SUPERVISORS'S DECLARATION

"I hereby declare that I have read this thesis and this work is sufficient in terms of concept and quality for the award of a Bachelor of Mechanical Engineering (Thermal-Fluid)"

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Date	: JUNE 2012

COMPARISON ON THE MICROSTRUCTURE AND HARDNESS OF GTA WELDING AND GMA WELDING OF DUAL PHASE STEEL

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This report was submitted in accordance with the partial requirements for honor of Bachelor of Mechanical Engineering (Thermal-Fluid)

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JUNE 2012

DECLARATION

"I declare that this report is the result of my own work except for the summary and every passage I only have a clear source and references "

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ACKNOWLEDGEMENT

In name of GOD I would like to express my first and foremost thankfulness for giving me the optimum health, courage and strength along the period of completing this project.

It gives me the greatest pleasure to express my sincere gratitude to my supervisor, Cik Nor Liana Binti Salleh of which we had an excellent working relationship, and who offered tremendous help and encouragement throughout the course of my graduate studies and completion of this project.

My sincere thank also to my friends, all technicians and staffs in Faculty of Mechanical, UTeM; thank you for the co-operations, helps, and patience.

Thanks also to Universiti Teknikal Malaysia Melaka for giving me the opportunity to complete my degree program successfully.

I would also like to take this opportunity to thank my family members who inspired and supported me throughout the completion of my project.

ABSTRACT

Welding is a process that is used in industry to join two pieces of metal by the application of heat. The main objective of this study is to compare the hardness of weldment produced by using Gas Tungsten Arc Welding (GTAW) and Gas Metal Arc Welding (GMAW). The specimen that will be used in the experiment is dual phase steel. Dual phase steel is a type of steel that offers combination high strength and ductility as a result from heat treatment that consists of hard martensitic microstructure and soft ferritic microstructure. The dual phase steel is obtained through heat treatment process by using low carbon steel or called as mild steel. This mild steel is placed in the furnace at 740 °C for 40 minutes and by using the quenching technique, dual phase steel will be produced. The specimen then will undergo welding process which will be GTAW and GMAW. Only one type of joints will be produced using these welding. It is butt joint. The strength of weldment will be tested using Rockwell hardness test and the microstructure will be analyzed under optical microscope to determine the best joint produced from these two types of welding.

ABSTRAK

Kimpalan ialah process yang digunakan dalam industri untuk menyambung dua kepingan logam dengan penggunaan haba. Objektif utama kajian ini adalah untuk membezakan kekerasan hasil kimpalan antara kimpalan arka tungsten gas (GTAW) dengan kimpalan arka logam gas (GMAW). Spesimen yang akan digunakan dalam eksperimen ialah keluli dua fasa. Keluli dua fasa ialah keluli yang mempunyai kekuatan dan kemuluran yang tinggi hasil dari proses rawatan haba yang terdiri daripada fasa martensit yang keras dan fasa ferit yang lembut. Keluli dua fasa ini diperolehi daripada proses rawatan haba oleh keluli yang mempunyai kandungan karbon yang rendah. Plat ini akan diletakkan dalam ketuhar pada suhu 740°C selama 40 minit dan dengan menggunakan teknik penyejukkan cepat melalui pemendapan dalam air, keluli dua fasa akan dihasilkan. Kemudian keluli dua fasa ini akan melalui process kimpalan yang akan menggunakan GTAW dan GMAW. Satu jenis sambungan akan dihasilkan melalui kimpalan iait sambungan hulu. Hasil kimpalan akan diuji dengan menggunakan ujian kekerasan Rockwell dan mikrostruktur akan dianalisis di bawah mikoskop optik untuk menentukan sambungan yang paling kuat daripada dua jenis kimpalan.

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CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

Welding is manufacturing process by which two pieces of materials (metals or thermoplastics) are joined together through coalescence. This is usually achieved by melting the work pieces and adding a filler material that causes coalescence and, after cooling forms a strong joint [1]. Nowadays, welding is preferred as a joining method as it is one of the most cost effective methods of joining metal components. Welding is also suitable for work piece with smaller thickness to large thickness [2]. From the pass research, it has been shown that the grain-coarsened zone (GCZ) and heat affected zone (HAZ) for welding of low carbon steels are critical since embitterment is concentrated in this area [3]. As for this study, the microstructure and hardness of Gas Tungsten Arc Welding and Gas Metal Arc Welding of dual phase steel will be investigated.

