DETERMINATION OF DEFECT AND MECHANICAL PROPERTIES FOR TUNGSTEN INERT GAS (TIG) WELDED CARBON STEEL

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DECLARATION

I declare that this report entitled *"Determination of Defect and Mechanical Properties for Tungsten Inert Gas (TIG) Welded Carbon Steel Plate"* is the result of my own research except summaries and quotations which have been acknowledged. The report has not been accepted for any other degree and is not concurrently submitted in candidature of any other degree.

Signature: .....

Name: MOHD FITRI BIN MUSTAPHA

Date: .....

Dedicated to my parents,

Mustapha b. Md. Daud & Kamariah bt Md.Din

My respectful lecturer,

and

My entire friends in UTeM

For their encouragement

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ABSTRACT

This is a research on studying the effect of current and voltage towards weldment and mechanical properties in welding of carbon steel of plate using Tungsten inert gas welding (TIG). Construction growth rapidly year by year. Welding technique for plate is the one of factor to ensure the quality of joint. In fabrication process, welded joint will be tests to ensure the quality and defect free. The familiar problem happen at plate joint is corrosion, misalignment, erosion, cracking and etc. lead to leakages or explosion Welded joints may be tested either destructively or non-destructively following the acceptance criteria and standards The focus of this project is to detect defect that occur inside the welded butt joint on a carbon steel plate using Non-Destructive Testing Method (NDT) which are Visual Inspection (VI), Magnetic Particle Inspection (MT), dye-penetrant testing (PT) and Ultrasonic Testing (UT). This project also investigate Mechanical properties consists of hardness and bending. The data of the properties can be obtained from several testing procedure which are specifically designed for it. The test that going to be conducted are bending test and hardness test. In this project specimen are develop from carbon steel plate. These specimen will be joint together on butt joint using TIG welding technique. NDT inspection will be carried out to detect all the defect. The result outcome is to come out with the appropriate welding procedure for butt joint plate using TIG welding technique for produce the enhanced quality of weldment.

ABSTRAK

Ini adalah kajian mengenai mengkaji kesan arus dan voltan ke arah hasil kimpal dan sifat mekanikal dalam kimpalan keluli karbon plat menggunakan Tungsten kimpalan gas lengai (TIG). Pertumbuhan pesat pembinaan tahun ke tahun. Kimpalan teknik untuk plat adalah salah satu faktor untuk memastikan kualiti terjamin. Dalam proses fabrikasi, sendi dikimpal akan menjadi ujian untuk memastikan kualiti dan bebas kecacatan. Masalah biasa berlaku pada plat bersama adalah kakisan, salah jajaran, hakisan, keretakan dan lain-lain menyebabkan kebocoran atau letupan dikimpal sendi boleh diuji sama ada ujian musnah atau ujina tanpan musnah mengikuti kriteria penerimaan dan standard. Fokus projek ini adalah untuk mengesan kecacatan yang berlaku di dalam sendi punggung yang dikimpal pada plat keluli karbon dengan menggunakan Kaedah Ujian Tanpa Musnah (NDT) yang Pemeriksaan Visual (VI), Pemeriksaan Zarah Magnetik (MT), ujian pewarna penusuk (PT) dan Ujian Ultrasonik (UT). Projek ini juga menyiasat sifat-sifat mekanikal terdiri daripada kekerasan dan lentur. Data sifat-sifat mekanikal ini boleh didapati dari beberapa prosedur ujian yang direka khusus untuk itu. Ujian yang akan dijalankan adalah ujian lenturan dan kekerasan ujian. Dalam projek ini adalah membangunkan spesimen daripada plat keluli karbon. Ini spesimen akan bersama bersama-sama pada sendi punggung menggunakan teknik kimpalan TIG. Pemeriksaan NDT akan dijalankan untuk mengesan semua kecacatan itu. Hasil dijangka akan datang dengan prosedur kimpalan yang sesuai untuk plat bersama menggunakan teknik kimpalan TIG untuk menghasilkan kualiti yang dipertingkatkan hasil kimpal.

