FEASIBILITY STUDY OF LASER CUTTING PARAMETERS ON THE SURFACE FINISHED OF THE GALVANIZED PLATE

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

FEASIBILITY STUDY OF LASER CUTTING PARAMETERS ON THE SURFACE FINISHED OF THE GALVANIZED PLATE

Submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree in Manufacturing Engineering (Hons.)

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Sesi Pengajian: **2020/2021 Semester 2**

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APPROVAL

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ABSTRAK

Penyelidikan mengenai kajian kemungkinan parameter pemotongan laser pada permukaan plat galvanis ditulis dalam laporan khusus ini. Oleh kerana ciri anti karatnya, besi galvanis sering digunakan dalam projek pembinaan untuk membina struktur seperti balkoni, beranda, tangga, laluan pejalan kaki, dan juga peralatan permainan kanak-kanak seperti rak basikal dan set ayunan. Mengetahui kualiti permukaan bahan yang menggunakan kaedah memotong laser adalah penting kerana ia menyumbang kepada masalah keselamatan. Oleh kerana fakta ini, tujuan penyelidikan ini adalah untuk mengkaji pengaruh parameter pemotongan laser pada pemotongan permukaan untuk besi galvanis. Parameter pilihan adalah kelajuan pemotongan dan tekanan gas terbantu. Kedua-dua parameter ini dicapai dengan analisis saringan dengan melakukan jurang kajian dari penyelidik sebelumnya. Kelajuan pemotongan 1800mm/min, 2500mm/min, dan 3000mm/min dikategorikan kepada tahap rendah ke tahap tinggi. Julat dari ujian perintis untuk tekanan gas dibantu adalah 1 bar hingga 8 bar. Kekasaran permukaan adalah tindak balas proses yang akan diukur dengan menggunakan penguji kekasaran permukaan mudah alih pada akhir eksperimen. Untuk kedua-dua parameter, kedudukan fokus dan daya laser yang digunakan adalah sama. Mitsubishi Electrical Model ML2512HV2-R PLUS adalah mesin yang digunakan dalam penyelidikan ini. Teknik Reka Bentuk Eksperimen (DoE) telah diterapkan untuk merancang keseluruhan kajian. Eksperimen ini dirancang dengan dua tahap reka bentuk faktorial menggunakan perisian. Analisis ANOVA menunjukkan bahawa tekanan gas yang dibantu mempunyai kesan yang lebih besar pada kekasaran permukaan daripada kelajuan pemotongan. Model matematik dibina dari analisis ANOVA, dan bahagian kesalahan antara model dan nilai eksperimen disahkan menjadi 0.5%. Respons yang optimum diperoleh pada kelajuan pemotongan 1800 mm/min dan tekanan gas dibantu 8 bar pada akhir penyelidikan. Pengesahan parameter optimum ini dibuat antara model dan eksperimen. Hasilnya nilai ralat optimum tersebut sebanyak 7.08%.

ABSTRACT

The research on the feasibility study of laser cutting parameters on the surface finished of the galvanized plate is highlighted in this particular report. Due to its anti-rust feature, galvanized iron is frequently used in construction projects to build structures such as balconies, verandahs, staircases, ladders, walkways, and even children's playground equipment such as bicycle racks and swing sets. Knowing the surface quality of the material that used the laser cutting method as it contributes to the safety problem is important. Due to this fact, the purpose of this research is to investigate the effect of laser cutting parameters on surfaced cutting for galvanized iron. Cutting speed and assisted gas pressure are the preferred parameters. Both these parameters are accomplished by screening analysis by doing the research gap from previous researchers. The cutting speed of 1800mm/min, 2500mm/min, and 3000mm/min is categorized into three levels which are from low to high levels. The range from the pilot testing for assisted gas pressure is 1 bar up to 8 bar. Surface roughness is the process response that will be measured by using a portable surface roughness tester at the end of the experiment. For both parameters, the focus position and the consumed power of the laser are constant. Mitsubishi Electrical Model ML2512HV2-R PLUS is the machine used in this research. The Design of Experiment (DoE) technique has been applied to plan the entire study. The experiment is planned with two levels of factorial design using the software. ANOVA analysis indicates that assisted gas pressure has a greater effect on the surfaced roughness than cutting speed. Indeed, a mathematical model is constructed from the ANOVA analysis, and the proportion of error between the model and experimental values is validated to be approximately 0.5%. The optimal responses were obtained at a cutting speed of 1800 mm/min and an assisted gas pressure of 8 bar at the end of the research. Validation of these optimal parameters was made between the model and the experiment. As a result, the optimum error value is 7.08%

DEDICATION

I dedicate this final year project to:

My beloved parents;

Saiful Bahri & Rozidah

My dear friends;

For providing myself with endless moral encouragement, collaboration, support, and understanding.

