UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF LASER POWER AND SPEED ON SURFACE QUALITY WHEN ENGRAVING ON ALUMINIUM

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A thesis submitted
in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this Choose an item. entitled " Effect Of Laser Power And Speed On Surface Quality When Laser Engraving On Aluminium" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : Muhammad Syukri Bin Ahmad

Date : 10 / 01 / 2023

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

Signature : .....

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DEDICATION

This study is dedicated from the bottom of my heart to my loved and respected family, especially my parents, who have been my source of inspiration which given me strength during my hardship, who have never left my side, and who never give up to provide moral, spiritual, emotional, and financial support. This work is dedicated to my supervisor, Prof. Madya Ir. Dr. Mohd Hadzley Bin Abu Bakar, and special appreciation are expressed for all of his assistance during the process. This research is also dedicated to my instructors and friends who have always provided me with guidance and inspiration to complete it

ABSTRACT

In recent years, laser engraving has become one of the most promising technologies for engraving or marking an item. The purpose of this research is to investigate the impact of laser engraving settings on the surface morphology and quality of an aluminium. The laser engraving method is applied to the surface of aluminium, and therefore, the engraving parameters are researched to produce the optimal engraving rates on aluminium. Laser engraving is a kind of machining used whenever a material is engraved using a laser. Laser engraving is the easiest method for cutting difficult materials, because it eliminates material layer by layer. For laser engraving, the most common types of industrial lasers are the carbon dioxide (CO2) laser, the neodymium-doped yttrium aluminium garnet (Nd: YAG) laser, the fibre laser, and the semiconductor laser. The purpose of this experiment is to determine the effect of technique parameters (laser power, scanning speed, and laser frequency) on material removal rate, engraving depth, and surface roughness. Aluminum is engraved with digitally created patterns during this study. The removed material layer thickness and, therefore, the material removal rate were the measured parameters that determined the method's success. Then, using the Misumi Digital Depth micrometer and a digital USB microscope, a surface roughness test will be conducted to evaluate the surface quality and microscopic of an aluminium alloy

ABSTRAK

Dalam beberapa tahun kebelakangan ini, ukiran laser telah menjadi salah satu teknologi yang paling menjanjikan untuk mengukir atau menandakan sesuatu item. Tujuan penyelidikan ini adalah untuk menyiasat kesan tetapan ukiran laser pada morfologi permukaan dan kualiti aluminium. Kaedah ukiran laser digunakan pada permukaan aluminium, dan oleh itu, parameter ukiran dikaji untuk menghasilkan kadar ukiran yang optimum pada aluminium. Ukiran laser ialah sejenis pemesinan yang digunakan apabila sesuatu bahan diukir menggunakan laser. Ukiran laser adalah kaedah paling mudah untuk memotong bahan yang sukar, kerana ia menghilangkan bahan lapisan demi lapisan. Untuk ukiran laser, jenis laser perindustrian yang paling biasa ialah laser karbon dioksida (CO2), laser garnet aluminium yttrium berdop neodymium (Nd: YAG), laser gentian dan laser semikonduktor. Tujuan eksperimen ini adalah untuk menentukan kesan parameter teknik (kuasa laser, kelajuan pengimbasan, dan kekerapan laser) ke atas kadar penyingkiran bahan, kedalaman ukiran dan kekasaran permukaan. Aluminium diukir dengan corak yang dicipta secara digital semasa kajian ini. Ketebalan lapisan bahan yang dikeluarkan dan, oleh itu, kadar penyingkiran bahan adalah parameter yang diukur yang menentukan kejayaan kaedah. Kemudian, menggunakan Mikrometer digital dan mikroskop USB digital, ujian kekasaran permukaan akan dijalankan untuk menilai morfologi permukaan dan struktur mikro aloi aluminium.

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CHAPTER 1

INTRODUCTION

1.1 Background

In recent decades, lasers have been widely used for cutting and welding tasks. By introducing laser sources with shorter and shorter pulses spanning from nanosecond to femtosecond, this approach has recently been used in different industrial processes such as marking, selective removal, and processing of various materials. Engraving is a method of creating product identifiers such as time stamps, component labels, and barcode tagging. Engraving can be done in a variety of techniques, including tin marking, mechanical engraving, and electrochemical engraving. Laser marking offers various advantages over traditional marking methods, including the fact that it does not need tool wear due to its high level of automation, as well as free programming and character selection.

