UNIVERSITI TEKNIKAL MALAYSIA MELAKA

QUALITY INVESTIGATION OF LASER WOOD MACHINING

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

by

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This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Process) (Hons.). The member of the supervisory is as follow:

……

(PROF. MADYA IR. DR. SIVARAO)

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DECLARATION

I hereby, declared this report entitled "Quality Investigation of Laser Wood Machining" is the results of my own research except as cited in references.

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ABSTRAK

Pengukiran kayu ialah sejenis kerja kayu dihasil daripada alatan tangan seperti pisau ukir dan penukul tangan. Cara pengukiran adalah menggunakan pisau ukir sahaja atau dengan penukul kayu sekali. Hasil pengukiran dikenali sebagai patung kayu atau perhiasan kayu. Industri pengukiran kayu adalah sangat popular di budaya Melayu dimana mereke akan menggunakan hasil-hasil ukir kayu di sektor perabotan atau kraft tangan. Reka bentuk dan profil untuk ukiran kayu adalah pelbagai jenis berdasarkan permintaan pelanggan. Memandangkan kebanyakan industri pengukiran kayu manggunakan cara tradisional untuk produksi meraka, banyak kelemahan telah ditemui dengan kegunaan cara tradisi. Oleh itu, cara alternatif dengan mengguna mesin laser telah dicadangkan untuk menyelesaikan masalah yang ditemui dengan pengukiran secara manual. Untuk mencapai objektif yang dinyatakan dalam kajian ini, satu lawatan ke kilang ukir kayu telah dijalankan supaya informasi terhadap prosess pengukiran kayu secara manual dapat diketahui dengan lebih jelas terutamanya kelamahan proses tradisi. Setelah melawat ke kilang itu, adalah mendapati bahawa permukaan hasil kerja adalah kasar dan menjejaskan kualiti pengukiran. Oleh itu, cara pemotongan dengan penggunaan mesin laser dicandangkan sebagai cara alternatif yang dapat meningkatkan kualiti pemotongan untuk kayu atas sebab kebaikan qualiti produk yang dapat dihasil dengan mesin laser. DoE ataupun dikenali sebagai “design of experiment” dalam bahasa Inggeris digunakan untuk menentukan bilangan set pemboleh ubah yang akan digunakan untuk menjalankan eksperimen di lanjutnya. Pemboleh ubah seperti kuasa laser, kelajuan dalam memotongan, dan tekanan untuk gas yang digunakan dalam proses ditentukan sebagai pemboleh ubah yang boleh dimanipulasi dan kualiti pemotongan dikaji selepas eksperimen dijalankan. Kualiti produk yang bagus dapat dicapai dengan mengguna kuasa 2.2 kW, kelajuan 1500 mm/min, dan tekanan gas 9 bar.

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ABSTRACT

Wood carving is a form of working wood by means of a cutting tool in one hand or a chisel by two hands or with one hand on a chisel and one hand on a mallet, resulting in a wooden figure or figurine, or in the sculptural decoration of a wooden object. This kind of industry is very popular in Malay culture either in agriculture or craft. The design or profile of wood carving can be varying based on how a customer required. As the wood carving industry is mostly used manual or conventional method in the production line, it was interested to find out the limitation of the traditional method, and thus propose a suitable process as the improvement method that to be used. For this study, laser machining had been chosen as the alternative method in order to cut the wooden product based on the advantages can be achieved by this method. In order to achieve the aims for this study, a visitation to a wood carving industry was done to search for more information about the conventional process. The main limitation by using conventional method was poor surface finish. Laser cutting had been proposed as the improvement method and design of experiment (DoE) was used to approach for this study. The parameters used in this study are laser power, cutting speed, assisted gas pressure, and focal length distance. The cut quality such as surface finish and kerf width are investigated to find out the optimum parameters for laser wood cutting. The optimum parameters to achieved good surface finish and narrow kerf width was using laser power 2.2 kW, cutting speed 1500 mm/min, and gas pressure 9 bar.

