



**NATIONAL TECHNICAL UNIVERSITY COLLEGE OF
MALAYSIA**

**The Investigation of MIG Welding
Parameter Effects on Welding of
Dissimilar Metal
(Stainless Steel to Cast Iron)**

Thesis submitted in accordance with the requirements of the
National Technical University College of Malaysia for the Degree of
Bachelor of Engineering (Honours) Manufacturing (Process)

By

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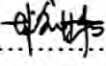
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APPROVAL

This thesis submitted to the senate of KUTKM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Engineering (Honours) Manufacturing (Process). The members of the supervisory committee are as follows:



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ABSTRACT

Experimental project to combine different metals (martensitic custom 450 SS to white cast iron) welded using metal inert gas welding or MIG. The reason of this experimental project is done is to examine the effect of the MIG weld towards the combination of different metals. The research 's objective is to prove that stainless steel can and will combine with cast iron with welding process based on the condition made from theory, other that look into the congruently, and the strength of the weld and the driving force between these different metals. The goal of this research is if there are perfect fit and congruently in the combination, it will make way to a more effective research and could be application in different industries mostly in vehicle construction sector. This MIG welding will be using robot with the help of two different filler wire as a variable that is stainless steel and mild steel. The speed of welding by the robot is constant at 30 cm/m. The voltage of the welding also constant at 19.9 volt. Power that is being used when welding is made into a variable that can be set at 3 stages that are 120 Amp, 150 Amp and 170 Amp. Two types of welding joint that has chosen as variable are butt joint and lap joint. The location of the end of the robot's nozzle while welding is set for lap joint at 60° while for butt joint is set at 25° angle. The size of every material have a dimension of length x width x thickness (140 mm x 140 mm x 3mm) and will be held onto the table with G-vice when welded. The sample for lab testing was cutted into small size with dimension of length x width as 20 mm x 70 mm (butt joint) and 20 mm x 90 mm (lap joint) after welding done. Tests that will conducted after the welding are, mechanical test as tensile test, morphological observation to investigated weld fracture zone after performing the tensile test by using SEM and physical test as hardness test. The finding from this research project is achieving the objective that is stainless steel and cast iron can merged together using chosen filler metal and getting value reading of tensile strength for every joint following a determined parameter also the sample hardness on the welding surfaces zone can determine.

ABSTRAK

Projek ujikaji untuk mencantumkan besi yang berbeza (*martensitic custom 450 SS to white cast iron*) dikimpal dengan menggunakan kaedah kimpalan arka logam gas ataupun MIG. Tujuan projek ujikaji ini diadakan untuk melihat kesan kimpalan MIG terhadap sambungan dari besi yang berbeza. Objektif kajian bertujuan untuk membuktikan bahawa besi tahan karat boleh dan mampu bercantum dengan besi tuang melalui proses pengimpalan berdasarkan syarat-syarat yang ditetapkan dari bahan teori, selain itu melihat keserasian, kekuatan cantuman yang terhasil dan daya penusukan antara kombinasi besi berlainan jenis ini. Matlamat penyelidikan ini ialah jika didapati ada kesesuaian dan keserasian pencantuman antara besi tuang dan besi tahan karat, akan mencetuskan titik permulaan ke arah usaha penyelidikan yang lebih efektif dan diaplikasikan dalam pelbagai industri terutama dalam sektor kenderaan. Kimpalan MIG ini akan menggunakan kaedah robot dengan bantuan 2 jenis logam pengisi sebagai pembolehubah iaitu jenis besi tahan karat dan keluli lembut. Kelajuan robot semasa mengimpal dimalarkan iaitu 30 cm/m. Voltan yang digunakan adalah pemalar iaitu 19.9 volt. Bekalan kuasa yang digunakan semasa proses mengimpal dijadikan sebagai pembolehubah yang dilaraskan pada 3 tahap iaitu pada 120 Amp, 150 Amp dan 170 Amp. Dua jenis sambungan kimpalan yang dipilih sebagai pembolehubah iaitu berbentuk sambungan temu dan sambungan lekap. Kedudukan hujung muncung robot semasa mengimpal dimalarkan iaitu untuk sambungan lekap ditetapkan pada kedudukan 60° manakala untuk sambungan temu ditetapkan pada kedudukan 25° . Saiz setiap besi ialah mempunyai panjang x lebar x tebal (150 mm x 150 mm x 3 mm) dan diikat pada meja kerja menggunakan pengapit-G sewaktu mengimpal. Bahan dipotong kecil mengikut saiz panjang x lebar iaitu 20 mm x 70 mm (sambungan temu) and 20 mm x 90 mm (sambungan lekap) selepas selesai proses mengimpal. Antara ujian-ujian yang dijalankan selepas proses mengimpal adalah ujian mekanikal iaitu ujian tegangan, kajian morfologi untuk mengkaji kesan patah pada bahan selepas menjalani ujian tegangan menggunakan SEM dan ujian fizikal iaitu ujian kekerasan. Keputusan daripada projek ujikaji ini ialah ianya telah mencapai objektif iaitu kemampuan besi tahan karat mampu bercantum dengan besi tuang menggunakan bahan pengisi terpilih dan memperolehi nilai bacaan kekuatan tegangan bagi setiap sambungan mengikut parameter yang ditentukan juga kekerasan pada sepanjang permukaan kimpalan juga diperolehi.

