PRELIMINARY INVESTIGATION OF PLASTICS JOINING PROCESS

SITI NOORAISHAH BINTI ELIES
B051010171

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
2013

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PRELIMINARY INVESTIGATION OF PLASTICS JOINING PROCESS

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

by

SITI NOORAISHAH BINTI ELIES

B051010171

900409015894

FACULTY OF MANUFACTURING ENGINEERING

2013

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Preliminary Investigation of Plastics Joining Process**

SESI PENGAJIAN: 2012/13 Semester 2

Saya **SITI NOORAISHAH BINTI ELIES**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (/)

☐ SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysiasebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐ TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐ TIDAK TERHAD	

Disahkan oleh:

_____ _____

Alamat Tetap:

NO. 1 Jalan KM 2,

Taman Kota Mas,

81900 Kota Tinggi, Johor.

Cop Rasmi:

Tarikh: _____ Tarikh: _____

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled "Preliminary Investigation of Plastics Joining Process" is the results of my own research except as cited in references.

Signature	:
Author's Name	: Siti Nooraishah Binti Elies
Date	: 19th June 2013

APPROVAL

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 (Manufacturing Process) (Hons.). The member of the supervisory committee is as follow:

……

(Project Supervisor)

ABSTRAK

Kajian awal terhadap proses gabungan plastik dengan menggunakan laser telah dijalankan ke atas botol plastik terpakai (polietilena berketumpatan tinggi, HDPE) yang mempunyai purata ketebalan 1.5 mm. Jenis gabungan yang telah dihasilkan ialah gabungan tindan bagi memdapatkan luas permukaan yang maksima semasa proses penggabungan. Plastik ini digunakan semula untuk mengurangkan kadar buangan sisa pepejal dalam masa yang sama mengekalkan sifat dan ciri-ciri sesuatu bahan tersebut kerana pemprosesan semula hanya akan mengurankan sifat bahan. Tiada tindakbalas dan sentuhan secara langsung terlibat semasa pemprosesan laser. Dengan itu, kerosakan mata alat dan getaran pada mesin dapat dielakkan. Mesin pemotong laser karbon dioksida (Helius Hybrid 2513) telah digunakan untuk proses gabungan menggunakan laser. Proses parameter yang telah dipilih hasil daripada eksperimen OFAT ialah kuasa laser, kelajuan laser dan tekanan gas. Eksperimen ini dijalankan dengan menggunakan kaedah faktorial penuh untuk merekabentuk eksperimen bagi mendapatkan gabungan parameter yang optimum. Eksperimen ini melibatkan dua proses dalam satu masa yang sama iaitu proses gabungan dan proses pemotongan. Hasil kajian membuktikan bahawa mesin laser pemotong telah berjaya menggabungkan dua kepingan plastik hasil daripada haba yang dihasilkan oleh laser. Kualiti dan analisis bagi setiap gabungan yang terhasil telah dilakukan dengan pemeriksaan visual dan ujian lenturan. Hasil analisa menunjukkan bahawa gabungan parameter yang baik dan tindak balas yang optimum dapat dihasilkan daripada gabungan parameter pada peringkat yang lebih tinggi.

ABSTRACT

A preliminary investigation on plastics joining process by laser on waste plastics (HDPE) with average thickness 1.5mm is carried out. Stack joining is performed on the plastic in order to obtain maximum joining surface area. The plastic is re-used in order to minimize rate of solid waste also to maintain the material's properties since re-processing will just decrease it. Furthermore, indirect contact between laser beam and material has resulting little to no reaction forces imparted upon the material in the same time eliminate tool wear, material damage and machine vibration. Process parameters that have been chosen in this study is based on OFAT experiment which are laser power, travel speed and gas pressure. Full factorial method of parameter design is used as design of experiment (D.O.E) technique to obtain optimal process parameters. The experimental is performed by simultaneous process of joining and cutting. The machine used was Helius Hybrid 2513 Laser Cutting Machine. Results show that Laser Cutting machine has successfully joined the plastic. Quality and performance analysis of the join are performed by visual inspection and flexural test. From analysis, it shows that higher level has produced optimum responses.

DEDICATION

To my beloved family and friends.

ACKNOWLEDGEMENT

With the name of Allah, I would like to thank Him for giving me this opportunity to complete this work. Million thanks to my parents and family for their infinite support all this while. They had scarified a lot especially in financial, time and moral support. Very special thanks to my supervisor, Associate Professor Ir. Dr. Sivarao Subramonian for guiding and helping me in conducting this research from the very beginning till the end. Your endless guidance and supports even in financial are the backbone of this work. Thank you for your kindness and patient for guiding me and give me loads of additional knowledge and information throughout this project. Besides that, lot of thanks also goes to my fellow friends who helping me days and night. Special thanks dedicated to technicians and FKP staff for their consideration and help throughout the year. Last but not least, I would like to thank to the librarian of UTeM's library and all people that involve either direct or indirectly in this study. I really appreciated your cooperation. Only God can repay all the kindness given to me.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