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DEDICATION

To my beloved parents

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ACKNOWLEDGEMENT

I would like to thank to my project supervisor Prof. Madya Ir. Dr. Sivarao who assisted and guided me in order to accomplish this project. The title of the project was “Laser Cutting of Wood” which is a combination of research and experimental based research. This investigation is proposed to wood carving industry in order to solve the problem meet by the industry which using conventional method, jigsaw as the cutting tool for the production. In conjunction to this, I would like to offer my deepest gratitude to Mr. Sivarao from the bottom of my heart for all the support, encouragement, and inspirations manage to obtain all the way through of this project. The excellent working relationship between my supervisor and me has provided me with bountiful knowledge and experience for the future. The help rendered to me is priceless, be in from the smallest of its kind to the largest.

Besides that, I also would like to thank to Mr. Mustazarin, who worked in a wood carving industry, had spent his time for my visitation and sharing his working experience to me. On the other hand, I also would like to thank to the technicians at UTeM who had exposed me to the LVD laser cutting machine, and helping me when I do the result analysis in metrology lab. Last but not least, it is thankful to all my family members, course mates, friends, and other parties who had helped me direct or indirect in all the way until completion of my project.

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TABLE OF CONTENT

Abstrak		i
Abstract		ii
Dedication		iii
Acknowledgement		iv
Table of Content		v
List of Tables		viii
List of Figures		x
List of Abbreviations, Symbols, and Specialized Nomenclatures		xiii
CHAPTER 1: INTRODUCTION		1
1.1	Background	2
1.2	Problem Statement	7
1.3	Objective	8
1.4	Scope	8
1.5	Proposed method: Laser Cutting	9
	1.5.1 Types of Laser	13
	1.5.2 Advantages and Limitations of Laser Cutting	16
	1.5.3 Types of Parameters	17

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CHAPTER 2: LITERATURE REVIEW 25

2.1 Laser Cutting 26

2.2 Laser Cutting on Metallic Materials 27

2.3 Laser Cutting on Non-metallic Materials 29

CHAPTER 3: METHODOLOGY 40

3.1 Primary Investigation 41

3.2 Material Selection 41

3.3 Process Parameters: Screening 42

3.4 Selection on Parameters 43

3.5 Experimental Matrix and Design of Experiment (DoE) 45

3.5.1 Factorial Design 47

3.5.2 Level 48

3.5.3 Variable 48

3.6 Experimental Setup 51

3.7 Output Analysis 52

CHAPTER 4: RESULTS AND DISCSSION 54

4.1 Surface Roughness 54

4.1.1 Parallel to Wood Trachieds 55

4.1.2 Perpendicular to Wood Trachieds 60

4.2 Kerf Width 64

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4.2.1 Top and Bottom Kerf Width 64

4.2.2 Variance of Kerf Width 70

4.3 Discussions 77

CHAPTER 5: CONCLUSION & RECOMMNDATION 82

5.1 Recommendation (Future Work) 83

REFERENCES 85

APPENDIX

A – Example Graphs on Roughness Results

B – Data Collections

C – Graphs of Output Responses

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LIST OF TABLES

1.1	Steps for manually or conventional wood carving process	4
3.1	Inputs and response used in laser cut of wood materials	42
3.2	Frequency for input parameters and responses	43
3.3	The parameters and responses which had arranged according to descending order	44
3.4	Summary of input and output parameters for laser wood carving	45
3.5	Basic Specification of Laser Machine Helius – 2531	46
3.6	General cutting parameters for wooden material in previous record	46
3.7	Parameter used for experiment	48
3.8	Number of experiment and parameters used (full factorial)	50
4.1	Average Ra value measured parallel to wood trachieds	58
4.2	Average Ra value measured perpendicular to wood trachieds	61
4.3	Average kerf width for top and bottom surface	66
4.4	Example measured value for top and bottom kerf width	72
4.5	Variance of kerf width for each sample	73

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4.6 Comparison of Ra between two cut surfaces 78

