Alteration Of Copper Surface by Using Laser Engraving Process for Deep Pattern Marking

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (MAINTENANCE TECHNOLOGY) WITH HONOURS

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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 “Alteration Of Copper Surface by Using Laser Engraving Process for Deep Pattern Marking” 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 Ayyub bin Mohamad Sofi

Date : 11/1/2023

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	:	
Supervisor Name	:	PROFESSOR MADYA IR. DR. MOHD HADZLEY BIN ABU BAKAR
Date	:	11/1/2023

DEDICATION

I dedicated this study to my beloved parent, who always keep supporting me with everything that I need through my journey and always be my side to support me with moral, love and financial support,

I dedicate this study and give special thanks to my supervisor Prof. Madya Ir. Dr. Mohd Hadzley Bin Abu Bakar for all his guidance throughout the process to finish this study.

I also dedicated this to all my lectures and friends who always encouraged and helping me to finish this study.

ABSTRACT

Laser engraving is a technology that has potential to be one of the promising in industry area. Laser machines are specifically designed for engraving on different types of materials, cutting, etching, and marking. The parameters in this process are really important as when a parameter changes, the outcome will become different. The larger the gap of the parameter change will show a hugely different result. Furthermore, the duration of the engraving is also important as when the duration is increased, the depth of the engraving is also increased. The main objective for this study is to investigate the effect of the parameter for the laser engrave. The other objective is to evaluate the deep pattern marking based on the laser period. Lastly, to analyze surface quality of the copper after marking process by microscopic observation The raw material used for as the specimen is copper. There are several parameters that are important for this laser engraving process that are laser loop count, laser speed, laser power and laser frequency. The main material that will be used is a plate of copper 10cm × 10cm with a thickness of 0.5mm. The parameters that change throughout the study are the frequency, the period of the engrave and the loop count of the laser. The best result among the results in this study are the one in 8 minutes duration and at the frequency of 100Hz and the loop count one. The best results are evaluated as we consider the best quality of the engravement that consist of the precision, roughness, and detailing.

ABSTRAK

Ukiran laser adalah teknologi yang berpotensi untuk menjadi salah satu yang menjanjikan dalam bidang industri. Mesin laser direka khusus untuk mengukir pada pelbagai jenis bahan, memotong, mengetsa dan menanda. Parameter dalam proses ini sangat penting kerana apabila parameter berubah, hasilnya akan menjadi berbeza. Semakin besar jurang perubahan parameter akan menunjukkan hasil yang sangat berbeza. Tambahan pula, tempoh ukiran juga penting kerana apabila tempoh ditambah, kedalaman ukiran juga bertambah. Objektif utama kajian ini adalah untuk menyiasat kesan parameter untuk ukiran laser. Objektif lain adalah untuk menilai penandaan corak dalam berdasarkan tempoh laser. Akhir sekali, untuk menganalisis kualiti permukaan kuprum selepas proses penandaan dengan pemerhatian mikroskopik Bahan mentah yang digunakan sebagai spesimen ialah kuprum. Terdapat beberapa parameter yang penting untuk proses ukiran laser ini iaitu kiraan gelung laser, kelajuan laser, kuasa laser dan frekuensi laser. Bahan utama yang akan digunakan ialah plat tembaga bersaiz 10cm × 10cm dengan ketebalan 0.5mm. Parameter yang berubah sepanjang kajian adalah kekerapan, tempoh ukiran dan kiraan gelung laser. Keputusan terbaik antara keputusan dalam kajian ini ialah satu dalam tempoh 8 minit dan pada frekuensi 100Hz dan kiraan gelung satu. Hasil terbaik dinilai apabila kami mempertimbangkan kualiti terbaik ukiran yang terdiri daripada ketepatan, kekasaran dan perincian.