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

Nowadays, steel is one of the important things in the industry. In industrial such as automotive, oil and gas, and aerospace using steel as structure and components for their parts. This industry needs a high quality parts to sustain the parts lifetime and also to avoid hazard. One of the main factor to evaluate the steel component parts is from the joint. One of famous jointing technique is by welding. Welding is one of the most important means of fabrication available to industry. Actually, many products could not even be made without the use of welding for example guided missile, nuclear plants, jet aircraft, transportation vehicle and literally thousands of others (Arcelor Mittal, 2012). Many problems that inherent to welding can be avoided by proper consideration of the particular characteristics and requirement of the process. There are many type of welding technique used at automotive and aerospace industry such as Shielded Metal Arc Welding (SMAW), Metal Inert Gas (MIG), and Tungsten Inert Gas (TIG). Many development and construction has been done for this industry. Keeping a good quality for aerospace and automotive parts throughout the years is not that simple. If have any failure, pollution and accident will be happen. For this reason, the parts must have a good quality and robust.

Generally the quality of a parts depending on the many factor such as welding technique, geometric shape, design and nature of the applied stress. Welding is most important process in components fabrication (Arcelor Mittal, 2012). Welding is process join together (metal parts) by heating the surfaces to the point of melting

with a blowpipe, electric arc, or other means, and uniting them by pressing, hammering, etc. pipe will be connected using welding technique. Welding have various technique such as shielded metal arc welding (SMAW), gas metal arc welding (GMAW), Tungsten Inert Gas (TIG), and many more. TIG welding technique can produce the best quality of weld such as good weld bead appearance and good weld bond. By the way, every technique have their own advantages and benefit.

In fabrication process, welded joint will be tests to ensure the quality and defect free. Welded joints may be tested either destructively or non-destructively following the acceptance criteria and standards. The acceptance criteria and standards are available from many organization such as the American Society for Testing and Material (ASTM), the American Society of Mechanical Engineering (ASME), American Petroleum Institute (API) and many more. Testing technique can be categorized into destructive test (DT) and non-destructive test (NDT). Destructive test (DT) includes methods where your material is broken down in order to determine mechanical properties, such as strength, toughness, tensile and hardness. Non-destructive test is also used as part of in-service inspections or preventive maintenance to quantify the status of critical components and equipment without causing any damage. NDT have various technique such as Visual inspection (VI), Magnetic particle Inspection (MPI), Radiography Testing (RT), Dye-Penetrant Testing (PT), and Ultrasonic Testing (UT), Eddy Current Testing (ET). Every NDT technique have their own advantages, specialty and limitation. Benefits of using NDT is can prevents failure or break down of critical equipment. It also save money and time.

The familiar problem happen at aerospace and automotive parts is corrosion, misalignment, erosion, cracking and etc. lead to crack or explosion. The problem can cause pollution and accident. For the safety reason. To control this factor, preventive and monitoring action is compulsory. To ensure the safety of the parts, NDT can be used to apply the monitoring and to detect the early sign before the accident happen.

1.1 BACKGROUND

In this research, the specimen will be using is low carbon steel plate. Chemical composition for this specimen according ASTM A106 contained carbon max 0.25%, manganese 0.27% to 0.93%, phosphorus max 0.035%, sulfur max 0.035%, silicon min 0.1%, chromium max 0.40%, and nickel max 0.40%. The tensile requirements for this specimen also according ASTM A106 is 48000 psi for tensile strength and 30000 psi for yield strength. Welding method used for this study is Tungsten Inert Gas (TIG). This method most high quality welding method in industry because it can produce high quality joint, low-distortion welds, give precise control of weld heats. The **Tungsten Inert Gas (TIG)** process is applicable when the highest weld quality is required. It can be used to weld almost all types of metals. The operator has excellent control of heat input, and vision is not limited by fumes or smoke from the process. The power source for this machine provides constant current and may be either direct current (DC) or alternating current (AC) and measured in voltage and current. TIG uses a non-consumable electrode and a separate filler metal with an inert shielding gas. (D. Yapp,2004) TIG process welding set utilizes suitable power sources, a cylinder of argon gas, welding torch having connection of cable for current supply, tubing for shielding gas supply and tubing water for cooling torch (D. Yapp,2004). Welding joint is also important part in fabrication, the welding joint used for this project is butt joint. Butt joint are chosen because the durability, simplicity and uniformity factor. Each weldment have possibility defect will occur. Taking into consideration environmental factors of pipeline, possible defect will occur such as porosity, misalignment, lack of fusion, cold cracking, and lack of penetration and others. Defect can lead to decreased quality of weldment, thus resulting in a weak joint strength.