Laser engraving is a subtractive manufacturing method that involves changing the surface of an object with a laser beam. This method is often used to create images that are presented at eye level on the material. The laser produces a lot of heat, which causes the material to spray and show the holes that make up the final image. The laser is used to mark the surface of a metal workpiece

(Mehta et al., 2015) discovered that laser engraving has various benefits over regularly used engraving methods, including the fact that it does not require any inks or tool bits. Furthermore, the major advantages of laser engraving include noncontact working, which decrease the probability of product damage, high precision, faster scanning speed, as well as great flexibility and automation. The interaction of a laser system through a focusing lens (convex lens) between material and laser beam leads in the vaporization and melting of the materials employed in the operation, which is the working principle of laser engraving. It's also a great example of how a fundamental theoretical concept may persist until a technology application is rediscovered. As a result, the material is abated from the workpiece in layers by an ablation process.

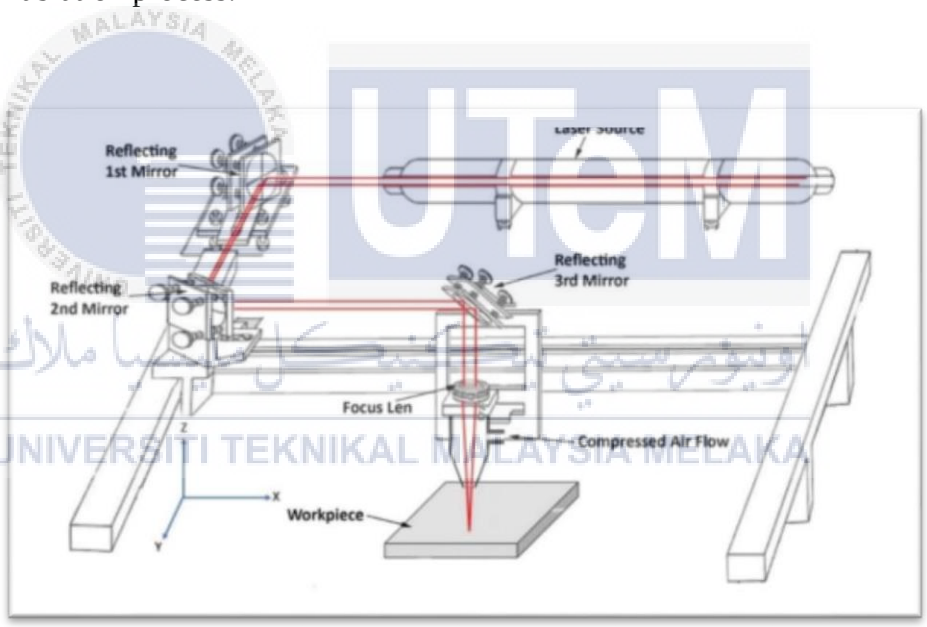

Figure 1.1 Schematic Laser Engraving System (Aziz Khan & Kibria 1, 2021)

1.2 Problem Statement

Laser engraving is a common technique used to carve virtually every material that previous methods cannot. The laser engraving procedure is enabled by the mechanism that vaporises the surface of the material. The laser process is one of the most well-known technologies of the past several decades. A Fiber Engraving Laser is often utilised for a variety of purposes, such as in the electrical industry. In spite of this, a laser engrave technique utilising the Master Oscillator Power Amplifier (MOPA) Fiber Laser is still fairly uncommon on the Malaysian market due to the various specific requirements and the high cost of this technology in comparison to fibre engraving lasers.

Because of its enormous benefits, such as noncontact, no cutting force, and a small area of heat impact, laser engraving is extensively utilized for a variety of metals. However, there are several drawbacks to the laser engraving process, such as extremely poor combustion surface morphology and a certain number of deformation on the surface, which have a significant influence on treatment quality. As a result, there is a requirement to analyze the crucial laser parameters such as laser power, laser speed, and laser frequency values so that they may be applied to the aluminium alloy workpiece to achieve optimal products. Aluminum alloys are utilized in industry because they are corrosion-resistant, lightweight, and strong. High strength-to-weight ratio makes it an ideal structural material. It's ductile, traceable, corrosion-resistant, thermally and electrically conductive. To reduce overburning during the engraving process, metal material parameters such as laser power, beam speed, and frequency should be monitored based on the material's mechanical qualities.