DEDICATION

Specially Dedicated To :

My beloved Father, Buyong Bin Alin

My Mother, Khafizah Binti Harun

My youngest Sister, Erni Zaimona

My youngest Brother, Mohd Fairi Fazli

who are very concern, understanding, patient,
support, and for demonstrating the value education, hard work, and persistence.

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I would also like to say thanks.

A time to remember family and friends, too;

A time reminisces, and says;

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LIST OF ABBREVIATIONS

ASTM	American Standard Testing of Materials
ASM	American Standard of Material
Fe ₃ C	Cementite
HAZ	Heat Affected Zone
KUTKM	Kolej Universiti Teknikal Kebangsaan Malaysia
MIG	Metal Inert Gas
MS	Mild Steel
SEM	Scanning Electron Microscopy
SS	Stainless Steel
TIG	Tungsten Inert Gas
Rpm	Rotational per Minute

CHAPTER 1

INTRODUCTION

1.1 Research Background

Drastic advancement have happened for metal based technology have happened over the past 100 years (Jeremy, M., 1971). The industrial transformation that happened in that era have sparked tones of research ideas about the contents that is possessed by different types of metals even until now, strive to create new upgrades for current metals with higher achievements and competitive.

The combination between stainless steel and cast iron have never been commercialized because not found any specific source during the research, whether from books, research from internet or even journals that could be set as proof to show the welding of stainless steel and cast iron have been done and commercialized. But, the combination able to join if the filler metal selection is suitable (Cam and Kocak, G. *et al.*, 1998). Suggestion by Khanna, (1999) about the connection of cast iron and stainless steel can be done with tungsten inert gas welding technique or TIG. The plausibility of the theory haven't been tested out other than to do it myself with research with the supposed metals. Before this, the welding between metals are done with the same kind especially with vehicle industries, cooking equipment, operating equipments and such.

The purpose of this combination project is to examine how far one the strength of the penetration and the driving force of two different metals. Can it weld with each other

or not. This also hangs from the choosing of the type of metal itself, the filler metal that is suitable for adhesive agents and also the types of welding that is suitable for the welding to joint the both of the metals (Bosshard and Schlumpf *et al.*, 1987). Not only that, other factors that are important while welding and must be paid attention to are speed, suitable power output, welding angle, shape of weld and the thickness of metal (Mohd Nasir Bin Ahmad *et al.*, 1987).

The usage of stainless steel in the automotive industries and other industries are spreading fast because high demands from time to time sparked by it's features such as lightweight, high strength, low cost and multiple usage. That is also the case with cast iron that have high demands especially in the automotive sector because it has good mechanic properties, high machineability and also high strength (Zainal Abidin Ahmad *et al.*, 1998).

From the sources from books and internet, there are not much research done to the combination of different types of metal such as between cast iron and stainless steel. Because of that, the research has to be done about the welding weldability of stainless steel and cast iron to look for the specialty of the combination. If from the research, there are matching between cast iron and stainless steel, than hope this is could spark a new beginning towards the efforts of a new commercialized research that could be application in the future inside different sectors especially in automotive sector and aerospace.

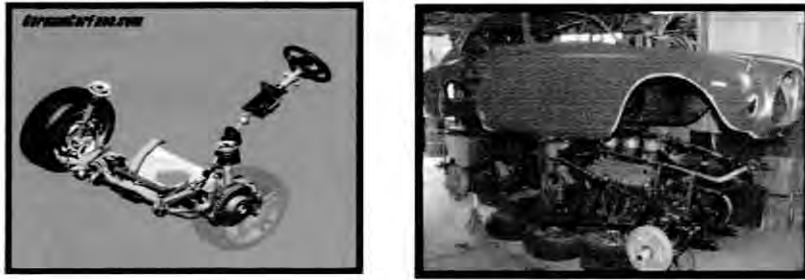


Figure 1.1 : Example of application of the combination of different metals in the vehicle component sector (German Car Fans Com., 2003).

1.2 Importance and Benefits of Research

Some of the most important prospect that is expected to make this research project valuable and can being positive impact is to determine whether stainless steel could be merge with cast iron or not. Eventhought it is know before that only merges from same kind of metal is done, but if the connection between both the different types of metal successfully combined, than a new contribution in newing methods of producing a automobile, airplanes and space shuttle will exist in industrial engineering and even commercialized. Not only that, it will open more diversities in the exploration of the combination of other types of stronger metals.

