows users may use Laser Web.

Figure 2.2: Software Used During the Process.
2.8 Advantages of laser engraving

In practice, laser engraving has many advantages:

2.8.1 Speedy production process

Fast and stunning, laser engraving is. Since each laser pulse causes the substance to evaporate, the process completes quickly. It is especially useful when quick manufacturing and production times are a problem because of the quick procedure.

2.8.2 Wide range of materials

The ability to engrave on a variety of materials is another benefit of laser engraving. Customers can select from a variety of wood alternatives, including MDF, POM, cardboard, plastic, and metal. Design and material options are open thanks to these many materials.

2.8.3 Precision

Laser engraving has excellent precision and can etch complicated pictures on small objects, especially small ones like rings and necklaces.

2.8.4 Reliable process

The entire procedure of laser engraving is quite dependable. Compared to conventional techniques, damaged items are quite uncommon.

2.9 laser engraver machines Categorizing

According to Li (2000), laser A laser-engraving machine consists of three major components: a laser, a controller, and a surface. Engravers are devices that selectively remove small layers of material, leaving visible traces on the treated surface. The controller may trace designs onto the surface using the laser's beam as a drawing tool. The laser beams spread, intensity, speed of travel, and direction are all controlled by the controller. The surface is picked based on the kind of material that the laser can work with as shown in figure 2.3.
2.9.1 CO2 Laser Engravers

The CO2 laser cutting machine, also known as a CO2 laser cutter, is a type of CNC laser machine used to cut and engrave materials utilizing CO2 laser technology. The CO2 laser cutting device is also known as a CO2 laser engraving machine or CO2 laser engraver since it can also engrave. Besides, some people also call it wood laser cutter or acrylic laser cutter, etc. The CO2 laser beam from the CO2 laser cutting device is focused onto the material's surface using a focusing lens to melt it. At the same time, the molten material is blown away by the coaxial compressed gas. The laser beam follows a specific route as it creates a slit with a specific shape. The cutting operation is then finished.

Bebghalem et al. investigated how CO2 laser engraving settings affected the glass. They engraved a measurement scale for measuring equipment with an accuracy of around 1/10m using optical and regular glass. In their experiment, a CO2 laser with a 25 W maximum output was employed. Laser scanning speed (400, 600, 800, and 1000 m/s), power (25, 75, and 80 percent of 25 W), and the number of passes were the variables employed in this method (one, two and three passes). Galvanometric heads, which are made up of two fixed mirrors, directed the laser beam to the substrate. The laser beam is directed by these two mirrors to the lens, which focuses it at the work area. They also performed a calibration between the reference sample and the sample marked with a laser. The calibration findings revealed high exactitude and a minimal reading value dispersion. However, because of the volume of passes, they detect certain cracks in the etched sample, which constitutes a flaw in their job. Some authors in the current work employ underwater techniques to cool down the sample, which
causes cracks and other defects, laser-marked, and a reference sample. The calibration findings revealed high exactitude and a minimal reading value dispersion. However, because of the volume of passes, they detect certain cracks in the etched sample, which constitutes a flaw in their job. Some authors in the current work employ underwater techniques to cool down the sample, which causes cracks and other defects.

Additionally, using conventional CO2 laser engraving equipment on 304-grade stainless steel, it was examined how the laser parameter affected the engraving’s characteristics and width size. In their work, engraving was carried out on 304 grades of stain-free steel utilizing a combination of eight tests and eight factors. The study’s process parameters, which include assisting gas, gas pressure, cutting speed, focal height, and focusing lens, are covered. The sample was examined and measured under the metallurgical microscope. Using Minitab, the experiment design and analysis were employed to examine the quantitative findings.

Cutting speed and the relationship between power and speed had a significant impact on the engraving width. Even though the qualitative analysis used the same set of parameters, different distinctive distinctions were still evident. They discovered from their investigation that engraving width size characteristics may be anticipated from the settings utilized with conventional CO2 laser equipment. The flaws in this work were in the sparse experimentation, which prevented the data from being sufficient for dependency. Additionally, there are several additional crucial laser factors that have an impact on the engraving process but are not currently being researched.