%	-	percent
&	-	and
”	-	inch
<	-	less than
>	-	more than
±	-	plus minus
≈	-	almost equal to
®	-	Right
3D	-	three dimensional
A	-	Absorption
angstroms	-	measure of length, 1 angstrom= $10E^{-10}$m
ANOVA	-	Analysis Of Variance
ANSI	-	American National Standard Institute
cm	-	centimetre
CO_2	-	Carbon Dioxide Gas
CVL	-	Copper Vapour
Cw	-	clock wise
CW	-	Continuous Wave
D	-	Diameter
D.O.E	-	Design of Experiment
DC	-	Duty Cycle
DIN	-	Deutsche Industry Norm
E	-	Energy per Pulse
e.g.	-	example
EB	-	Electron Beam
EDM	-	Electro Discharge Machining

etc.	-	Exedra/ and others
F	-	Frequency
F.D.	-	Focal Distance
FKP	-	Faculty of Manufacturing Engineering *(Fakulti Kejuruteraan Pembuatan)*
GP	-	Gated Pulse
H_2	-	Hydrogen Gas
HAZ	-	Heat Affected Zone
He	-	Helium Gas
Hz	-	Hertz
in.	-	inch
IPTA	-	The Public Institution of Higher Learning *(Institut Pengajian Tinggi Awam)*
ISO	-	International Organization for Standardization
J	-	Joule
K	-	Kelvin
k	-	kilo
kg	-	Kilogram
L	-	Length
LASER	-	Light Amplification by Stimulated Emission of Radiation
m	-	meter
mA	-	mili Ampere
MB	-	Mega Byte
Mil	-	1 mil = 0.254 mm
mJ	-	mili Joule
mm	-	millimetre
MPa		Mega Pascal
N		Nominal value
N_2	-	Nitrogen Gas
NC	-	Numerical Control
Nd:YAG	-	Neodymium Yttrium Aluminium Garnet

Nm	-	Nanometer
No/Num	-	Number
^{o}	-	Degree
ø	-	Diameter
O_2	-	Oxygen Gas
p	-	Pressure
P	-	Power
Pa	-	average power
P_p	-	peak power
ps	-	Pico second
PSM	-	Bachelors Degree Project *(Projek Sarjana Muda)*
R	-	Radius
R	-	Reflectivity
RF	-	radio-frequency
s	-	Seconds
SOD	-	Stand Off Distance
STD.		Standard
T	-	Transmissivity
t	-	Thickness
TEA	-	Transversely Excited Atmosphere Pressure
UTeM	-	Malaysia Melaka Technical University *(Universiti Teknikal Malaysia Melaka)*
UV	-	Ultraviolet
V	-	Volt
W	-	Watt
WJ	-	Water jet
λ	-	Wave length symbol
μm	-	micrometer
Σ	-	Total
τ	-	Pulse width symbol

CHAPTER 1
INTRODUCTION

Chapter 1 is basically includes the entire report content starting from Project Background up to Plastics Joining Processes. Related information regarding laser processing is included in this chapter.

1.1 Project Background

Laser machining is widely known for cutting almost any materials. The highly focus, high-density energy source melts and evaporates portions of the workpiece in a controlled manner. Laser cutting which is one laser machining process could be referred as a material removal process accomplished by laser material interaction. Besides machining, laser also is been used in processing such as welding. Laser welding is a non-contact process and involves localized heat treating of materials to modify the surface mechanical and tribological properties (Kalpakjian, 2010).

Used products with plastics based are usually recycled. When the material is recycled, the properties of the material will not remain the same. Usually the properties are reduced and qualities of secondary products are low. Instead of re-melt or recycle the material, the used product is reused. In addition, due to high investment cost needed to setup a laser machine, optimization of existing laser cutting machine is the main goal of this study. For experimental, laser joining process will be performed by laser cutting machine instead of laser welding machine. In laser processing, the controllable process parameters are quite same for any process.

The challenge in conducting this study is to identify the most suitable parameters to be applied in laser welding. This preliminary investigation will determined the capability of CO_2 laser to produce join between materials by varying some of process parameters. A laser cutting machine with rated power 3kW is used in this experimentation work.

The join is evaluated through visual inspection and destructive tests. Throughout this study, CO_2 laser cutting machine has proved its ability to melt and form join at the interface of the plastic sheets and pass minimum requirement in mechanical destructive test.

1.2 Problem Statement

Huge wastage of plastic bottle has become a big problem faced by the country. In average, one Malaysian citizen has produced abut 0.8kg waste per day. It is expected that in 2020, 30 000 tonne waste will be produced since only 5% of the total waste is recycled. This is a hug number for a small country like Malaysia. Due to this problem, waste plastic (HDPE) is chosen as the main material to be used in experimentation. The plastic is re-used in order to maintain its properties since re-meting will just reduce it. Besides, high cost is required to setup recycling equipment.

The challenge in this study is to determine which parameters that is suitable to be manipulated so that two plastic sheets can be joined together to increase its use. Since laser cutting and laser welding have almost same parameters, the requirement to buy a new laser welding machine can be eliminated because there is high possibility that a laser cutting machine can do joining without changing any part of the machine. Even though the materials can diffuse together, the joining will determined quality of the bond produced. Defects such as weld width inconsistency, anomalies and thermal decomposition are to be seen and observed directly from visual inspection. The inconsistency also may cause poor strength of the join.

1.3 Scope of Project

The aim of this project is to identify the best controllable process parameters that have big impact in laser processing. In order to produce good join, a set of process variables is developed and recommended. The values of each three chosen parameters which are laser power, travel speed and gas pressure are varied within the range of experiment while other controllable parameters are fixed. The model of laser cutting machine to perform joining process is Helius 2513 hybrid series that was made in Belgium. The laser machine is equipped with nitrogen and oxygen as laser assisted gas and carbon dioxide (CO_2) laser beam with rated power of 3kW. The experimental on research work was conducted by stack joining on used high-density polyethylene (HDPE) plastics material. The joined is then examined by visual inspection and destructive test.

1.4 Objectives

The main objectives of this project are:

i. To investigate the ability to form stack joining of HDPE by CO_2 laser.

ii. To conduct quality and performance analysis of the join.