UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

The Optimization of Cold Metal Transfer (CMT) Welding Process Parameters on 5052 Aluminium Alloy Tensile Strength Using Taguchi Method.

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

by

Nur Fazreeha Ameelya Binti A.Fadzil

B 071410395

950313 01 5756

FACULTY OF ENGINEERING TECHNOLOGY

2017

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **The Optimization of Cold Metal Transfer (CMT) Welding Process Parameters on 5052 Aluminium Alloy Tensile Strength Using Taguchi Method**

SESI PENGAJIAN: **2017/18 Semester 1**

Saya **NUR FAZREEHA AMEELYA BINTI A.FADZIL**

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 Malaysia sebagaimana 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:

Lot 1385, Jalan Haji Noh,
Batu 18, Kg Sungai Tiram,
81800, Ulu Tiram,
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.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FAKULTI TEKNOLOGI KEJURUTERAAN
Tel : +606 234 6623 | Faks : +606 23406526

Rujukan Kami (Our Ref) :
Rujukan Tuan (Your Ref) :

28 JAN XXXX - Cth

Pustakawan
Perpustakaan UTeM
Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya,
76100 Durian Tunggal,
Melaka.

Tuan/Puan,

PENGKELASAN LAPORAN PSM SEBAGAI SULIT/TERHAD LAPORAN PROJEK SARJANA MUDA TEKNOLOGI KEJURUTERAAN PEMBUATAN (COURSE NAME): AAA BIN BBB

Sukacita dimaklumkan bahawa Laporan PSM yang tersebut di atas bertajuk ***"Quality and Performance Investigation of TiAlN Coated Drill Tools"*** mohon dikelaskan sebagai *SULIT / TERHAD untuk tempoh LIMA (5) tahun dari tarikh surat ini.

2. Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian dimaklumkan. Terima kasih.

Yang benar,

____
Tandatangan dan Cop Penyelia

* Potong yang tidak berkenaan

NOTA: BORANG INI HANYA DIISI JIKA DIKLASIFIKASIKAN SEBAGAI SULIT DAN TERHAD. JIKA LAPORAN DIKELASKAN SEBAGAI **TIDAK TERHAD**, MAKA BORANG INI **TIDAK PERLU DISERTAKAN** DALAM LAPORAN PSM.

DECLARATION

I hereby, declared this report entitled "The Optimization of Cold Metal Transfer (CMT) Welding Process Parameters on 5052 Aluminium Alloy Using Taguchi Method" is the results of my own research except as cited in references.

Signature	:	………………………………………….
Author's Name	:	Nur Fazreeha Ameelya Binti A. Fadzil
Date	:	…………………………………………

APPROVAL

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

………………………………

(En. Mohd Hairizal Bin Osman)

ABSTRAK

Jika dibandingkan dengan aloi Aluminium yang lain, aloi Aluminium-Magnesium Siri 5XXX terkenal dengan sifatnya yang keras, tinggi daya kekuatan dan sukar untuk terhakis. Ini kerana aloi Aluminium jenis tersebut mengandungi jumlah elemen magnesium yang tinggi. Dalam industri automotif, proses untuk mencantum dua atau lebih, sama atau berlainan plat aloi Aluminium yang nipis adalah merupakan salah satu permasalahan yang besar bagi jurutera dan syarikat yang terlibat kerana parameter yang spesifik sukar untuk dicapai lebih-lebih lagi apabila menggunakan teknik kimpalan yang berasaskan robot seperti proses kimpalan Cold Metal Transfer (CMT). Jadi, satu penyelidikan telah dijalankan bagi mengenal pasti parameter kimpalan yang optimal untuk mencantum aloi Aluminium Siri 5052 dengan menggunakan robot kimpalan Cold Metal Transfer (CMT) selain mengenal pasti kesan parameter yang digunakan terhadap daya kekuatan hasil daripada cantuman tersebut. Plat aloi Aluminium Siri 5052 yang berukuran 2mm tebal, 150 panjang dan 120mm lebar dicantumkan dengan menggunakan robot kimpalan Cold Metal Transfer (CMT) melalui corak kimpalan yang berlainan iaitu, corak lurus, pekeliling dan zig zag. Sumber tenaga elektrik ditetapkan pada 85, 95 dan 105Amp, sementara kelajuan kimpalan pula akan ditetapkan pada kadar 0.50, 0.75 dan 0.95 mm/min. Di dalam kajian ini juga, kaedah Taguchi telah digunakan untuk mengenal pasti parameter kimpalan yang optimal untuk mencantum plat aloi Aluminium Siri 5052. Hasilnya, berdasarkan analisis daripada kaedah tersebut, parameter kimpalan yang paling memberi kesan terhadap daya kekuatan yang terhasil ialah dengan menggunakan corak kimpalan secara pekeliling, sumber tenaga elektrik sebanyak 95 Amp dan kelajuan kimpalan sebanyak 0.50 mm/min.