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LIST OF SYMBOLS AND ABBREVIATIONS

CO_2	-	Carbon Dioxide
℃	-	Degrees Celsius
ALE	-	Atomic Layer Etching
2D	-	Two-Dimensional
HeNe	-	Helium-neon
VB_s	-	Vortex beams
OAM	-	Orbital Angular Momentum
Nm	-	Nanometers
Cm	-	Centimeter
mm	-	Millimeter
%	-	Percentages
UHSS	-	Ultra-High Strength Steel
MOPA	-	Master Oscillator Power Amplifier
AI	-	Adobe Illustrator
USB	-	Universal Serial Bus
Hz	-	Hertz

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Laser engraving technology has advanced rapidly in recent years, and it is now displacing traditional mechanical methods. With a high-power laser beam, laser engraving enables great precision for a wide range of materials in a contactless high-speed process. Laser engraving is faster than other commonly used applications like laser welding or cutting, which may reach speeds of several meters per second. (M. Ruutiainen, H. Roozbahani, M. Alizadeh, H. Handroos and A. Salminen, 2022).

Laser marking is an innovative material processing technique that leaves a permanent mark on materials. Through melting displacement, ablation, and evaporation, the materials are removed layer by layer via laser engraving in the laser channel. Laser processing techniques are suitable for cutting, marking, drilling, and micromachining in most materials, including metals, plastics, ceramics, and composites. Laser also offers high speed, accuracy, and versatility in completing the process.

Pulsed Nd:YAG lasers and continuous CO_2 lasers are the most common types of lasers used in manufacturing processes. Due to many advantages such as high intensity and -+small spot size, pulsed Nd: YAG lasers are suitable for machining processes. Laser machining is a dynamic process that is influenced by a number of variables that must be accurately managed (Noorossana et al., 2020)

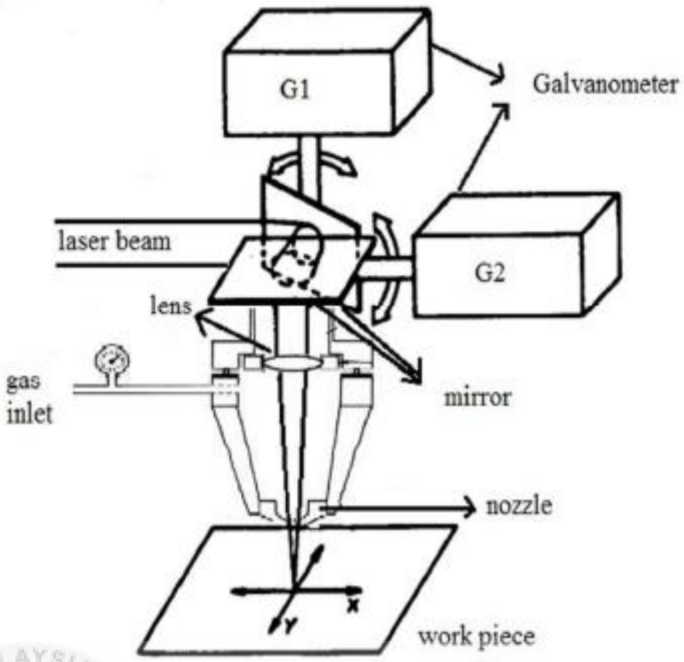

Figure 1.1 Laser Marking Process (Noorossana et al., 2020)

1.2 Problem Statement

Laser engraving is a process that engraving on a surface using laser. The parameters in this process are really important as when a parameter changes, the outcome will become different. The larger the gap of the parameter change will show a hugely different result. Furthermore, the duration of the engraving is also important as when the duration is increased, the depth of the engraving is also increased. The material that is used in this study is copper. Copper have been commonly used in many industries such as building construction, power generation and transmission, electronic component, the production of industrial machinery and transportation vehicles.(Wan et al., 2021). Copper also has an extremely low chemical reactivity. This research aims to identify the ability of laser engraving to perform with a slight change in the parameter and the period of the engraving on copper plate.