The most efficient detecting the defect and strength on the pipe is combination of suitable non-destructive testing (NDT) method and mechanical testing. For this study, the suitable NDT method is Visual Inspection (VI), Magnetic Particle Testing (MT), Ultrasonic Testing (UT) and Dye-Penetrant Testing (PT).

Each NDT methods have their own capability and limitation. Normally VI is the first step in the examination process. VI is the process of evaluating of system and component by using human sensory and aided only by mechanical enhancement such as magnifiers, dental picks and etc. For VI methods can detect only on surface defect but this method save time and cost. It's different for MT method, this method can detect surface and sub-surface defect in ferromagnetic material. Ferromagnetic material are material that can be magnetized. MT uses magnetic fields and small magnetic particles to detect flaws in components. Dye-penetrant testing (PT) is method can detect the surface flaws. The basic principle of this method is ability of a liquid to be drawn into a surface breaking flaw by capillary action. After a period of time called 'dwell', excess surface penetrant is removed and developer applied. The developer will absorb back the dye from the flaw to reveal its presence. Lastly for NDT method is ultrasonic testing (UT). UT uses high frequency sound energy to conduct testing. The equipment of the UT will produce high frequency ultrasonic energy and will propagates through the material in the form of wave. If any discontinuity in the wave path, the wave will be reflected back to the receiver and from the signal information about the flaw will displayed on a screen.

Mechanical testing will be used for investigate material mechanical properties such as strength, hardness, toughness, durability and etc. Normally the testing will be conduct at laboratory. The test performed for this research is bending test, impact test and hardness test.

1.2 PROBLEM STATEMENT

Nowadays, many application of welding made of carbon steel such as bridge structure, automotive parts, aerospace parts, pipelines and many more. All stated above need to be robust and of good quality. Weldment on these joint of parts or pipes are likely to failure during its life time

Various types of defect on welds are typically unique to the specific welding procedure. Some of the defects that were left undetected can fail lead to failure during in-service application due to fatigue, stress corrosion cracking or other mechanisms that way lead to failure.(Prof. DR. Muna Khethier Abba), n.d] Generally the quality welded of pipeline is depending on many factor such as welding parameters, welding current, welding speed and gases. In order to produce

high quality pipeline,(B.S Paveen Kumar,2012)all the factor have to be put into consideration and inspection after the welding must be thoroughly made to avoid sudden unexpected failure to the weld structure.

This project in going to develop standard of procedure for the examination of defect in pipe based on investigate using nondestructive test method dye-penetrant testing (PT), magnetic particle testing (MT), visual inspection (VI), and ultrasonic testing (UT). This project also investigate mechanical properties of material and joint using mechanical testing bending test, and hardness test.

1.3 OBJECTIVE

1. To perform the butt joint welding on pipe using TIG with different current and voltage
2. To inspect the defect on V butt joint pipe using NDT method (VI, PT, MPI, and UT) and prepare the standard of procedure.
3. To study mechanical properties using bend test, and hardness test

1.4 SCOPE

1. Produce the plate specimen by using tungsten inert gas (TIG)
2. Perform butt joint welding technique on carbon steel plate with different parameter which is voltage and current.
3. Using Nondestructive test (NDT) inspection which is visual inspection, ultrasonic inspection, magnetic particle inspection, and liquid penetrant testing.
4. Investigate and analyze the mechanical testing on the sample using bend test and hardness test.

