AN INVESTIGATION OF DEFECTS ON BUTT JOINT OF DIFFERENT WELDING TECHNIQUE USING ULTRASONIC METHOD

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SUPERVISOR 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 (Structure and Material)"

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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	:	....
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Date	:	....

To my lovely family, friends and lecturer for understanding and everlasting love supports.

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ABSTRACT

The focus of this project is to detect and localize the defect or discontinuities inside the welded joint on a dual phase steel sample specimen by using a Non Destructive Method (NDT) which is Ultrasonic Testing (UT). In this project, 4 pieces of heat treated steel plate is joined together by butt joint on shielded metal arc welding process(SMAW) and combined tungsten inert gas welding technique(TIG-C) into two specimen. Both specimens is marked as plate C1 and C2 respectively. The welding process is done by experienced welder in order to get a good weldment piece. The inspection of the weldment using ultrasonic testing take place after all the welding process is finished. The UT process start with the probe calibration where the probe is calibrated with V1 and V2 calibration block before goes to the plate inspection. There are three types of angle probe which are 45˚, 60˚, 70˚, but for this project the 70˚ of angle probe is used to identify and locate the defect inside the welded area on plate specimen. The result obtained from the ultrasonic testing is then compared with the radiographic testing technique to check the reliability of the ultrasonic testing on the plate. Finally, in the result and discussion chapter discuss about the result gathered for both ultrasonic testing and radiographic testing.

ABSTRAK

Fokus projek ini adalah untuk mengesan kedudukan kecacatan atau ketaksinambungan di dalam sendi yang dikimpal atas sampel spesimen besi dua fasa dengan menggunakan kaedah ujian tanpa musnah (NDT) iaitu Ujian Ultrasonik (UT). Dalam projek ini, 4 keping plat besi yang telah dirawat di sambung di penghujung plat dengan menggunakn kaedah proses kimpalan arka (SMAW) dan gabungan kimpalan gas lengai tungsten (TIG-C) menjadi 2 spesimen. Kedua-dua spesimen ditandakan sebagai plat C1 dan C2. Proses kimpalan dilakukan oleh pengimpal yang berpengalaman untuk mendapatkan sekeping hasil kimpal yang baik. Pemeriksaan hasil kimpal dengan menggunakan ujian ultrasonik berlaku selepas semua proses kimpalan telah selesai. Permulaan proses UT dengan penentukuran siasatan di mana siasatan ditentukur dengan blok tentukuran V1 dan V2 sebelum ke pemeriksaan plat. Terdapat tiga jenis probe sudut yang terdiri daripada 45 ˚, 60 ˚, 70 ˚, tetapi untuk projek ini 70^{o} prob sudut digunakan untuk mengenal pasti dan mengesan kecacatan di dalam kawasan yang dikimpal pada spesimen plat. Keputusan yang diperolehi daripada ujian ultrasonik kemudian dibandingkan dengan teknik ujian radiografi untuk memeriksa kebolehpercayaan ujian ultrasonik. Akhirnya, dalam bab keputusan dan perbincangan membincangkan tentang keputusan yang di kumpul untuk kedua-dua ujian ultrasonik dan ujian radiografi.

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CHAPTER 1

1.0 INTRODUCTION

Automotive manufacturer nowadays widely used of aluminum as their material to build cars. Due to its lightweight and strong characteristic, aluminum is a suitable replacement for steel in modern cars body frame, comes with expensive price. Therefore, as the alternative, steel has been upgraded to dual phase steel through heat treatment process. Its increase its strength but remains its good features such as good formability, weight, and price.

In body of a car, it involves hundreds of joint from various part of the car body panel. Each body panel is joined by different welding process. Welding process commonly used in automotive industry is combined tungsten inert gas (TIG-C) and shielded metal arc welding (SMAW). Different welding process used in different joint. Therefore, welding codes and specification has been created to guide the welders to choose the proper welding technique to be used in different joints.

Non-Destructive Testing (NDT) is a method where the component, material or sample is being checked to detect flaws, cracks, and discontinuities without damaging the component features. NDT commonly used in service situation where the component being check is at the site and has been assembled and NDT can also be used in non-service situation where the component being check before it goes to the assembly process. There are five types of NDT method which are Penetrant Testing (PT), Magnetic Particle Testing (MPT), Ultrasonic Testing (UT), Radiographic Testing (RT), and Eddy Current Testing (ED).