ABSTRACT

The 5XXX Series Aluminium-Magnesium alloy is well-known as a hard, high strength and excellent corrosion resistance material among the other alloys due to the high content of magnesium elements in the series. When come to the automotive industry, the process to assemble a thin-sheet similar or dissimilar Aluminium alloy is became one of the major problem against the engineers and companies as the optimal parameter setting for joining this material is hard to achieve especially when using the robotic welding technique such as Cold Metal Transfer (CMT) welding process. Hence, this research is concerned about the optimization of welding process parameters on 5052 Aluminium alloy tensile strength using Cold Metal Transfer (CMT) welding process. The 2mm in thickness, 120mm x 150mm in width and length respectively of 5052 Aluminium alloy is welded by using the advanced Gas Metal Arc Welding (GMAW) robot with the welding patterns involved are straight stepped, zig zag (Tripecoid) and circular (Spiral). Welding currents will be set on 85, 95 and 105Amp while welding speeds use are 0.50, 0.75 and 0.95 $mm.min\text{-}^{1}$. The Taguchi's method is used in order to identify the optimal welding process parameter setting. After run the analysis, the result shows that the most significance factors that affect the 5052 Aluminium alloy tensile strength are the welded specimen with the welding process parameters of spiral type welding pattern, 95Amp of welding current and 0.50 mm/min welding speed.

DEDICATION

To my beloved parents, Rohaya Binti Abu Bakar and A.Fadzil Bin Abdullah. Also to my brothers and sister, teachers in Sekolah Menengah Kebangsaan Adela, Kota Tinggi, Sekolah Menengah Kebangsaan (P) Sultan Ibrahim, Johor Bahru, Sekolah Menengah Kebangsaan Pasir Gudang 1, Pasir Gudang, Sekolah Menengah Kebangsaan Sungai Tiram, Ulu Tiram Johor and Kolej Matrikulasi Selangor.

ACKNOWLEDGEMENT

Assalamualaikum W.B.T and Salam Sejahtera. First and foremost, with all my heart, I would like to thank to Allah S.W.T as by His blessing and destiny, these project and its report can be accomplished within the time given. A lot of appreciations were also dedicated to my supervisor, En. Mohd Hairizal Bin Osman and my family, Ibu and Ayah especially, for their guidance, understanding and support along the journey to complete this project.

Next, I'm very glad to dedicate a million of appreciations and thanks to assistant engineers from the Faculty of Engineering Technology, En. Fakhrulnaim Bin Ibrahim, En. Mohd Basri Bin Bidin, En. Azizul Ikhwan Bin Mohd and En. Salleh Bin Aboo Hassan towards their guidance, advices and expertise onto the machines and equipments that used during conducting the project's experiment. Their efforts, sharing, time and energy used in order to complete theis project are highly appreciated and will be never forgotten.

Last but not least, I also would like to give this appreciation and a lot of thanks to my project's team mate, Madiha Husna Binti Ahmad, Nor Faizah Binti Abdul Halim, Nur Fatihah Binti Nasrudin and Riduan Bin Hairus Salleh, as they are always gave me support and very handful during runs the project's experiment. All the time that already spent together with them will be remembered as long as I can and may Allah S.W.T ease their life in here and here after as the returned of their kindness.

Thank you very much.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Al	-	Aluminium
ANOVA	-	Analysis of Variance
CMT	-	Cold Metal Transfer
TIG	-	Tungsten Inert Gas
kN	-	kilo Newton
mm	-	milimeter
GTAW	-	Gas Tungsten Arc Welding
AC	-	Alternating Current
DC	-	Direct Current
5XXX	-	5000 Series Aluminium Alloy
Mg	-	Magnesium
Cr	-	Chromium
Fe	-	Ferum
Si	-	Silicon
Cu	-	Copper
Mn	-	Manganese
E	-	Young Modulus of Elasticity
ε	-	Strain
σ	-	Stress
UTS	-	Ultimate Tensile Strength
OA	-	Orthogonal Arrays
DF	-	Degree of Freedom
Adj SS	-	Adjusted Sum of Square
Adj MS	-	Adjusted Mean Square
MIG	-	Metal Inert Gas
SC	-	Short-circuiting
Ar	-	Argon
CO_2	-	Carbon Dioxide

He	-	Helium
O_2	-	Oxygen
GMAW	-	Gas Metal Arc Welding
Amp	-	Ampere
mm/min	-	milimeter per minute
S/N Ratio	-	Signal-to-Noise Ratio
DOE	-	Design of Experiment
MPa	-	Mega Pascal
°C	-	Degree Celcius

CHAPTER 1

INTRODUCTION

1.0 Introduction

Basically, this section will be described on the background of the project, the problem statement of the project, the objectives and the scopes of the study. From the background of the study, the problem statement will be identified and later it will lead to the identification of the project's objective. This study will be based on the objective that have been determined and are limited by the project's scopes.

