MODELING AND OPTIMIZATION THE EFFECT OF PROCESS VARIABLES ON MECHANICAL PROPERTIES OF AL- 6061 T6 ROBOTIC CO_2 WELDMENTS

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SUPERVISORS DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of

Bachelor of Mechanical Engineering (Design and Innovation)"

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MODELING AND OPTIMIZATION THE EFFECT OF RESPONSE VARIABLES ON MECHANICAL PROPERTIES OF AL- 6061 T6 ROBOTIC GMAW WELDMENTS

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DECLARATION

“I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged.”

Signature : ……………..…………….
Author : …………………………...
Date : …………………………...

But seek ye first the kingdom of God, and his righteousness;
and all these things shall be added unto you
KJV (Matthew 6:33)

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ABSTRAK

Kimpalan struktur Aluminium yang menggunakan T6-6061 adalah satu proses yang kompleks dan mencabar kerana kesukaran dalam mencari kimpalan parameter kawalan proses optimum untuk mencapai sifat-sifat mekanik yang baik seperti kekerasan dan kekuatan hasil kimpal itu. Pemilihan parameter optimum yang secara umumnya adalah berdasarkan kepada kemahiran dan pengetahuan tentang juruteknik yang terlibat dan masa dan bilangan memakan kos percubaan dan kesilapan berjalan. Satu percubaan telah dibuat itu untuk menyiasat secara sistematik pengaruh parameter kawalan proses kekerasan manik Aluminium 6061-T6 dengan menggunakan Response Surface Method (RSM) dengan lima tahap reka bentuk komposit empat faktor utama untuk mewakili hubungan antara kimpal faktor proses dan tindak balas mereka. Model matematik telah dibangunkan untuk menunjukkan hubungan antara pembolehubah proses dan jawapan mereka yang akan membantu para jurutera kilang untuk memilih dan mengawal pembolehubah proses berkesan, untuk mencapai keputusan yang dikehendaki. Ia telah mendapati bahawa voltan dan arus mempunyai kesan tertinggi pada kekerasan hasil kimpal itu.

ABSTRACT

Welding of Aluminium structures that uses T6-6061 is a complex and challenging process due to the difficulties in finding the optimum weld process control parameters for achieving the desirable mechanical properties such as hardness and strength of the weldment. The optimum parameters selection which generally is based on the skill and knowledge of the technicians involved and the time and cost consuming number of trial and error runs. An attempt was hence made to systematically investigate the influence of process control parameters on the hardness of the bead of Aluminum 6061-T6 by applying Response Surface Methodology (RSM) technique with five level four-factor central composite design to represent the correlation between the weld process factors and their response. Mathematical models were developed to show the relationship between process variables and their responses that will help the plant engineers to select and control process variables effectively, to achieve the desired results. It has been found that Voltage and Current have the highest effect on the hardness of the weldment.

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CHAPTER I

INTRODUCTION

This chapter describes the background of Gas metal arc welding (GMAW) as well as Aluminum Alloy 6061T6. Subsequent is followed by the problem statement of the thesis project. Next, the objective of project will be explained and the scope of the project being covered. This chapter will end with the outline of the Thesis.

1.1 BACKGROUND

Gas metal arc welding (GMAW) process is largely common among researchers as well as in the industries and is commonly preferred for welding mainly in automobile and marine industry due to its exceptional mechanical properties (Baghel, 2012). The significance of a good weld joint is influence by the variable welding factors. Therefore it is vital to have a good weld joint

AL 6061-T6 also known as strengthened metal matrix composites (MMCs) due to its chemical composition where it has at minimum two parts of essential part, one presence of a metal. Reinforced metal matrix compounds are finding its way into engineering practices. In applications where good ability to endure high relative temperature as well the necessities of high specific strength and stiffness are the distinctive features of composite materials, AL 6061 T6 have its advantage.

Al 6061-T6 alloys are extensively used for viable uses in the engineering industries. One of the many advantages of Al 6061-T6 is that it has exceptional mechanical properties which allow it to be machined swiftly and sparingly.

1.2 PROBLEM STATEMENT

There are problems is faced by manufacture everywhere to control the process factor parameters to have a good weld with that have a minimal residual stresses. It is significant to decide the weld input with every new product within the specifications thus making it more troublesome. A pain staking test and error process with weld key in parameters heavily relying on the skills of the technician, Next welds are separately examine to decide whether it satisfy the requirement by conducting several test. Finally if all is well, the weld parameters are chosen together with the technician can proceed with the welding process. Therefore to overcome this problem, several optimization methods that can be developed to develop a mathematical model equation to specify the relationship between variable welding parameter and the desired outcome.