CHAPTER 2

LITERATURE REVIEW

2.1 WELDING

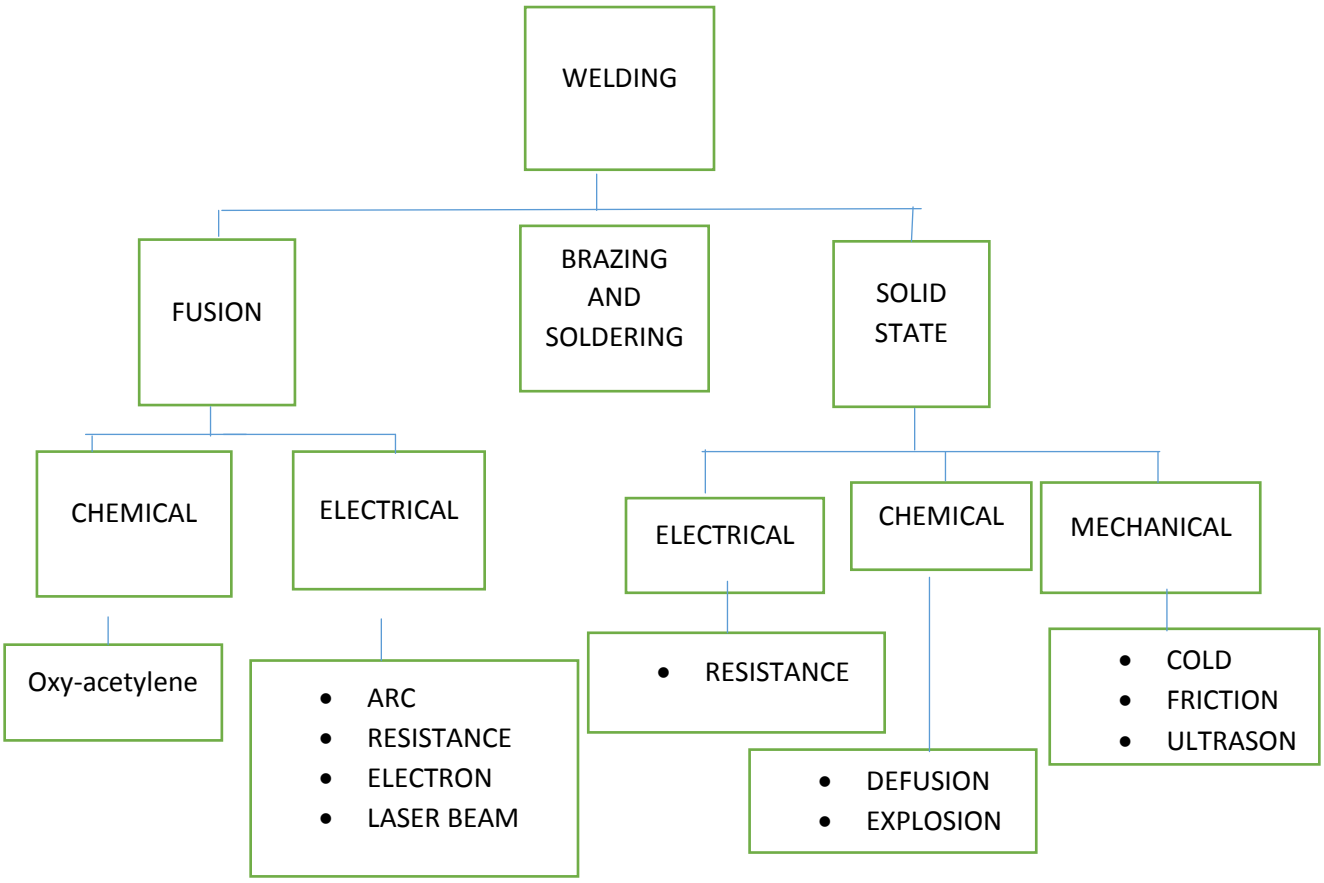


Figure 2.1: welding category chart

Welding is a joining process that produces a joining process that produces a coalescence of metals (or non-coalescence of metals (or non-metals) by heating them to the metals) by heating them to the welding temperature, with or without the application of pressure, or by pressure alone, and with or without the use of filler metals.

It's classified to three category namely fusion, brazing and soldering and solid state. Fusion welding can be defines as the melting together and coalescing of materials by means of heat, usually supplied by chemicals or electrical means; filler metals may or may not be used. Soldering and Brazing do not involve melting the work piece but rather a lower-melting-point material is melted between the work pieces to bond them together.