1.3 Research Objective

The general purpose of this research is to analyze the period of time taken to reach the perfect yet good condition for engraving on copper plate. Specifically, the objectives are as follows:

a) To investigate the effect of parameter consist of power, speed, frequency and the laser loop on the copper surface.

b) To evaluate the deep pattern marking based on the laser period.

c) To analyse surface quality of the copper after laser marking by microscopic observation.

1.4 Scope of Research

The scope of this research are as follows:

- Adjusting laser parameter of the laser engrave machine.
- Evaluate the microstructure of the after-laser surface as the result of the study.
- Study the application of laser engravement on copper plate with a certain period.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section is focusing on the laser process, material and the parameter that used in this process. The effect of the laser process change by the parameter will also be put in this chapter. All the types of lasers engrave, the parameter and the other information about laser engrave were defined. (M. Ruutiainen, H. Roozbahani, M. Alizadeh, H. Handroos and A. Salminen, 2022)

2.2 History of Laser

Laser marking has been around for a while, especially in the electronics industry, where it evolved from laser resistor trimming. Laser marking has proven to be a cost-effective competitor to stamping, chemical etching, and other alternate techniques in the electronics industry, including the case of silicon wafer identification. In the general industrial world, laser marking has proven to be a cost-effective competitor to stamping, chemical etching, and other alternate techniques (Baker, 1982)

Albert Einstein suggested under a certain circumstance atom could release an energy as light in 1916. Another person in 1928, German physicist Rudolf Walther Ladenburg found the stimulated emission. In that time, there is no practical use of it yet. Later in 1951, Charles H. Townes thought of a way to generate a stimulated emission at microwave frequency. In all these years, many improvements are being made to perfecting the laser and finally a very first semiconductor laser are made in 1962 by Robert N. Hall and co-workers at the General Electric Research and Development Centre in Schenectady

The first lasers with widespread commercial uses were helium-neon lasers. They found immediate application projecting straight lines for alignment, surveying, building, and irrigation since they could be adjusted to emit a visible red beam instead of an infrared beam. Ruby laser pulses were soon being use by eye surgeons to weld separated retinas back into place without cutting into the eye. The laser scanner for automated checkout in supermarkets, which was invented in the mid-1970s and became ubiquitous a few years later, was the first large-scale application for lasers. Compact disc audio players and laser printers shortly followed personal computers (Hecht, 2021).

2.3 Type of Carving

2.3.1 Engraving

Engraving is one of the well-known traditional graphics techniques. It first developed in the fourteenth century as an illustrative backup for developing printing on the book, but thanks to its unique expressive ability, it swiftly became an art form in its own. Artists utilize four basic types of engraving, silk screen and lithography, intaglio or in-hollow printing, letterpress, or relief printing with several different techniques in each class (Ostromoukhov, 1999).

Printmaking's history is littered with prosperous periods of processes that eventually collapsed for a variety of causes. When photography did not yet exist back then, facial engraving was amazingly well known in seventeenth and eighteenth centuries, this superb artisanship got to be nearly unused, due to the extraordinary special requests that it made on the etcher. Figure 2.1 shows the example of copper plate engraving of post stamp. Proficient copper plate etchers are uncommon nowadays, and the fetched of genuine engraving is essentially as well restrictive to be utilized in regular printing. At the same time, conventional facial engraving has no question exceptionally particular request: its slick, sharp appearance recognizes it beneficially from photographs. In order to appreciate the graphic effect of engraving it is sufficient when compare the etching representations within the Divider Road Diary with representations in other daily papers created with conventional generic screening (Ostromoukhov, 1999).