### 2.9.2 Advantages of Co2 Laser engraver machine

From While the Co2 Laser engraver has numerous benefits, such as: -Rapid cutting speeds, we learned through reading this and other material that it also has some drawbacks.

- High efficiency of cutting
- Minimal heat-affected area
- Narrow incision for cutting
- Almost any nonmetal materials may be used.
- Unaffected by the work piece's form
- Saves on labor and materials
Additionally, it has some drawbacks that cannot be ignored, such as

- Low rate of photoelectric conversion
- Extremely high energy use
- Low operation cost
- Lenses need routine upkeep and cleaning.
- A number of consumables need regular maintenance.

![Figure 2.4: CO2 Laser Engravers](image)

### 2.9.3 Laser Diode Engravers

The semiconductor diode is the main component of a diode laser. More specifically, this is a p-n junction diode composed of a p-type semiconductor and an n-type semiconductor. Electrons can pass over the barrier with the help of the p-n junction, which functions as a turnstile.

Semiconductors constructed of gallium arsenide or aluminum alloys are frequently used in laser diodes. The diode receives electrical current, which causes electrons to flow via the p-n junction. The extra energy is then released as photons when these electrons mix with holes on the other side of the junctions. The "mirror" that increases the photons' intensity is the space between the two semiconductors. The photons clash with other particles as they bounce back and forth across this gap. It takes several hundred collisions to attain the desired optical gain in a diode laser.
Multiple semiconductor diodes can be stacked together for more intricate applications. These diodes' many beams may be concentrated into a single beam, greatly increasing the output's power. Additionally, this enables the production of several lasers with various investigations.

A pattern in the form of the number one (1) was etched on both of the two materials. The desktop laser engraving kit machine was utilized in this investigation with input settings (engraving speed, burning duration, and laser height) and output parameters (surface roughness and depth) in accordance with the careful design of the experiment. They examined the impact of these input factors on the output parameters in accordance with this experiment design. Surface Roughness Mitutoyo SJ-400 equipment was used to measure the etched depth (Rz) and surface roughness (Ra). This device is from the UTHM metrology laboratory. Ra and Rz are two different surface roughness characteristics that have been studied in this investigation wavelengths.

RA means roughness depth, which is the mean value of the five Rzi values from the five-sampling length inside the evaluation length. Ra is arithmetical mean roughness, which is the arithmetical mean of the absolute values of the profile deviations (Zi) from the men line of the profile. This investigation will also make use of a scanning electron microscope (SEM) to provide high resolution and long depth field pictures of the sample surface. It is also the kind of electron microscope that scans a sample with a focused electron beam to make pictures of it. Additionally, the electrons interact with the atoms in the sample to provide a variety of signals that reveal details about the sample's topography and the composition. This analysis was needed in this study because the Heat Affected Zone (HAZ) effect on the engraved materials needs to be discuss due to parameter selected for both materials. An analyze of variance (multifactor NOVA by the Design Expert software) was used to determine if the input parameter significantly affected the output parameter.

This review work has found a gap in the literature since, typically, only engineering journal papers, articles, and books provide in-depth descriptions of the terminologies and technical procedures. The effects of employing low-power diode lasers on materials are not discussed, nor are the settings required to create clean engraving on the surface suggested. Additionally, there are some published experimental results made by professionals that have employed lasers for design.
2.9.4 Application of Laser Diode Engravers

For the application of the design shown in figure 2.6, laser diodes are excellent because, among other things:

- They have a low cost compared to other laser modules.
- They are small, making them more rigid than CO2 lasers.

Because they are lightweight, the complete design will become lighter as they are transported over a tiny CNC gantry.

- They are sturdy.
- They require far less maintenance than CO2 lasers.