Thank you so much and may Allah bless all of you.

ACKNOWLEDGEMENT

All praise be upon His Messenger to Allah, Lord of the World, and peace, in the name of Allah, the Most Gracious and Merciful. On top of all, I would like to thank him for rewarding me with patience and perseverance in completing this final year project successfully through ups and downs. I have learned so much not only in terms of academics, but also in terms of my personality during this process.

To my supervisor, Profesor Madya Dr. Mohd Amri Bin Sulaiman, I would like to express my deep and sincere and sincere gratitude for leading and supporting continuous morality and research in this whole research. His infinite technological advice and innovations helped me conquer challenges and kept me motivated and incredibly experienced in this study. Getting him as my supervisor was an outstanding pleasure and honor. I would also like to thank the three of my panels for their brilliant comments and suggestions. Particularly, my family members have my sincere appreciation. This thesis could not be written without their support. They have always embraced my academic efforts and have followed every step of the way regardless of my choices.

My heartfelt appreciation also goes to Mr. Mohd Ghazalan Bin Mohd Ghazi, and Mdm. Siti Aisah Binti Khadisah, who worked diligently and were cooperated to supply relevant information and technical knowledge to complete my research on laser cutting. Last but not least, I would like to thank all of my panels for providing me with a lot of motivation and cooperation in the completion of this study. During my study, they gave their critical suggestions and comments. Finally, I would like to thank all those who were relevant to this study, as well as express my apology for not being able to mention each one of you personally.

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LIST OF ABBREVIATIONS

LASER	-	Light Amplification through Stimulated Radiation
MASER	-	Microwave Amplification by Spontaneous Emission Radiation
ANOVA	-	Analysis Of Variance
FF	-	Full Factorial
FD	-	Two-Level Factorial Design
RPM	-	Robust Parameter Methodology
TM	-	Taguchi Methods
Fs	-	Focal Position
CO_2	-	Carbon Dioxide
DoE	-	Design Of Experiment
FD	-	Factorial Design
GI	-	Galvanized Iron
HAZ	-	Heat Affected Zone
MRR	-	Material Removal Rate
N_2	-	Nitrogen
Nd: YAG	-	Neodymium-Doped Yttrium Aluminium Garnet
HeNe	-	Helium-Neon
Ra	-	Edge Surface Roughness
Al-Cu	-	Aluminum Copper
Zn	-	Zinc
Wa	-	Arithmetic mean waviness
Rz	-	Arithmetic mean value

LIST OF SYMBOLS

mm/min	-	Millimetre per minute
m/min	-	Metre per minute
rpm	-	Revolution per minute
W	-	watt
m	-	Metre
Hz	-	Hertz
mm	-	Milimetre
sec	-	Second
bar	-	Pressure-bar
µm	-	Micrometre

CHAPTER 1

INTRODUCTION

The entire introduction to this work will be covered in this chapter. It began with a background of this study in the context. The problem statement that occurred is then followed by that. Then, the objectives in this report that need to be accomplished are described. The remainder of this chapter revealed the scope that narrows down the area of research, study significance, and also the summary of the chapter.

1.1 Background of Study

The laser beam cutting (LBC) method has a wide range of applications in various production processes within the industry because of its advantages of high cut quality and cost-effectiveness by large-scale production volume. Laser cutting is a typical production method used to economically cut different kinds of materials. Many current researchers like Eltawahni et al. (2012), said that the laser cut distance, cut edge quality, or finished surface quality are influenced by laser strength, cutting speed, gas pressure assistance, nozzle diameter, and focus point location, as well as workpiece material.

One of the most commonly used in construction projects to produce structures such as balconies, verandas, building frames, staircases, ladders, walkways, and more are galvanized iron materials. It is also particularly for playground equipment structures such as bicycle racks, jungle gyms, and swing sets because it’s rust-resistant. According to Yeomans

(2004), galvanizing has been used in many types of elements exposed to a variety of environmental conditions for corrosion safety since the 1930s. Therefore, the consistency of the laser cut on the galvanized plate surface finish is very important to know.

One of the key measures of quality measurement of finished parts processed by laser cutting is surface roughness. Knowing the surface quality of the material that used the laser cutting method is important as it contributes to the safety problem. Laser cutting is commonly used in the cutting process, where the quality of the finished product depends primarily on the process parameters such as laser beam power, cutting speed, focal position, and assist gas pressure. Hence, this is an incredibly topic to be investigated in detail to increase the profound comprehension of laser cutting parameters that are significant to the finished output.