Figure 2.1 Copperplate engraving of a post stamp (Ostromoukhov, 1999)

2.3.2 Etching

Today, etching technology that is famous is atomic layer etching (ALE). ALE is being compared with long-established traditional etching techniques, connecting with the ancient art of etching's basic principles. ALE is now faster than before thanks to plasma, which was previously thought to be too sluggish. Plasma etching has advanced significantly in the last 40 years, thanks to improved plasma sources and control technologies. At technology nodes with dimensions of less than 10 nanometers, the industry nowadays becomes more attached to determine the sharpness, precision, and shape of features. Our focus has turned to the underlying surface processes as we strive to etch logic and memory structures to within a few atoms on features less than 40 atoms wide (Kanarik et al., 2018).

Etching is the process of disrupting bonds that attach atoms to one another to remove them from a substrate. The binding energy is a common energy, given that Each atom has a barrier that is determined by its precise location and orientation on the surface. Figure 2.2 shows the comparison of removal mechanisms. There are many alternative ways to modify or remove energy binding with chemistry, temperature, and collisions

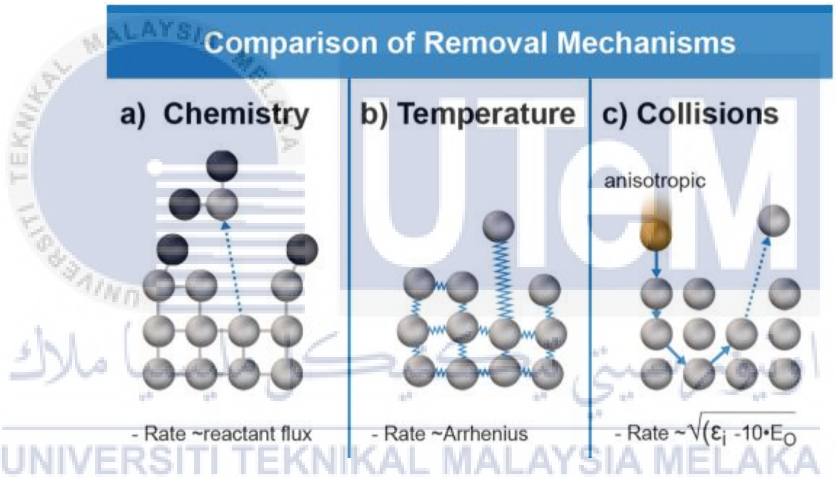

Figure 2.2 Comparison of Removal Mechanisms (Keren J. Kanarik, Samantha Tan, and Richard A. Gottscho, 2018)

2.3.2.1 Chemistry

Reaction on the surface can produce less tightly linked to the surface and can easily be removed. Plasma is more widely employed in the semiconductor industry because it dissociates gases into extremely reactive radicals.(Sarkar Phyllis et al., 2022) Chemical etching is typically transport-limited, which means the etch rate is a strong function of reactant flux. Without a crystallographic dependence, it is generally isotropic.

2.3.2.2 Temperature

If the kinetic energy of vibrating surface atoms exceeds the energy of gravity, they will sublime. According to the Arrhenius law, the etch rate for thermally induced etching depends on temperature. The typical substrate temperature operating range is −20 to 150 °C. Thermal etching is isotropic, absent crystallographic dependencies (Lin et al., 2008).

2.3.2.3 Collisions

An atom can be rejected when an object that has strong energy hits the surface if the atom collects enough kinetic energy while moving upward through momentum transfer to remove surface binding energy. The most common bombarding object in the semiconductor industry is the surface erect to ion accelerated. (Keren J. Kanarik, Samantha Tan, and Richard A. Gottscho, 2018)

2.3.3 Aquatint

Aquatint is a hypersensitive dance of shapes, colors, and abstract imagery that depicts the emotional response to intense natural settings. Strong, sensual, earthy atmosphere, but created by systematic nature inside a manufactured vacuum. A universal yet personal sensory mapping is perhaps an essential function of abstraction in an all-encompassing universe of instantly recognized sights and details (Dondieu et al., 2020). When referred to as conventional art by painterly and industrialized delivery, which is meticulous thought about presenting beauty and the quasi-religious adoration that might cause the countryside, aquatint is romantic, critical, and similar to recollections and dreams than film.