![Example of Design of CO2 Laser Engraver](image1)

**Figure 2.5**: Example of Design of CO2 Laser Engraver

![Laser Engraving Applications](image2)

**Figure 2.6**: Laser Engraving Applications
Chapter III
Design & Methodology

3.1 Introduction

In this chapter we will go through presenting all Electronic and mechanical components with their specifications. Obviously, this type of construction of the machine cannot provide much rigidity so we cannot use it as a CNC router or a mill. Though, if we attach a more powerful laser, we could use it to cut various materials, like this MDF board that we are using here or other types of wood boards and with quite good accuracy. The working area of is quite big 400 by 400 mm, and the level of details that this laser engraver can produce is impressive. To be honest I was surprised how good the engravings turned out. I started by designing the machine using SOLIDWORKS for Makers. The two main components of this CNC machine is this v slot profile together with their suitable sliding wheels.

Figure 3.1: Finished Design

For driving the blocks or the two axes, we are using two NEMA 23 stepper motors and some
suitable GT2 pulleys and timing belts. For connecting everything together we are using an 8mm MDF board, and for homing the machine, two micro limit switches.

3.2 Electronic Components Description and Specifications

3.2.1 Laser Application

According to Bullinger (2009), in 1960, the laser was created, and later on it was referred to as "a solution looking for a problem." Two mirrors make up the foundation of the laser. They are positioned parallel to one another to form an optical oscillator, or chamber, through which light can pass between the mirrors and the optic axis. Without absorption, this motion would continually go back and forth between the mirrors. By stimulating emission, an active medium positioned between the mirrors can intensify the oscillations of light. To activate the energy-based media, there is another system. These systems typically consist of a DC OR RF power supply, in this case CO2, HE/NE, or a focused light pulse for ND-YAG lasers.

- Different types of Lasers

According to Bullinger (2009), Applications for laser technology can be found in a wide range of fields, including strong light, measurements, holography, inspection, recording, communication, medicine, material processing, and more. (Steen, 2005) Carbon dioxide (CO2), carbon monoxide (CO), neodymium-yttrium aluminium garnet (ND-YAG), ND-glass, excimer (KrF, ArF, XeCl), and diode lasers are some of the lasers that are frequently used for material processing (GaAs, GaAlAs, InGaAs, GaN).

![Laser Source](image)

*Figure 3.2: Laser Source*
• Specifications of the Laser

The following table represents the Specifications of the Laser shown in figure 3.1.

Table 3.1: Specifications of the Laser

<table>
<thead>
<tr>
<th>Laser</th>
<th>Multi diode pump fibre laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal average power</td>
<td>20w (optional 10 w)</td>
</tr>
<tr>
<td>Max. Peak Power</td>
<td>&gt;7.5 KW</td>
</tr>
<tr>
<td>Pulse Repetition Rate</td>
<td>20-80 KHz</td>
</tr>
<tr>
<td>Wave length</td>
<td>1060 +/- 10nm</td>
</tr>
<tr>
<td>Pulse duration @20 KHz</td>
<td>&lt;120 ns</td>
</tr>
<tr>
<td>Power Stability</td>
<td>&gt;95 %</td>
</tr>
</tbody>
</table>

• Advantages of the Design

The proposed design will allow lighter weight and it will be able to work on any flat surface. The design will be made with mostly parts that are locally available. The cost will be minimal.

3.2.2 Stepper motor

DC motors that move in distinct increments are called stepper motors. They have several coils that are arranged into "phases" or collections. The motor will rotate one step at a time by activating each stage in turn. You can regulate your speed and/or location with extreme precision using computer-controlled stepping. Stepper motors are the preferred motor for numerous precision motion control applications as a result. Stepper motors are available in a wide range of sizes, designs, and electrical properties. This tutorial explains how to choose the best motor.

Figure 3.3: Stepper Motor
• The Specifications of the stepper motor NEMA 17

The following table represents the Specifications of NEMA 17.