Gas Tungsten Arc Welding (GTAW) is a type of fusion welding. Fusion welding is a process in which two pieces are joined together by the application of heat, which then melts and fuses the interface [4]. GTAW joins two pieces of metal by using a tungsten electrode [4]. During the welding process, the electrode does not melted. This type of welding needs filler metals to build up the weld. A shield of inert gas is used to protect the molten metal in the weld pool, tip of filler wire and the hot electrode from atmospheric contamination [5]. Normally argon is used as the shielded gas. But for some special applications such as that involve stainless steel, a mixture of argon and helium is used as the shielded gas. GTAW is most commonly used to weld thin sections of stainless steel and non-ferrous metals such as aluminum, magnesium, and copper alloys. In addition GTAW welding is employed to weld small-diameter, thin-wall tubing such as those used in the bicycle industry [5].

Gas Metal Arc welding (GMAW) is also formally known as Metal Inert GAs (MIG) welding [6]. GMA welding uses bare consumable wire electrode which means at the end of the welding process, the wire electrode will be consumed. An electric is arc is used to melt those consumable wire electrodes as it is fed to the weld puddle. Like the GTA welding, GMA welding is also uses inert gas to prevent the weld metal from atmospheric contamination [6]. GMA welding is used to weld all important metals such as steel, aluminum, stainless steel, copper and several others. GMA welding is the most widely used of the arc welding processes, suitable for everything from small fabrications or repairs, to large structures, shipbuilding and robotic welding [6].

Dual phase steel is a type of steel that offers combination high strength and ductility as a result from heat treatment that consists of hard martensitic microstructure and soft ferritic microstructure. Dual phase steel is achieved by heating steel in furnace at 732 °C. The austenite phase will transform into martensite phase during rapid cooling. Rapid cooling is also known as quenching. The ductility arises from ferrite while martensite gives the strength characteristic [7]. The combination of both characteristics offers dual phase high strength with ductility.

In this study, the microstructural characterization and hardness in the welding zone of dual phase steel with dissimilar joint are compared by means of optical microscopy and Rockwell hardness test. Fine structures in the weld metal and heat affected zone are analyzed.

1.2 PROBLEM STATEMENT

Welding is a process that is used to join two pieces of metals permanently. Welding is used widely in various fields such as aerospace application, shipbuilding, automobile manufacturing and repairing to many other manufacturing activities [8]. Although the joints from welding are very strong and reliable, there are still many contrasts in welding process. One of the problems is porosity. It is doesn't matter what types of welding are used, porosity still is a major problem in welding. Porosity is a situation where gas pockets or void occur in a metal weld. Porosity is a result from improper shielding of gas coverage the wrong usage of shielding gas or filler material, too much heat and a base material that is not cleaned properly [9]. Due to this, the weld area is not strong enough and will break into pieces even though a small amount of force is applied. Therefore, studying the microstructure of the welded material will help us to determine the cause of weld joint failure.

1.3 OBJECTIVE

The study on microstructural characterization and hardness of GTA welding and GMA welding of dual phase steel is developed with a few objectives in this project. Those objectives are:

1. To study microstructure and hardness of a weld joint using GTA welding and GMA welding.
2. To analyze microstructure and hardness of a weld joint failure using GTA welding and GMA welding.
3. To investigate the effect of welding types on the microstructure of GTA welding and GMA welding.

1.4 SCOPE

Following statements are the scopes of the study:

1. Two types of welding will be focused in this study which is GTA welding and GMA welding.
2. Low carbon dual phase steel is used as the specimen material.
3. Welding will involve only butt joint.
4. Investigation using Rockwell Hardness Test to determine the hardness of weld joint surface.
5. Investigation using optical microscopy to analyze microstructure of the welded joint surface.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter explains about the types of welding and the microstructural of steel in detail. Gas Tungsten Arc Welding and Gas Metal Arc Welding are two types of welding will be used for the study purpose. Type of specimen used for experiment also discussed in detail which is DP steel. Types of mechanical test such as impact test, tensile test and hardness are included in this chapter.