1.2 Problem Statement

Several variables can impact the efficiency of laser cutting, such as the unit, the operator, and the material can all affect the cut edge quality. However, the cutting speed, laser power, focal position, and supported gas pressure are the most important parameters for laser cut efficiency. To achieve high quality, optimization of process parameters is critical. The effect of the variance of input parameters on process output to achieve the goal of better product quality is often needed in any manufacturing process.

Noor et al. (2010) stated that there are different variables in laser cutting, including beam power, cutting speed, and distance of tips that affect the finished surface. The finished surface value decreases as the cutting speed and frequency increase and the laser power and gas pressure decrease. Based on the previous research and the analysis made by Löschner et al. (2016) on the cutting speed of stainless steel have a major effect on the surface finished, the heat-affected area, and the existence of macro defects, such as the presence of dross, molten and burned material. The heat-affected zone (HAZ) width also increases with the reduction in cutting speed, and the lower part of the cut surface is weakened below a certain threshold. In the manufacturing industry, if the input settings, such as the cutting speed and assisted gas pressure level, are incorrect, it results in problems for the entire batch of production. The cutting speed must be compatible with the work-piece form and thickness. A speed that is excessively fast or too slow prompts expanded roughness, the formation of burrs, and wide draglines.

Regarding the surface roughness, Madić et al. (2012) claimed that the most influential parameters were those related to the help gas, such as pressure, the diameter of the nozzle, and distance of stand-off. The roughness of the surface was found to be decreased by an increase in gas pressure support. It is important to adjust the thickness of the work-piece material to the gas pressure. Through torch cutting, the thin metal materials with high gas pressure are removed. The gas pressure must be very carefully set because even small adjustments in oxygen pressure affect the accuracy of the cutting. When defects happen, they influence the entire production line, reducing productivity. Apart from generating waste Work in Progress (WIP), the production schedule will be impacted due to the numerous rework processes required to cover the flaws caused by human error during the setting stage. Due to this inaccuracy, defects such as burrs will occur. When this issue develops as a result of the input parameters being set incorrectly, it affects the lead time in the manufacturing business. Worse yet, customers may lose trust in the organization.

The previous studies generally focused on the factors of laser cutting parameters that are significant to the surface finish for carbon steel, mild steel, or stainless steel, based on the above research. Thus, this thesis focuses on the galvanized iron laser cutting parameters.

1.3 Objectives

The objectives of this study are as follows:

a) To investigate the effect of laser cutting parameters on surfaced cutting for galvanized iron.

b) To optimize the surface quality of the finished output that used the laser cutting process.

1.4 Scope

The scopes of research are as follows:

(a) To study the effect of cutting speed, laser beam power, assisted gas pressure, and focal position on an interaction between the laser and galvanized iron material.

(b) This study will use the availability of raw material and laser cutting machines located in the Manufacturing Lab.

(c) Analyze the laser cutting quality parameters such as surface roughness.

(d) Optimization of the surface quality of the cutting part by using the design of the experiment (DOE) will be the ultimate finding of this study.

1.5 Significant of Study

The rationale of research is as follows:

(a) One of the essential quality features in a process of laser cutting is surface roughness. In microstructure, some defects such as burning, melting, and wavy surfaces have been identified. This analysis will recognize the impact of boundaries laser cutting on surface roughness. Thus, the optional cycle can be limited. Therefore, creation time and cost will be decreased.

(b) This thesis specifically explores optimization as a better approach to evaluating optimal system parameters and conditions for the laser cutting process than the "trial and error" approach.

1.6 Organization of the Thesis

To begin the investigations into laser cutting, the organization of this thesis is as follows. This thesis will be arranged according to the following chapters and is divided into three chapters. Chapter 1 includes the introduction of this project, problem statement, objective, project scopes, the significance of the study, thesis organization, and summary. The introduction involves laser data as a cutting device and galvanized iron as a workpiece. Chapter 2 highlights the project's literature analysis of articles, journals, and many more. The theories and components of research on the galvanized iron properties of the laser machine and laser-cut quality will be described. The result of a recent research paper focused on the laser. The methodology of this study is explained in Chapter 3. The proposed working process, the project procedures, and the collection of data will be defined. In this chapter, the flow chart also shows the progress of the project. Chapter 4 summarises the experiment's results and discussions, including the Design of Experiment (DOE), experimental setup, and experimental results and analysis. Each method used in this project is demonstrated and discussed in detail about the project's objectives. Each technique employed in this project is aimed at achieving the desired results. Chapter 5 is the concluding chapter of this thesis and will summarise the overall findings and results. Additionally, this chapter includes recommendations for future study and research.

1.7 Summary

Relatively, this chapter offers a summary of the project, problem statement, objectives, background, and also the scope and limitation. Overall, the chapter contains the key elements discussed in the entire review.