**Table 3.2:** Specifications of the DC Motor of the NEMA 17

<table>
<thead>
<tr>
<th>Stepper motor selection criteria</th>
<th>Our needs</th>
<th>Stepper Motor data sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>✔</td>
<td>45.33 USD</td>
</tr>
<tr>
<td>Current Consumption</td>
<td>1…3 A</td>
<td>2.8 A</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>10…30V</td>
<td>12V</td>
</tr>
<tr>
<td>Power consumption</td>
<td>✔</td>
<td>23W</td>
</tr>
<tr>
<td>voltage type</td>
<td>DC</td>
<td>DC</td>
</tr>
<tr>
<td>Construction</td>
<td>✔</td>
<td>PERMANENT MAGNET</td>
</tr>
<tr>
<td>Efficiency:</td>
<td>✔</td>
<td>IE 1 According to IEC 60034-1</td>
</tr>
<tr>
<td>Speed</td>
<td>60RPM</td>
<td>45RPM</td>
</tr>
<tr>
<td>Torque</td>
<td>120kg.cm</td>
<td>120kg.cm</td>
</tr>
<tr>
<td>Type</td>
<td>Stepper motor</td>
<td>Stepper motor</td>
</tr>
</tbody>
</table>

### 3.2.3 A4988 Stepper Driver

The A4988 is a complete micro stepping motor drive with built-in translator for easy operation. It is designed to operate bipolar stepper motors in full-, half-, quarter-, eighth-, and sixteenth-step modes, with an output drive capacity of up to 35 V and ±2 A. The A4988 includes a fixed off-time current regulator, which can operate in slow or mixed decay modes. The translator is the key to the easy implementation of the A4988. Simply inputting one pulse on the STEP input drives the motor one micro step. There are no phase sequence tables, high-frequency control lines, or complex interfaces to program. The A4988 interface is an ideal fit for applications where a complex microprocessor is unavailable or is overburdened. During stepping operation, the chopping control in the A4988 automatically selects the current decay mode: slow or mixed. Mixed decay current control results in reduced audible motor noise, increased step accuracy, and reduced power dissipation.
3.2.4 Limit switches

Mechanical limit switches are contact-sensing devices widely used for detecting the presence or position of objects in industrial applications. The term limit switch is derived from the operation of the device itself.

Figure 3.4: Limit Switch

Figure 3.5: Limit switch
3.2.5 Arduino Uno

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is similar to Arduino Nano and Leonardo. The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available. The word "Uno" means "one" in Italian and was chosen to mark the initial release of Arduino Software. The Uno board is the first in a series of USB-based Arduino boards; it and version 1.0 of the Arduino IDE were the reference versions of Arduino, which have now evolved to newer releases.

![Arduino Uno](image)

**Figure 3.6:** Arduino Uno
**Arduino Uno Specification**

- Microcontroller: ATmega328P
- Operating Voltage: 5V
- Input Voltage (recommended 7-12V)
- Input Voltage (limit): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader.
- SRAM: 2 KB (ATmega328P)
- EEPROM: 1 KB (ATmega328P)
- Clock Speed: 16 MHz
- LED_BUILTIN: 13
- Length: 68.6 mm
- Width: 58.4 mm
- Weight: 25 g

**3.2.6 Arduino Uno CNC shield**

Arduino CNC shields provide an Arduino microcontroller with the power necessary to drive stepper motors and run all the other functions that contribute to a CNC machine's operation. Depending on the shield, this could include end stops, spindle speed control, and probing.

CNC shield V3 is an open-source hardware used to control stepper motors. Allows you to control 4 motors simultaneously. It uses removable A4988 stepper controls. Stepper motors are connected via 4-pin connectors. Its supply voltage is 12-36 V.

Arduino shields provide some important advantages: **Sortable.** The layout of a shield board will be compatible with a basic Arduino board, which means they can be plugged in straight away. Signals are sent from the GPIO pins or other MCU interface, and multiple shields can be stacked together to form a complex system.
Specification:

- Voltage motor power supply (depending on driver): from 12 V to 36 V
- Power supply voltage is connected via a screw connector ARK
- Operating voltage logic signal: 5 V
- Connectors of the motor driver compatible with A4988 and the like
- Output connectors, UART and I2C
- Inputs for end sensors, limit switches type END STOP: Z+ / Z-, Y+ / Y-, X+ / X-
- Embedded capacitors 100 uF and 50 uF 8 mm
- Resistors 10 ohms
- Outputs for motors
- Compatible with GRBL 0.8 c