4.7 Comparison between K_t and K_b 81

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LIST OF FIGURES

1.1	Wood carving product which used to decorate fence or staircase	3
1.2	Example of wood carved pattern	9
1.3	Laser cutting descriptions	11
1.4	Examples of three different focal points	13
1.5	Poor cut quality due to high cutting speeds, the sample thickness 6mm construction steel	19
1.6	A comparison of (a) CW laser cutting and (b) pulsed laser cutting	20
1.7	Effect of CW and pulsed laser cutting at sharp corner	21
1.8	An illustration of the effect of focal position on cutting performance (a) Focal distance too high, 3mm (b) Focal distance too low, -2.5mm, (c) Focal distance correct, 0.0mm	23
1.9	Nozzle geometry definitions and nozzle standoff distance	24
3.1	Flow chart for approach the study	40
3.2	Flow of experimental method	51
3.3	Pre-machining design for sample	52
3.4	Measurement of kerf width	53
3.5	Zero taper, negative taper, positive taper	53

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3.6	Surface roughness measurement across the striation	54
3.7	Surface roughness measurement	54
4.1	Microscopy image of striation (white arrowed)	56
4.2	Laser cut perpendicular (a) and parallel (b) to the wood trachieds (fibres)	57
4.3	Relationship between Ra value and cutting speed for various gas pressure at laser power (a) 2.8kW and (b) 2.2kW	59
4.4	Relationship between Ra value and gas pressure for various laser power at cutting speed (a) 1500mm/min and (b) 1700mm/min	60
4.5	Relationship between Ra value and gas pressure for various cutting speed at laser power (a) 2.5kW and (b) 2.2kW	63
4.6	Relationship between Ra value and cutting speed for various laser powers at gas pressure (a) 9 bar and (b) 10 bar	64
4.7	Kerf width for top surface (K_t) and bottom surface (K_b)	66
4.8	Top surface (a) and bottom surface (b) of material after laser cutting	67
4.9	Influence of cutting speed to kerf width at constant laser power for top surface (a) and bottom surface (b)	69
4.10	Effect of laser power on Kerf width in constant cutting speed for top surface (a) and bottom surface (b)	70
4.11	Kerf width obtained from results	71
4.12	Zero taper, negative taper, positive taper	74
4.13	Effect of cutting speed on variance of kerf width in laser power (a) 2.8kW and (b) 2.2kW	75

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4.14 Effect of laser power on variance of kerf width in cutting speed (a) 1300mm/min and (b) 1700mm/min 76

4.15 Illustration of wood's macrostructure cut parallel and perpendicular to trachieds 79

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURES

%	–	percent
°C	–	degree Celsius
AC	–	alternating current
AFRP	–	aramid fibre reinforce polymer
Al/SiCp	–	Aluminium matrix/Silicon Carbide particulate
CAD	–	Computer Aided Design
CFRP	–	carbon fibre reinforced polymer
cm	–	centimetre
CO_2	–	Carbon Dioxide
CW	–	continuous wave
DC	–	direct current
DoE	–	Design of Experiment
FP	–	focal point
g	–	Gram
GaAs	–	Gallium Arsenide
GFRP	–	glass fibre reinforce polymer
GP	–	gate pulse
HAZ	–	heat affected zone

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HCL	–	Hydrochloric acid
Hz	–	hertz
InP	–	Indium Phosphate
kJ	–	kilo joule
kPa	–	kilopascal
kW	–	kilo Watt
MDF	–	medium-density fibreboard
Max.	–	maximum
Min.	–	minimum
min	–	minute
mm	–	millimetre
MMC	–	metal matrix composite
MRR	–	material removal rate
N_2	–	nitrogen
Nd: YAG	–	Neodymium Yttrium Aluminium Garnet
PC	–	Polycarbonate
PE	–	Polyethylene
PMMA	–	Polymethylmethacrylate
PP	–	Polypropylene
PSO	–	partial swarm optimization
PVC	–	Polyvinyl chloride
PZT	–	Lead Zirconate Titanate

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Ra	–	arithmetic average of the roughness profile
RF	–	radio frequency
RSM	–	response surface methodology
s	–	Second
S.O.D	–	stand of distance
W	–	Watt
μm	–	micrometer