1.1 BACKGROUND

Car body frame consist of many part that joined together by welding process. There are spot welding process for critical joints such as main body frame, butt TIG-C and SMAW welding process for butt joint, and some more. Different type of joints required different types of welding process. However, errors occurred during the welding process which leads to some discontinuities, crack, and flaws on the welded part. This can be dangerous since the crack exist on the welded part can distribute to the fracture of the vehicle. Non-destructive method had been used to identify the cracks on different weld joint such as T-joint, butt joint and dissimilar joint.

1.2 PROBLEM STATEMENT

Dual phase steel has a great potential to be used as the outer body panel in automotive industry due to its high strength and good formability. However, discontinuities developed during the TIG-C and MIG welding process can be considered dangerous and past from the tolerate level. To identify the possible defects and the behavior of the flaws, ultrasonic testing methods will be applied in this project. In accordance to the ASTM standard practice for the ultrasonic testing, this method will be conducted and use to analyze the defect size and types of the butt welded joint.

1.3 OBJECTIVES

The objectives of this project are:

1. To produce a dual phase steel by doing a heat treatment on a low carbon steel
2. To locate the location of defect in welded specimen using ultrasonic testing.

3. To compare the result from ultrasonic testing with the X-Ray testing technique.
4. To identify the types of defect found in welded specimen.

1.4 SCOPE

The scope of this project will be focusing on the usage of ultrasonic testing technique to indicate defects or discontinuities on the butt welded joint in TIG-C and SMAW welding technique.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction of Steel.

Steel is a material that generally strong, durable, malleable containing alloying element such as manganese, chromium, nickel and carbon [1]. Steel that has carbon as the alloying element will has either brittle or strong characteristic depends on the carbon content in the steel and also known as carbon steel [1].

2.2. Type of Steel

There are three types of carbon steel which is low carbon steel, medium carbon steel, and high carbon steel.

2.2.1. High Carbon Steel

Contain an amount of carbon from 0.6 to 1.4 wt%, high carbon steel have the characteristic of less ductile, strong, and hard among the family of carbon steel [3]. Most of the high carbon steel used in machining tool, cutting tool, and some more, where it require the tool to be wear resistant and hard [3]. Normally, to strengthen the high carbon steel, it is often addition of other alloying element such as chromium, vanadium, tungsten and molybdenum.

2.2.2. Medium Carbon Steel

Medium carbon steel generally has carbon concentration between 0.25 and 0.60 wt% [4]. Different from high carbon steel, medium carbon steel has lowered mechanical properties in term of hardness, strong, brittleness, and some more. However, these mechanical properties of medium carbon steel can be optimizing by doing heat treatment process where the microstructure of the medium carbon steel were changed into martensite microstructure [4]. In order to get high in strength and hardness, medium carbon steel has to sacrifice its ductility and toughness.

Some applications of medium carbon steel is in automotive industry where it use medium carbon steel as body panel in a car. Another example of application in medium carbon steel is railway wheels, railway tracks, gears, and machines part where it require material of high strength and wear resistance.

2.2.3. Low Carbon Steel

In low carbon steel, the carbon contain were less than 0.25 wt% [3]. Low carbon steel microstructure consists of ferrite and pearlite microstructure. The existence of ferrite and pearlite in the low carbon steel gave the low carbon steel an outstanding ductility and toughness [3]. Besides, it also give the low carbon steel the ability of good machinability, weld able and low carbon steel is also less expensive than the two carbon steel. Heat treatment and quenching process of low carbon steel will change the microstructure of the low carbon steel from ferrite and pearlite to ferrite martensite microstructure [7]. The existence of martensite after quenching process, increase the low carbon steel toughness, hardness, and maintain its machinability and ductility features.

Low carbon steel is widely use in automobile body panel, pipelines, buildings and some more.

2.2.3.1. Iron-iron Carbide Phase Diagram

Figure 2.1 shows the phase diagram for iron-iron carbide. Based on the phase diagram, 727°C is the eutectoid temperature. Beyond this eutectoid temperature line, the microstructure of the iron will change into alpha ferrite and austenite microstructure. The X-axis for the phase diagram represents the percentage of carbon content in the steel. While the Y-axis represents the temperature in degree Celsius (°C) and Fahrenheit (°F). Since in this project we used low carbon steel, therefore the region that covered by the low carbon when doing a heat treatment is only in the Region A.