2.2 TYPES OF STEEL

The term steel is used for many different alloys of iron. These alloys vary both in the way they are made and in the proportions of the materials added to the iron. All steels, however, contain small amounts of carbon and manganese. In other words, it can be said that steel is a crystalline alloy of iron, carbon and several other elements, which hardens above its critical temperature [10]. Alloy agents are added to improve properties such as hardness, corrosion resistance, ductility, strength, and machineability. Steel normally comes in six forms. They are angle shape, channel shape, plate form, flat-rolled, reinforcing bar and sheet form. Each one of the forms has its own application. The angle shape and channel shape are used for trusses and built-up girders.

Heat treatment of steel is done to alter the property of steel. Annealing is a process where steel is heated to austenite range range (about 10°C above the austenite line) then slowly cool to room temp. As a result, softer steel is produced with reduced internal stress and increased ductility and toughness. Normalizing is another process same like the annealing process except steel is heated to 40°C above the austenite line. Then it is air cooled. Normalizing produces a uniform, fine-grained structure. Besides that, normalizing is considered as a corrective treatment and not for strengthening.

2.2.1 Plain carbon steel

Carbon steel is the most common types of steel. The percentage of carbon in carbon steel determines its properties. Most carbon steel has a carbon content of less than 1%. Carbon steel is used widely for structural beams, car bodies, kitchen appliances, and cans. There are 3 types of plain carbon steel and they are low carbon steel, medium carbon steel, high carbon steel. Plain carbon steel is a type of steel having a maximum carbon content of 1.5% along with small percentages of silica, sulphur, phosphorus and manganese [10]. The strength and hardness of plain carbon steel increases with an increase in carbon content from 0.01 to 1.5% in the alloy. An increase beyond 1.5% causes reduction in the ductility and malleability of the steel [10].

Table 2.1 Physical properties of plain carbon steel

(Source: Material Science And Engineering, 4th Edition, V.Raghavan, p. 396)

Material	Density 10^3 kgm^{-3}	Thermal conductivity $Jm^{-1}K^{-1}s^{-1}$	Thermal expansion $10^{-6}K^{-1}$	Young's modulus GNm^{-2}	Tensile strength MNm^{-2}	% elongation
0.2% C Steel	7.86	50	11.7	210	350	30
0.4% C Steel	7.85	48	11.3	210	600	20
0.8% C Steel	7.84	46	10.8	210	800	8

2.2.2 Low carbon steel/ mild steel

Mild steel contains percentage of carbon up to 0.25%. Its properties are good formability and weldability but low in strength. Its properties can be improved by conducting heat treatment. Applications of mild steel are deep drawing parts, chain, pipe, wire, nails, and some machine parts [11].

2.2.3 Medium carbon steel

Medium carbon steels contains percentage carbon content ranging from 0.25 to 0.70%. Heat treatment is done to improve machineability. It offers good strength and toughness with ductility. Medium steel carbon generally is used where surface hardness is desirable such as automotive industry [11].

2.2.4 High carbon steel

High carbon steels, is steel-containing carbon in the range of 0.70 to 1.05%. The hardenability of high carbon steel is very poor because at maximum hardness the steel become brittle. This limits the usage of the steel. Generally, the properties of high carbon steels are hardness and wear resistance with high strength and moderate ductility. Normally high carbon steel used for rope wires, hammers, band saws and screw drivers [11].

2.2.5 Dual phase steel

DP steels are one of the important new advanced high strength steel (AHSS) products developed for the automotive. DP steel refers to the presence of essentially two phases, ferrite and martensite, in the microstructure, although small amounts of bainite, pearlite and retained austenite may also be present [12]. The simplest way to obtain a dual phase ferritic-martensitic steel is intercritical annealing of a ferritic-pearlitic microstructure in the $\alpha + \gamma$ two-phase field, followed by a sufficiently rapid cooling to enable the austenite to martensite transformation [12].