1.3 Research Objective

The general purpose of this research is to analyze effect of laser power and speed on surface quality when laser engraving on aluminium. Specifically, the objectives are as follows:

a) To develop 2D design using Master Oscillator Power Amplifier (MOPA) Fiber Laser on aluminium.

b) To evaluate the effect of laser engraving parameters on surface quality of aluminium.

c) To analyze the characteristics of physical changes produced by the laser engraving on aluminium.

1.4 Scope of Research

The primary purpose of this study is to create a design for a workpiece made of metal using laser engraving. The impacts of laser engraving parameters on surface morphology on aluminium, such as the speed, frequency, and power of the laser engrave machine running throughout the process, is then analyzed. Finally, a study of the impact of laser graving on structural and microstructural alterations of aluminium . The research scopes are as follows:

- Study structural and microscopic change produced by laser engraving on the surface of aluminium.
- Determine the best values for parameters to obtain perfect depth of 2D design on aluminium.
- Identifying engraving parameters that impact material removal rates, engraving definition and surface quality.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Based on the (Sikora et al., 2019) basic meaning of the term "laser" is "light amplification through stimulated emission of radiation." A laser is a device that stimulates atoms or molecules to emit light at specific wavelengths and then amplifies that light to produce a very narrow beam of radiation. Typically, the emission encompasses a small range of visible, infrared, and ultraviolet wavelengths. As technology progressed, lasers gained the ability to mark or engrave materials, allowing them to generate barcodes, serial numbers, 2D codes, UDI codes, labels, patterns, and more. Bill Lawson of LMI began exploring the capabilities and potential of laser engraving in the 1970s in order to build the then-popular computerized engraving devices. Depending on the user's option, Lawson's method that includes scanned black-and-white artwork, information, or designs dramatically improves the final product by engraving either the white or black portion

Figure 2.1 Fiber Laser
Engraving machine

The laser's light source may be explained simply by comparing it to a light bulb or neon tube. The chamber's molecules are "stimulated" to the point that the gas or "laser medium" begins lasing and amplifying light energy, thus the acronym LASER, which stands for Light Amplification by Simulated Emission of Radiation. Once activated by the control software, the object in question will be engraved or marked. Laser engraving is also known as laser etching. Almost all materials are suitable to laser marking and engraving(Nikolidakis & Antoniadis, 2020).

Laser engraving offers numerous essential advantages over conventional engraving techniques. The laser beam enables more precise work to be performed. It is possible to etch or engrave very tiny and fragile objects. Unlike other types of etching, laser engraving does not use harsh chemicals or high temperatures. No residues of dust or chemicals are left behind. It is simple to engrave on uneven surfaces since the laser beam is easy to manipulate and concentrate on different surfaces. As technology has advanced, pictures and logos may be copied onto a variety of surfaces in greater depth and complexity.(Leunda et al., 2012)

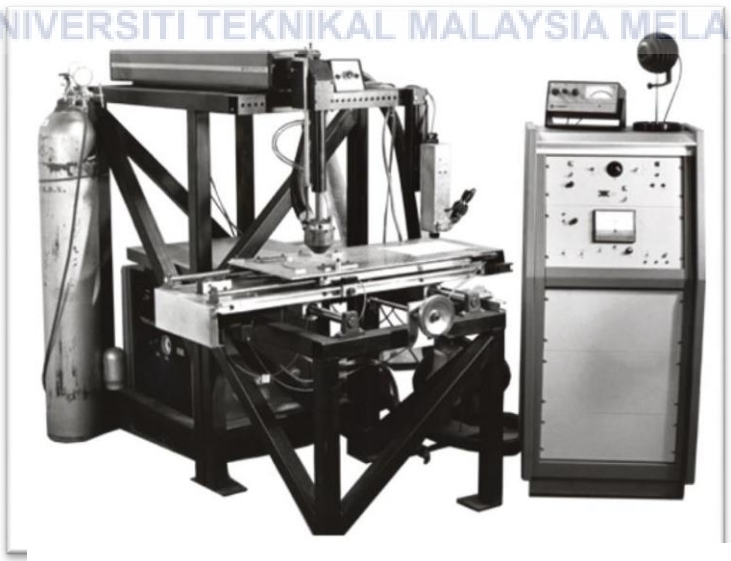

Figure 2.2. First turnkey laser engraving system :
Laser Machining's "Laser Graver"