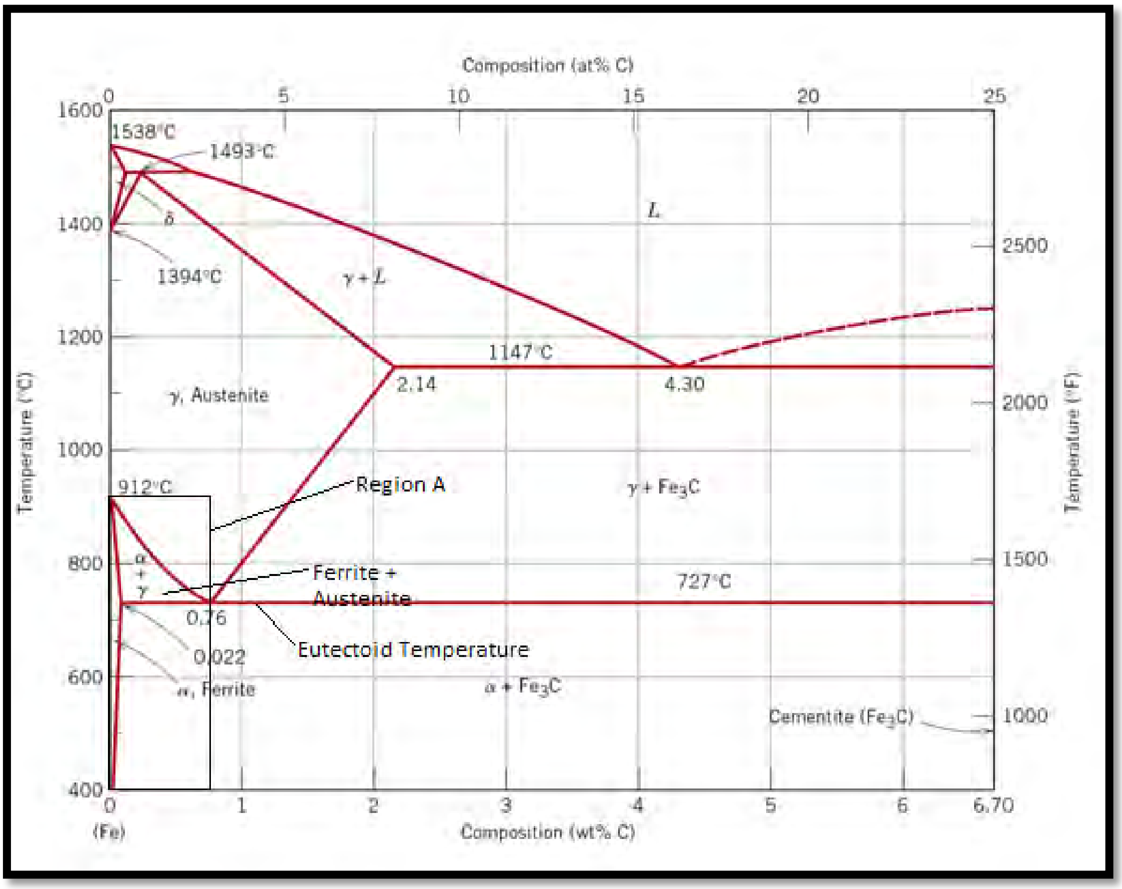

Figure 2.1: The iron-iron carbide phase diagram.

[Source: Binary Alloy Phase Diagrams, 2nd edition, Vol. 1, T. B. Massalaki, 1990]

2.2.3.2. Ferrite (α-iron)

Alpha ferrite (α iron**)** is the stable form of iron in a room temperature. Alpha ferrite has the body centered cubic (BCC) crystal structure where a cubic unit cell having atoms positioned at all eight corners and a single atom at the cube center. With the 0.68 packing density, body centered cubic crystal (BCC) structure has a little dislocation movement among the atoms since it has small gap between the atoms. **Figure 2.2** shows the microstructure of alpha ferrite under the microscope with the magnifying of 90 times zoom.

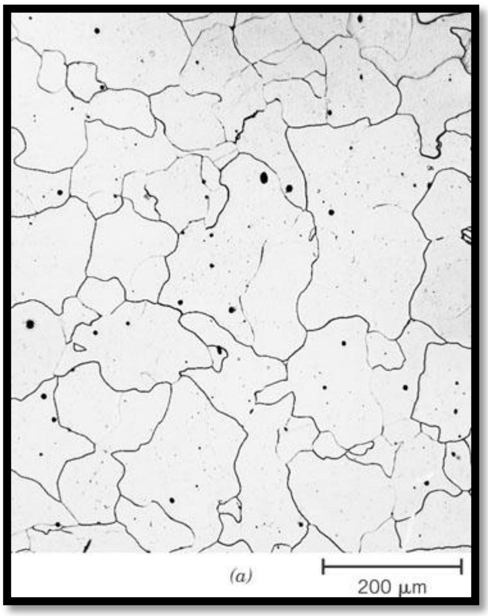

Figure 2.2: Alpha Ferrite Microstructure.