Martensite phase is much stronger than ferrite phase. Increasing the percentage of martensite phase will increase the strength. Dual phase steel is achieved by heating steel in furnace at 740 °C. The austenite phase will transform into martensite phase during rapid cooling. Rapid cooling is also known as quenching. The ductility arises from ferrite while martensite gives the strength characteristic.

DP steels has higher ultimate tensile strengths than conventional steels with similar yield strength due to work hardening rate with elongation. Another important benefit the reason for dual phase steel having high strength than conventional high strength steel is due to bake hardening effect. The bake hardening effect is the increase in yield strength resulting from elevated temperature aging. The additional effect of the bake hardening on advanced high strength steel depends on the specific chemistry and thermal histories of the steels.

In DP steels, martensite is formed by carbon increasing the hardenability of the steel at practical cooling rates. Transitional metals such as Manganese, chromium, molybdenum, vanadium, and nickel also help increase hardenability either individually or in combination. Carbon also acts as ferrite solute strengthener for martensite. Mechanical properties and good resistance spot welding ability are as results from carbon that acts as ferrite solute strengthener for martensite. However, some adjustment is required to weld highest strength grade steel (DP 700/1000).

2.3 WELDING PROCESS

Welding is manufacturing process by which two pieces of materials (metals or thermoplastics) are joined together through coalescence. This is usually achieved by melting the work pieces and adding a filler material that causes coalescence and, after cooling forms a strong joint [1]. Nowadays, welding is preferred as a joining method as it is one of the most cost effective methods of joining metal components. Welding is also suitable for work piece with smaller thickness to large thickness [2].

2.3.1 GTA welding

Gas tungsten arc welding (GTAW) is an arc welding process that uses a non-consumable tungsten electrode and an inert gas shield to protect the electrode, arc column and weld pool. A shield of inert gas is used to protect the molten metal in the weld pool, tip of filler wire and the hot electrode from atmospheric contamination. The electrode used in welding process is not consumed at the end of welding process as it is used only to create the arc. Generally the weld produced by GTAW is stronger than those produced by metallic arc welding electrodes.

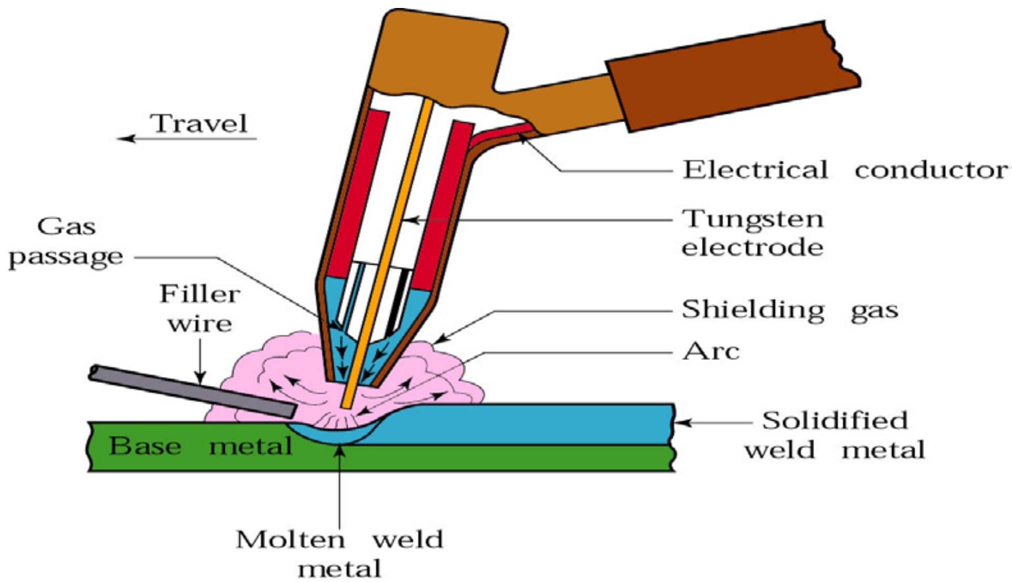

Figure 2.1 Gas Tungsten Arc Welding (GTAW)

(Source: Kalpakjian, Schmid, Manufacturing Engineering and Technology, (2001))