1.3 OBJECTIVES

1. To investigate a study and record the relationship between process variables and mechanical properties during the robotic welding of AL 6061 T6 alloys
2. To develop mathematical models. In addition, to predict, compare the developed model for optimization of responses

1.4 SCOPE

The scope of this research will cover the literature reviews that are related to this project. Besides that, the scope is to study, understand the theory and correlation between the weld control factors and the response variables during robotic GMAW process. In addition, it will also apply design of experiment methodologies to develop mathematical models for prediction of responses and optimization

1.5 THESIS OUTLINE

Chapter One describes the main objective of this project and its scope of study. In Chapter Two, there is a complete literature study of the effects of response variable on mechanical properties and which related to this project. Chapter Three explains more in details about the method used to achieve the project objective. Chapter Four explains about the preparation for the experiment and Chapter Five explains about the testing and results analyzing from the experiment. Chapter Six explains the discussion made based on the overall results obtained. Conclusion and recommendation are explained in the final chapter of this thesis.

CHAPTER II

LITERATURE REVIEW

2.1 ALUMINIUM

Aluminium Alloys can be defined as a substance consists of metallic properties that have two or more element of which aluminum is the main part comprising 90-96% which other elements are added to provide a specific properties and characteristic

Aluminium has a very interesting characteristic that industries are favorable for usage The low density and high strength to weight ratio are one of the reasons why aluminum and its alloys are used widely in aerospace and automotive businesses. Aluminium comes in different size and type of application usage. Generally, Aluminium series are determined by the type of alloying element present which will influence that typical application and the characteristic of the element

Table 2.1 : Alloying Element of Aluminum (Kaufman, 2000)

Alloying Element	Wrought
None (99%+ Aluminum)	1XXX
Copper	2XXX
Manganese	3XXX
Silicon	4XXX
Magnesium	5XXX
Magnesium + Silicon	6XXX
Zinc	7XXX
Lithium	8XXX

Based on Table 2.1, For an example, for the 3XXX series the minor alloying element is manganese. 3XXX series alloys are non-heat treatable that can be strengthen using cold work. As for 6XXX series, it contains both magnesium and silicon that will have a different characteristic than other series. 6XXX series are heat treatable and that have high corrosive, resistive, excellent extrudability with relatively moderate strength. (Kaufman, 2000)

Table 2.2: Physical Properties of AL 6061-T6 (Kaufman, 2000)

Physical Property	Value
Density	2.70 Kg/cm^3
Melting Point	650 °C
Thermal Expansion	23.4 x10^-6 /K
Modulus of Elasticity	70 GPa
Thermal Conductivity	166 W/m.K
Electrical Resistivity	0.040 x10^-6 Ω .m

Table 2.2, consist of the physical properties of Aluminum 6061-T6 which have a modulus of elasticity of 70Gpa which makes it a primary usage in architectural and structural members besides that, the special properties of this series is the extrudability.

Table 2.3:Weldability of Aluminum 6061-T6 (Kaufman, 2000)

Weldability	Condition
Weldability	Gas: Good
Weldability	Arc: Very Good
Weldability	Resistance: Good
Brazability	Good
Solderability	Good

Based on Table 2.3, Aluminum 6061-T6 has a good working condition on several Weldability. Brazing and Soldering have a good working condition while using arc welding the working condition is very good

2.3 WELDING PARAMETERS

The selection of the precise welding circumstances for the plate width and joint planning to be welded is very vital if acceptable joints free from flaws such as cracking, porosity and undercut are to be acquired. The process factors, which have to be considered, are:

a. Electrode polarity.
b. Welding current.
c. Electrode diameter.
d. Arc voltage.
e. Welding speed.
f. Electrode extension.
g. Electrode angle.
h. Flux depth.

These are the factors that govern bead size, bead shape, and depth of infiltration and in some conditions metallurgical properties such as occurrence of cracking, porosity and weld metal configuration.

2.3.1 Electrode polarity.

The furthest penetration is gain with DC opposite polarity which also provides the finest surface presence, bead geometry and struggle to penetrability. Direct current straightforward polarity (DC conductor negative, DCEN) provides quicker burnoff (about 35%) and slighter infiltration since the maximum high temperature is established at the end of the electrode as a substitute of at the exterior of the plate.

2.3.2 Welding current.

One of the most significant parameter is welding current due to its effect on the shape of the bead and it controls the rate of which an electrode is heating above melting point and as a result it influence the deposition rate, depth of penetration and heat affected zone. The increment of welding current, will result to the increment of reinforcement If the current is also high at any given welding pace, the infiltration will also be too high so that the resulting weld may tend to melt through the metal being joined. Higher current also tend to squander of electrodes in the type of unnecessary strengthening and produce digging arc and undercut. This over welding increases weld shrinkage and causes greater distortion. Welding current and bead width correlate until a given critical point is reached and after that it starts decreasing if the polarity used is DCEP. Increase in current will result to increment of bead width when DCEN polarity is use for the entire range (McGlone, 1982). If the current is too low, inadequate penetration or incomplete fusion may result. Too low current also leads to unstable arc, inadequate penetration and overlapping

2.3.3 Electrode Diameter.

Electrode size affects the weld bead geometry and the depth of penetration at static current. Electrode size too affects the deposition rate. A small span electrode will have a greater current concentration and a greater deposition rate than a thicker electrode. However, a larger diameter electrode can transport more current than a smaller electrode, and yield a greater deposition rate at higher amperage. For the same values of current, arc voltage and welding speed, an upsurge in electrode diameter results in a minor increase in the spread of the bead.