Figure 3.7: Arduino Uno CNC shield
3.3 Mechanical Components

3.3.1 V-Slot Profiles with Wheel

V-SLOT profiles are used in machines that use linear motion, such as 3D printers and CNC milling machines. They move by means of rollers placed in grooves of V-SLOT profiles. The plates of the carriages are equipped with special holes allowing the installation of a tooth belt responsible for the drive. Pre-punched holes in the surface of the plate reduce the weight of the carriage and enable installation of the components to be set in motion.

![Figure 3.8: V-Slot Profile](image)

3.3.2 Wheels for V-SLOT profiles

Wheels for V-SLOT profiles are an indispensable element in systems based on aluminum profiles where movement is required, particularly in 3D printers and CNC milling machines. The shape of the rollers is adapted to the shape of the groove type V, V-SLOT. The inside of the roller is usually equipped with a bearing which is to ensure the lowest possible resistance in linear motion.

![Figure 3.9: V-slot Profiles with Wheel](image)
3.3.3 Pulley

A sheave or small wheel with a grooved rim and with or without the block in which it runs used singly with a rope or chain to change the direction and point of application of a pulling force and in various combinations to increase the applied force especially for lifting weights.

![Pulley Diagram]

**Figure 3.10: Pulley**

The pulleys should have a matching pitch and tooth profile for the selected belt. The choice of pitch would depend on the required precision and resolution of the system. A **pulley with a diameter of approximately 20-25 mm would be suitable for this application.**

3.3.4 GT2 timing Belt:

GT2 timing belts are intended for lower load applications such as the first reduction in a gearbox, or motor to flywheel. GT2 belts use a smaller pitch than HTD belts, which means you can use larger reductions in those tight fit areas of your robot.

![GT2 Timing Belt]

**Figure 3.11: GT2 Timing Belt**
3.4 Mechanical sizing and Calculation

CNC laser system with a workspace of 40 x 40

Figure 3.12: CNC laser system

3.4.1 x-axis

- **Load on X-axis is**
  - weight of laser diode, belt, wheals and other connections = 0.5 kg
  - Gear Ratio =1/2
  - Acceleration= 1 m/s^2
  - Maximum Speed = 500 rpm
  - Torque on X-axis = Load on X-axis * Gear Ratio * Acceleration / (2 * π * Maximum Speed / 60) = 0.5 kg * 1 * 1 m/s^2 / (2 * π * 500 rpm / 60) = 0.19 Nm
  - NEMA 17 stepper motor with .2 Nm torque will be suitable
3.4.2 Y-axis

- Load on Y-axis = 1.065 kg
- weight of laser diode belt, wheals and other connections 0.5 kg
- weight of X-axis motor 0.365 kg from the data sheet of NEMA 17 stepper motor
- Aluminum frame X-axis 20*20
- from the technical specifications, the weight of X-axis will equal 0.2 kg

![Image of Aluminum Frame X-axis 20*20]

Figure 3.13: Aluminum Frame X-axis 20*20

3.4.3 Features:

- Light duty
- Profile ideal for small frames
- Has four 6mm T-slots
- Center-bore is for an M6 or 1/4-20 tap
  - Gear Ratio = 1/2
  - Acceleration = 1 m/s²
  - Maximum Speed = 500 rpm
  - Torque on Y-axis = Load on Y-axis * Gear Ratio * Acceleration / (2 * π * Maximum Speed / 60) = 1.065 kg * 1 * 1 m/s² / (2 * π * 500 RPM / 60) = 0.38 Nm
  - So Based on these calculations, a NEMA 17 stepper motor will be suitable as it torques.
  - As NEMA 17 stepper motors typically have a torque range of 0.2 Nm to 0.4 Nm
3.4.4 Belt Type:
For a CNC laser system, a toothed timing belt is typically used, as it provides precise motion and high torque transmission. To determine the appropriate belt type, length, and tension for the CNC laser system with a workspace of 40 x 40 cm and torque requirements of 0.2 Nm in the X-axis and 0.4 Nm in the Y-axis.