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CHAPTER 1

INTRODUCTION

Wood carving is a form of working wood by means of a cutting tool in one hand or a chisel by two hands or with one hand on a chisel and one hand on a mallet, resulting in a wooden figure or figurine, or in the sculptural decoration of a wooden object. Most of the wood carving industry is using human power in its production line as it is an industry which involve the skills and knowledge that the operator has. Wood carving has been around just as long as man has been upon this earth. Due to wood being a material that will not withstand the test of time, wood carvings must be protected and taken care of if they are to endure. Wood carving is part and parcel of vernacular Malay architecture and craft in Peninsular Malaysia and Southern Thailand. Timber architecture, boats and canoes, hilts and sheath of weapons, musical instrument and utensils are adorned with carving motifs of flora, calligraphy, geometry, fauna and cosmic features. It is an art of partially removing wood from a board or a plank following specific motifs and orders (Ismail, 2002). In carving, Malay craftsmen demonstrated high skills of art manifesting abstract ideas into physical beauty. This manifestation developed through a long period whereby skills and knowledge of woodcarving was passed through apprenticeship. By imitating a carved masterpiece, a woodcarver gradually modifies the motifs and produces his own manifestation onto the timber piece.

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Generally, the carved components are depicted in three incision modes: relief, perforated or a combination of both (Ismail and Ahmad, 2001). Some of the components are wall panels, ventilation panels of door or window, door leaves, railings, gables and their boards, and fascia boards that dominate the elevation of the buildings. The degree of complexity in carving varies from one component to another, intricate ones include door leaves and wall panels, and simple carvings include bargeboard and fascia board. The carvings also signify the status and ownership of the residents and display the skilfulness of the craftsmen. Within the differences in motif and modes of incision and layout, a common factor holds the architecture that is, it is mostly constructed from heavy hardwood species particularly Cengal, Balanocarpsus Heimii sp. (Ismail, 2002). Apart from the skilfulness of the woodcarvers as one of the determining factors in creating the carving, the other factor is the abundance of tropical hardwood species. Thus timber constructions such as house, mosque, palace, entranceway or gateway, tomb and pavilion, and boat are made from heavy hardwood species which are strong and durable and resist the attacks of fungi, powder-post beetles and termites.

1.1 Background

It was interested to figure out the method used by most of the wood carving industry and learnt on it. One visitation on wood carving industry had been done to gather the information needed to approach on this study.

Mr. Mustazarin bin Abdul Majid who live in KM34, Jalan Haji Yahya, Parit Perawas, 77400 Sungai Rambai, is a person who work as a wood carving manufacturer. He has worked in wood carving industry (Anjung Ukir Enterprise) in three years and all the products are produced based on his knowledge and experience. Anjung Ukir Enterprise is a small wood carving industry which is a home-based industry. The method used by Mr. Mustazarin to produce wood

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sculptural is jigsaw, driller, and grinder. The wood sculptural produce by Mr. Mustazarin is more on decorations for building (which used to hang on the wall), wooden boxes, and small cupboards. Figure 1.1 shows the wood carving products which made by Mr. Mustazarin.

Figure 1.1: Wood carving product which used to decorate fence or staircase

There are three types of materials used to produce the products. They are Meranti (Merah and Putih) – Shorea sp., Mersawa – Anisoptera grossivenia sp., and plywood. Each wood are with different thickness: Meranti (1 cm – 2 cm), Mersawa (1.8 cm – 1.9 cm), and plywood (3 mm, 5mm, and 9 mm). Each type of wood will then used for different profiling.

The steps for wood carving process involved drafting patterns, drilling, sawing or cutting (profiling), trimming, and coating. Table 1.1 shows how the processes done to produce a carving product.

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Table 1.1: Steps for manually or conventional wood carving process

Process	Picture
<u>Prepare pattern:</u> The pattern or design was the idea either from the customers or the manufacturer. The design can be vary based on the customers' requirements. The design was drawn out in a cardboard which will then transferred to wooden material later.	
<u>Drafting the pattern on material:</u> After preparing the pattern, the design was transferred to the raw material such as Meranti, Mersawa, or plywood. The thickness of material used was based on the function of the products.	

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Drilling: Drilling was used to create a starting point for profiling. This is because the carving pattern was with the hollow parts in the centre of the wood. After drilled a hole, the blade can insert through the hole and start for the profiling process.	
Profiling: Jigsaw is used as the tool for profiling. There are many sizes for the blade. Large size blade was used to cut simple profile and cut off large area. Small size blade was used to cut the small hole or area, and normally is used to cut the sharp edge.	

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