(Shivakoti et al., 2019)

2.2 Process of Laser Engraving

The use of lasers to carve or mark an object is known as laser engraving. The removal of material from the top surface down to a specific depth is known as laser engraving. Laser engraving, as opposed to laser marking, is the process of engraving an item with lasers. Laser marking, on the other hand, only discolours the surface rather than cutting through it. There are no inks used in this method, and there are no tool bits that come into touch with the engraved surface and wear out. These characteristics set laser engraving apart from other engraving or marking methods in which inks or bit heads must be changed on a regular basis(Sikora et al., 2019a).

The purpose of laser engraving is to engrave a particular image or brand into a certain material. It is a subtractive production technique. Before the actual engraving process can begin, a computer file must be delivered to the machine's controller, which then sets the laser. When the Laser Engraving procedure begins, the beam generates intense heat that burns or evaporates the surface in accordance with the file's picture. The distinction should be made between line engraving and surface engraving. While the first employs vector pictures to follow routes or lines, the second vaporises the material to imprint an image into it or give the design a 3D appearance.

2.3 Laser Engraving Applications

As reported by (Cidade et al., 2018) laser engraving is very adaptable, which is why so many sectors depend on it for manufacturing. For medals and trophies, engraving is often used to produce a clear engraving on the surface. Nevertheless, Laser Engraving may also be used for decoration marks and letterheads. In the manufacturing business, barcodes are often engraved using laser engraving technology. Even if the component is utilised in manufacturing or other operations, the barcode may still be scanned for corporate reasons due to the durability of engraving. Other identifiers, such as QR codes, are also often used with engraving technology. Due of the exact engraving capabilities of the laser, the jewellery industry also employs this technology. It gives businesses the ability to provide rapid engraving services to their consumers. In the electrical and medical industries, components must always be identifiable. Laser engraving is often used to label these components for quick and precise identification.

Figure 2.3 Laser Engraving on Stainless Steel & Glass plague

2.4 Type of Laser

2.4.1 Fibre Laser

Fiber laser marking machine is one of the most sophisticated and widely used laser marking systems in use today. It is very adaptable, requires little maintenance, and uses no consumables in the marking process. For accurate and efficient marking, the fibre laser marker has widespread uses, particularly in the metal and plastic processing sectors. A fibre laser marking machine is a kind of laser marker equipment used to mark letters, numbers, and designs on certain materials. The fibre laser marking machine is also known as a fibre laser engraver or fibre laser engraving machine. It is also known as a fibre laser marker. Laser marking is the process of using laser beams to create permanent markings on the surface of different materials(Uli et al., 2011).

The idea behind laser marking is to expose the deep material by evaporating the surface material, or to engrave traces by changing the chemical and physical properties of the surface material with light energy, or to burn away part of the material with light energy to show the desired marks. Fiber laser marking machines are mostly used when more detail and accuracy are needed.

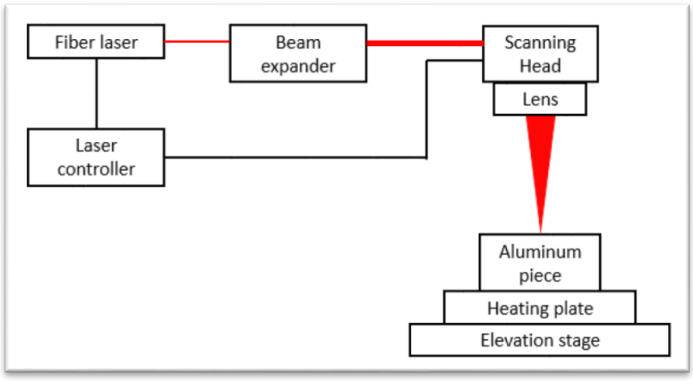

Figure 2.4. Fiber Laser Mechanism (Fibre Laser Marking | Knowledge | Laser Marking Basics | KEYENCE Malaysia, 2018)