1. **Calculate the load on each axis.**
   - Load on X-axis = 0.5 kg
   - Load on Y-axis = 1.065 kg

2. **Calculate the torque required for each axis as:**
   - Torque on X-axis = 0.2 Nm
   - Torque on Y-axis = 0.4 Nm

3. **Select the appropriate belt type.**
   A toothed timing belt with a pitch of 3 mm or 5 mm would be suitable for this application. The choice of pitch would depend on the required precision and resolution of the system.

4. **Calculate the belt length. The belt length can be calculated using the following formula:**
   The formula for calculating the required belt length is:
   \[
   L = 2C + \left( \frac{\pi}{2} \times (D1 + D2) \right) + \left( \frac{(D2 - D1)^2}{4C} \right),
   \]
   where \( L \) is the required belt length,
   \( C \) is the distance between the pulleys,
   \( D1 \) and \( D2 \) are the diameters of the pulleys,
   and \( \pi \) is pi (approximately 3.14).
   
   the distance between the two pulleys is 400 mm, and the other pulley's diameter is 20 mm,
   the formula for the required belt length is:
   \[
   L = 2C + \left( \frac{\pi}{2} \times (D1 + D2) \right) + \left( \frac{(D2 - D1)^2}{4C} \right)
   \]
   \[
   L = 2(400) + \left( \frac{\pi}{2} \times (20 + 20) \right) + \left( \frac{(20 - 20)^2}{4 \times 400} \right)
   \]
   \[
   L = 800 + [1.57 \times 40] + [0 / 1600]
   \]
   \[
   L = 800 + 62.8
   \]
   \[
   L = 862.8 \text{ mm (approximately)}
   \]
5. Determine the appropriate belt tension. The tension of the timing belt should be set to approximately 5% to 10% of the maximum breaking strength of the belt to ensure accurate motion and prevent slipping.

For example, if we assume a maximum breaking strength of 20 N for the timing belt, the tension should be set to approximately 1 N to 2 N.

3.4.5 The pulley

The pulleys should have a matching pitch and tooth profile for the selected belt. The choice of pitch would depend on the required precision and resolution of the system. A pulley with a diameter of approximately 20-25 mm would be suitable for this application.

3.4.6 the reaction forces

Aluminum frame Y-axis 40*20

- from the technical specifications, the weight of Y-axis will equal 0.5 kg
- the reaction force = the weights of (laser diode, Y-axis motor, X-axis motor, Aluminum frame Y-axis 40*20 and Aluminum frame X-axis 20*20)

\[ = (0.365 + 0.2 + 0.2 + 0.5 + 0.365) \text{ kg} \]

\[ = 1.995 \text{ kg} = 2 \text{ kg} \]

the reaction force on one support = total reaction/2 = 2/2 = 1 kg

To calculate “x”, take moment at point “O”

\[ \Sigma_x = 0 \]

\[ 0.365 \times 40 = 1(x) + 0.365 \times 5 \]

\[ X = 12.775 \text{ cm} \]

Take x = 15 cm for safety

![Figure 3.14: fraction Force](image)
3.5 Software And Circuit Design

3.5.1 Laser Engraver Circuit Diagram

So, an Arduino UNO board will be used in combination with a CNC Shield and two DRV8825 or A4988 stepper drivers. Two micro limit switches will be used for homing the machine and a 12V Laser module which can be PWM controlled. For powering 12v power supply with a minimum current rate of 3 amps is needed.

![Circuit Diagram](image)

Figure 3.15: Circuit Diagram of How Everything Needs to be Connected.

3.5.2 Firmware and Control Software

With this, we are done assembling the machine. What is left to do now is to give life to it or make it a real CNC machine. For that purpose, installing firmware is needed on the Arduino for controlling the motion of the CNC machine as shown in figure 3.10.