1.1 Project's Background

Well known as a lightweight, durable and highly recyclable material, Aluminium has become an essential element of daily life. As the sustainable material of choice, its applications span from everyday items, especially for heavy industrial markets such as transportation and aerospace companies. Aluminium helps these two mega industry by serve an innovative products without sacrificing safety or performance. Using light material is becoming more and more interesting in the automobile industry in order to protect the environment. Because of the Aluminium alloy special characteristics, the new types of car produced from thin Aluminium alloy are under rapid development and some products are already in market. Then, the welding of the thin Aluminium is the key problem to accelerate the use of the Aluminium alloy and guarantee the property of cars made of the Aluminium alloy materials. A recent development in welding technology is the Cold Metal Transfer (CMT) process which is ideally suited to welding Aluminium whereby this type of joining method are owing to the no-spatter welding process and low thermal input.

1.2 Problem Statements

Aluminium alloy is a soft, very sensitive and widely used in a thin shape or size of material when it comes to the welding process. As compared to the hybrid Tungsten Inert Gas (TIG) welding process which is the Cold Metal Transfer (CMT) welding process, the non-conventional TIG welding process is a process whereby the process parameters are hard to be controlled such as slow welding speed which it may tend to produce spatter and other welding distortions.

Hence, to overcome this problem, the new welding technology technique such as CMT welding process is used and the process parameters will be optimized in order to achieve a stable Aluminium alloy CMT welding process besides to reduce the welding distortion and increase Aluminium specimen capability.

1.3 Objective

The main objectives of this project are as follows:

- **i.** To determine the most significance process parameter setting that affect the tensile strength of 5052 Aluminium alloy using Cold Metal Transfer (CMT) welding process.
- **ii.** To optimize the tensile strength of the welded 5052 Aluminium alloy using the optimized Cold Metal Transfer (CMT) process parameter.

1.4 Project's Scope

The scopes of this project are as follows:

- **i.** The type of material used in the welding operation is 5052 Aluminium alloy with the dimension of 150mm in length, 120mm in wide and 2mm in thickness.

ii. The 5052 Aluminium alloy plates are welded by using the KUKA Cold Metal Transfer Robot Arm Welding Machine with aided by Migatronic Sigma Galaxy 400 power sources.

iii. The joined 5052 Aluminium alloy plates will be cut into the dog bone shape by using the F0 MII 3015 NT AMADA Laser Cutting Machine.

iv. The 5052 Auminium alloy dog bone shape specimens will be tested by using the 50kN Tab Top Model 5969 Instron Universal Tensile Testing.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, the basic knowledge of the Cold Metal Transfer (CMT) welding process, 5052 Aluminium alloy materials, Taguchi methods and the Analysis of Variance (ANOVA) techniques will be discussed. The important process parameters used to join the Aluminium alloy materials by using the CMT welding process will be identified and some journals regarding to the technique used in the tensile testing process will be summarized. The idea and dimension used to design the specimen and tensile testing have been referred back to the previous study.

2.1 Joining Process

Joining is a process of assembling two or more similar or dissimilar materials by using a specific joining method depending on the function of the component will be used. Since a few decades ago, joining process became one of the most important fabrication technologies in various type of heavy industry especially in automobile manufacturing. Due to functional needs and technological limitations, it is usually not possible to manufacture a product without joining of some sort. Products are typically assembled using multiple components and joining processes are essential in manufacturing to provide product function and increase manufacturing process efficiency. Basically, material joining is based on the three main principles whereby:

i. Material coalescence where the materials are held together by atomic or molecular binding forces. In this case, the atoms or /and molecules must be placed in close proximity to each other. For example, by processes without the presence of heat (solid state welding or diffusion), processes based on the mixing in a liquid state like (fusion welding) or processes with addition of a third, generally hardening, liquid substance (e.g. soldering or adhesive bonding).

ii. Interlocking joints are performed by the interlocking of two materials or by the anchoring of additional elements into or inside the corresponding materials. For example are the mechanical joints.

iii. Frictional connections which are the results of friction between the involved materials, enhanced by the application of an external force. For example is the shrinking of a hub onto a shaft.