This research is also important in contributing to the proving of the chemical composition is not 100% same and the melting point that differs made the failure of welding between two types of metal joining be otherwise (Jeefferie Bin Abd Razak, 2004).

For that reason, the research of the combination of stainless steel and cast iron by MIG robot welding will done to find the proof while nothing the specialty of the combination. From this initiative would repair the types of metal combination through

existly weld techniques. Also, other that giving cost reduction, than hope this new combination of metals would be apply in high tech in high technology industries such as automobile and aerospace.

1.3 Research Objectives

Based on research project, the potential to combine stainless steel to cast iron using MIG robot welding is researched and developed. Many literature research and reviews are done to see the matching of stainless steel and cast iron for merging through chemical compositions that is felt to be most fit for the merging. This is because it could contribute to the practical applications in the fields of industrial engineering that needs material with high expectations.

The research is to determine the ability of its merging with the right welding method, the right choosing of filler wire and to apply the right rules of welding and also testing of the metals. So, hope that the welding that would form will show good strength, high mechanic properties and also still strong physical after weld.

Main objective that is set through this research projects such as follows :

- To prove that the method that have been chosen is the best method for welding of dissimilar metal
- To study the effect of the robot welding mechanism toward welding of dissimilar metal; (stainless steel and cast iron).
- To proof that the weldability to be joint for welding of dissimilar metal (stainless steel to cast iron).

At the end of the research, with the collecting data and the observation acquired, the conclusion whether stainless steel is compliable to be merge with cast iron or not using robot welding and other filler wire as adhesive.

1.4 Research Scopes

To fulfill the objective goals, the welding of the stainless steel to cast iron will be done by using MIG robot welding. There are different types of filler wires that can be used as variables such as stainless steel and mild steel types. By setting certain parameters such as welding speed while welding, power output and voltage while welding, angle of welding, types of joint, types of gas, size and the thickness of every metal used.

The preparation of materials such as martensitic custom 450 SS and white cast iron that have length, width and thickness will be used in the weld process. The composition and microstructure of the stainless steel and cast iron needed to determine first before to weld process to make sure the types of each metal by using emission spectrometry and scanning electron microscope (SEM). The types of joining that will be done is lab joint and butt joint. While the welding process, the sample will be set on the table using the G-vice.

A few of lab test will be done to the samples that have been weld, the mechanical properties will be determined by using the tensile test, then the break off of both metals would also be analysis using scanning electron microscope (SEM). After that, to determined the hardness of the different types of filler wire after weld, the Rockwell Hardness testing is done.

BAB 2

LITERATURES REVIEW

2.1 Introduction to Cast Iron

Demand for materials with high standard are always constant from time to time. The criteria that is looked inside these materials such as lightweight, high strength, low cost and varied uses (Matthews and Rawlings *et al.*, 1994). For that reason, until now the scientists and material engineers have doubles their efforts in producing materials with criteria or better than before (Cottrell, C.L.M., 1985).

Realizing that fact, a material known as cast iron has been used for welding processes. Cast iron is actually not a really new discovery, but the fact are old materials that have be found since the bronze and metal age (Ali Bin Hamzah, 1997).

2.2 Definition and Classification of Cast Iron

Cast iron is a material that have about 91-94%metal and some other material such as carbon 1.74% to 4.5%, silicon 0.5% to 3%, manganese 0.2% to 1.3%, sulfur 0.2% maximum and phosphorus at maximum 0.8%. Cast iron have 2.5% to 4.0% carbon while other carbons about 1.2% (Anon *et al.* 1982).

2.2.1 Types of Cast Iron

2.2.1.1 Grey Cast Iron

According to Zainal Abidin Ahmad (1999), grey cast iron is made when the casting is left to cool slowly during its process. It has a high percentage of silicon and the slow cooling process makes some of the carbons to break off into graphite and sometimes called free carbons. The breaking off of the carbons from the iron caused this kind of cast iron to be so brittle. Grey cast iron usually used to make machine body. It can be identified by looking at the dark gray coloring and the structure that have pours when it breaks (Dr. O.P. Khanna, 1999).

- Grey cast iron can be weld using arc welding
- Grey cast iron will form a short flow of sparks followed by a short line coloured brick red and followed by yellow sparks if it is tempered.
- Reformingability is low.
- Have higher compressed strength exceeding steel that is form 140 MPa to 41 Mpa.
- Percentage of some of the element will change drastically but usually at a rate below :

Carbon	3.00% - 3.4%	Phosphorus	0.15% - 1.00%
Silicon	1.00% - 2.75%	Sulfur	0.02% - 0.15%
Manganese	0.40% - 1.00%		

- Balance is iron

2.2.1.2 White Cast Iron

White cast iron is also known as solid carbon iron or cold cast iron. Solid carbon iron means that the iron merge with carbon and the carbon is not free like the case in grey cast iron. The merging happens when the iron go through a quick cooling process. Cast iron is made with cold iron that make sure the surface is hard and worn resistant