![Software Diagram](image)

Figure 3.16: Firmware and Control Software Diagram
Chapter IV
Manufacturing and Assembly

4.1 Introduction
In this chapter, the manufacturing and assembly process of the proposed laser engraver design will be discussed. The design, which was developed in Chapter III, will be manufactured, and assembled to create a functional laser engraver.

![Sledworks Assembly](image)

Figure 4.1: Sledworks Assembly

4.2 Materials and Tools
Materials and tools required for the manufacturing and assembly process are listed below:
Materials:
- Aluminum extrusion profiles
- 3D printed parts
- Laser diode
- Stepper motor
- Timing belts
- Bearings
- Screws and nuts
- Wiring and cables
• Power supply

Tools:
• Saw
• Drill
• Taps and dies
• Screwdrivers
• Wrenches
• Pliers
• Wire stripper and cutter
• Multimeter

4.3 Manufacturing Process

The manufacturing process involves cutting, drilling, tapping, and assembling the components. The following steps will be followed:

Step 1: Cut the aluminum extrusion profiles to the required length using a saw. aluminum extrusion profiles 20*20 to x-axis and 20*40 to Y-axis

![Figure 4.2: Aluminum Extrusion Profiles 20*20 to x-axis and 20*40 to Y-axis](image)
Step 2: Drill holes in the profiles for mounting the components using a drill.

Step 3: Tap the holes for screws and nuts using taps and dies.

![Figure 4.3: Taps and Dies.](image)

Step 4: Print the required 3d printed parts

![Figure 4.4: 3d Printed Parts](image)
Step 5: Assemble the profiles and 3d printed parts using screws and nuts to create the frame of the laser engraver.

Step 6: Mount the stepper motor, bearings, and timing belts on the frame using screws and nuts.

Step 7: Install the laser diode on the frame and connect it to the power supply using wiring and cables.

Step 8: Install the control board and firmware on the laser engraver and test the functionality using a multimeter.

4.4 Assembly Process

The assembly process involves connecting the components and wiring them to create a functional laser engraver. The following steps will be followed:

Step 1: Connect the stepper motor to the control board using wiring and cables.

Step 2: Connect the laser diode to the control board using wiring and cables.

Step 3: Connect the power supply to the control board and the laser diode using wiring and cables.

Step 4: Install the firmware and control software on the computer and connect it to the laser engraver using a USB cable.

Step 5: Test the functionality of the laser engraver by engraving a sample design on a material.

Figure 4.5: final Design
Chapter IV
Conclusions and Future Work

5.1 Conclusions

To sum up, this project aims to develop a two axis CNC laser cutting and engraving machine to transform a large-scale industrial cutting machine into a compact portable lab equipment that can cut paper, polystyrene, and thin sheets through the following objectives:

This project discussed the different types of lasers used and software needed and the proposed design. The project also illustrates the components used, and the required calculations to achieve the required design through the following objectives:

- After Investigating the reasons and impacts of switching to CNC laser engraving machine from conventional equipment, we were able to understanding the effect of CNC engraving machine on the efficiency of engraving, heat-affected area and narrow incision for engraving.
- After Literature reviewing of earlier research on laser engraving equipment, we get the background on how it works and the previous designs besides several types of engraving machines.
- After Reviewing the concept of using the laser cutting and engraving machine, we can differentiate between the traditional machine and the CNC laser engraving and understanding the applications and advantages of laser engraving such as Speedy production process and precision.
- After Proposing a plan of action that will make the machine transportable and cut the cost of producing prototypes, collecting data and gathering information were begun.
- After collecting the information needed to create a design, Calculations and required components were discussed.
- After Identifying a method that would provide engraving with a high degree of accuracy and precision, the design of the CNC laser engraving machine will be started.
5.2 Recommendation

Based on the preliminary design of the proposed two-axis CNC laser cutting and engraving machine, the following recommendations are made:

5.2.1 Further Development and Testing

The proposed design should be further developed and tested to determine its feasibility and effectiveness. The machine should be fabricated and tested to evaluate its performance, accuracy, and reliability. The testing should be done with different materials to ensure that the machine can cut and engrave various materials effectively.