[Source: "Fundamentals of Materials Science and Engineering" (2008)]

2.2.3.3. Austenite (γ-iron)

Gamma phase iron is the other terms for austenite where it is a transformation of the alpha ferrite iron which exists above the critical eutectoid temperature in the iron-carbide phase diagram (**Figure 2.1**). Based on the **Figure 2.3**, austenite is a face centered cubic (FCC) crystal structure having a 0.74 packing density allows the atoms to have slip movement among the other atoms since the face centered cubic crystal structure is a close packed lattice structure.

Materials that in this austenite region structure tend to have harder mechanical properties than alpha ferrite. Most of application of austenite iron was used in making of stainless steel to be used in food-service and hospital equipment.

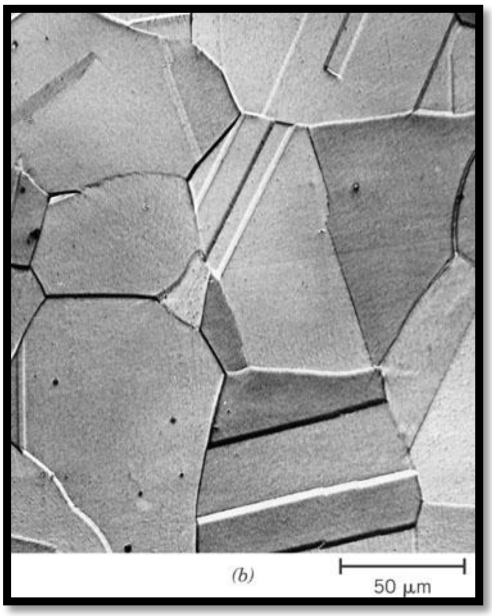

Figure 2.3: Austenite Microstructure

[Source: “Fundamentals of Materials Science and Engineering” (2008)]

2.2.3.4. Cementite

Cementite sometimes called as iron carbide is a combination of iron and carbon in the microstructure of a material. Having Fe_3C as its chemical formula, cementite is a hard and brittle material [8].

2.2.3.5. Pearlite

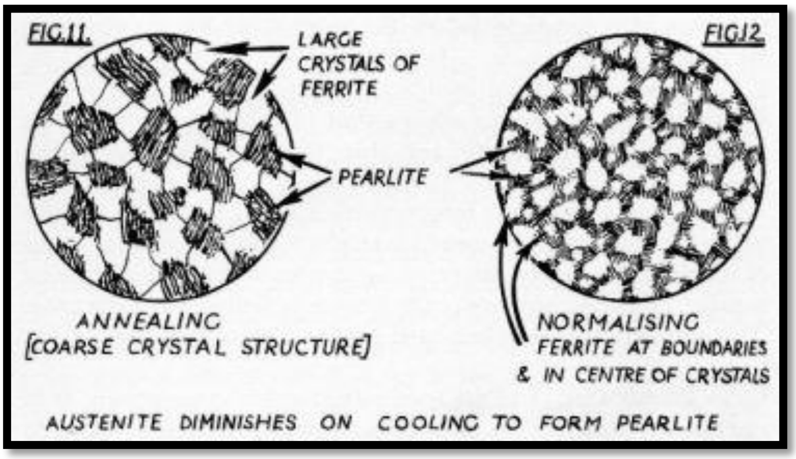

Figure 2.4: Pearlite Microstructure

[Source: http://autonopedia.org]

Pearlite is a combination of alpha ferrite and cementite microstructure that commonly occurred in many grades of steels. When a substance is slowly cooled until reach below the eutectoid line of temperature as in **Figure 2.1**, pearlite microstructure is obtained. For steel that contains higher number of carbon more than 6.7 wt%, it will transform into cementite rather than transform into pearlite microstructure [8]. As shown in **Figure 2.4**, the black labeled is the pearlite microstructure where, it is the combination of cementite and ferrite microstructure. Furthermore, the white region of the microstructure represent as ferrite microstructure.