5.2.2 Improvement of the Cooling System

The cooling system of the machine should be improved to ensure that it can sustain long periods of operation without overheating. This can be achieved by incorporating a more efficient cooling system that can dissipate heat effectively.

5.2.3 Integration of Safety Features

The machine should be designed with safety features such as an emergency stop button, laser power adjustment, and laser beam shielding to prevent accidents and injuries.

5.2.4 Cost Reduction

The cost of producing the machine should be reduced to make it more affordable for small businesses and hobbyists. This can be achieved by sourcing less expensive components and optimizing the design to reduce material waste.

5.2.5 User-Friendly Interface

The machine's user interface should be designed to be user-friendly and easy to operate. This can be achieved by incorporating a touchscreen interface and intuitive software that can be used by individuals with minimal technical expertise.

5.2.6 Maintenance and Repair

The machine should be designed in such a way that maintenance and repair can be performed easily. This can be achieved by incorporating modular components that can be easily replaced if damaged or worn out.

5.2.7 Marketing and Distribution

The machine should be marketed and distributed effectively to reach its target audience. This can be achieved by partnering with companies that specialize in the distribution of similar equipment and using social media and online platforms to promote the machine.

In conclusion, the proposed two-axis CNC laser cutting and engraving machine has the potential to revolutionize the cutting and engraving industry by providing a compact and affordable solution for small businesses and hobbyists.
References


Bullinger H-J (2009) Aside from the energetically loaded laser-active medium the crystal, liquid or gas – it is necessary to feed back the generated photons into the medium using a. Technology Guide


Appendices

Appendix A1: A4988 Stepper Driver

Appendix A2: Functional Block Diagram

Figure A1: A4988 Stepper Driver

Figure A2: Functional Block Diagram
Appendix A3: NEMA 17 Stepper Motor Pinout

Figure A3: NEMA 17 Stepper Motor Pinout

Appendix A4: NEMA17 Stepper Motor Dimensions

Figure A4: NEMA17 Stepper Motor Dimensions
الخلاصة

في النقش بالليزر ، يحرق شعاع الليزر الطبقة العليا من السطح ليتم نقشها. تبرز المنطقة المحترقة عن السطح المحيط لأنها غير ملونة. عند النقش بالليزر ، يجب أن يخترق شعاع الليزر السطح. يمكن تحقيق ذلك من خلال تركيز الشعاع على موقع معين لفترة طويلة من الزمن. اجمع المعلومات المطلوبة لمعرفة المزيد عن هذا الموضوع بعمق ، اعتمادًا على قوة مادة القطع. سيتم إنشاء نموذج عمل لآلة النقش بالليزر كجزء من المشروع. هذه المعدات مفيدة جدا في قسمنا لأنها تعمل كنوع من أجهزة النماذج الأولية السريعة.

قد تقوم بنقش صفائح وورق لدن بالحرارة لإنشاء الشكل المطلوب.

قد تقوم بحفر الألواح البلاستيكية الحرارية وأنماط تصميمات الورق لإنشاء الشكل المطلوب. لقد جمعنا معلومات عن الليزر بالليزر ، وما هو النقش حتى هذه النقطة. يختلف النقش بالليزر عن القطع بالليزر من حيث أنه يستخدم كثافة منخفضة جدا ، بينما يستخدم القطع بالليزر مشاعل الليزر. لقد حصلنا على نظرة عامة سريعة على الليزر ، بما في ذلك كيفية عمله وميزاته وكيفية إنتاجه وكيفية التحكم في شدته. تم تصميم الجهاز باستخدام ليزر أحمر بقوة 200 ميجاوات. قد يكون غير قادر على قطع الخشب.

يتم استخدام برنامج "Solid Work" لإجراء تحليلات محاكاة على كل مكون من مكونات الجهاز. كانت مفيدة إذا لزم الأمر.

الكلمات الرئيسية: ليزر ، عمل متين ، نقش ، محمول ، كثافة منخفضة.
MSA

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