2.1.1 Tungsten Inert Gas (TIG)

In this project, the focus on this type of welding. TIG is the highest quality, low defect absence and low heat effected zone. In this process, heat will generated by an electric arc between base metal and non-consumable tungsten electrode. When the electrode touching the base metal, electrode movement is manually controlled TIG welding can use both AC (alternating current) and DC (direct current), the constant current DC power source is usually used with all types of electrode (thoriated and zirconiated) irrespective of base metal (ferrous and non-ferrous) and DC produces smoother welding output than AC. (Peter W Muncaster, 1991).“The maximum current a given diameter of electrode can carry is determined by the onset of overheating and melting.

The arc welding area covered with inert gas to reducing the shielding gas, to protect the weld pool and consumable tungsten electrode. The welding process also can be operated without filler to joining plates. There are many types inert gas used for TIG welding technique such as argon, helium, krypton, xenon, radon and neon. Normally argon gas used for this welding technique. The main purpose of inert gas is to protect and prevent from any contamination of welding area or weld pool (W. Lucas ,1990)

TIG welding equipment

TIG process welding set utilizes suitable power sources, a cylinder of argon gas, welding torch having connections of cable for current supply, tubing for shielding gas supply and tubing water for cooling the torch. The shape of the torch is characteristic, having a cap at the back end to protect the rather long tungsten electrode against accidental breakage.

Application

The TIG welding technique is suitable for welding joints for wide range 8mm to 10mm thickness. The common used in industry for TIG welding technique is for sheet material and butt joint on piping. Beside the application, TIG also suitable for alloy, stainless steel fabrication and many more (W. Lucas, 1990)

2.1.2 The Weld joint, Material, Quality and Testing

In welding, as the heat source interacts with the material, the severity of thermal excursions experienced by the material varies from region to region, resulting in three distinct regions in the weldment. The important parts of the weldment can be identified at three zones base metal, heat-affected zone (HAZ) and weld metal.

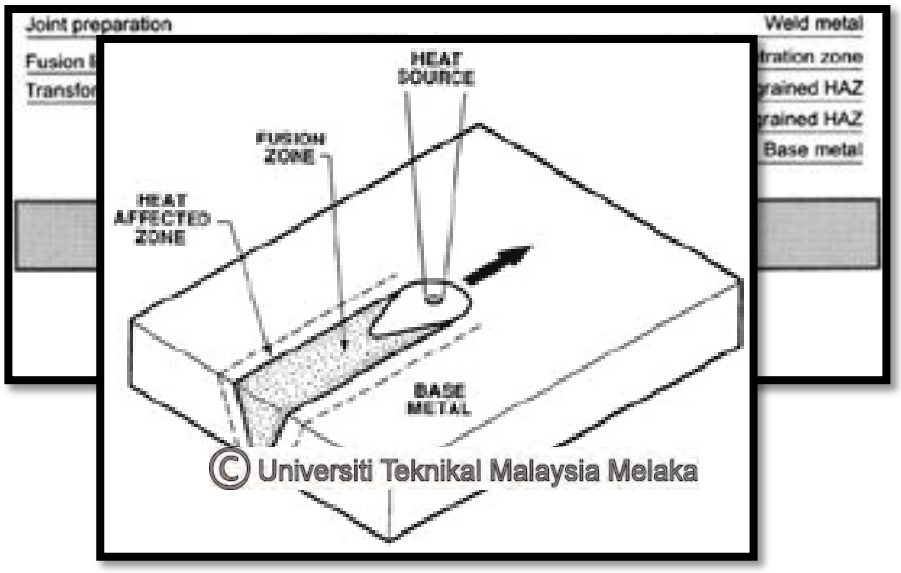


Figure2.2: Weldment zone
(http://www.tms.org/pubs/journals)

The zone at the center of the weldment called fusion zone, the microstructure in the fusion zone depend on solidification of weld pool. The fusion zone is composed of a mixture of the base and the filler metal. Base metal zone is zone without mixture of filler metal.

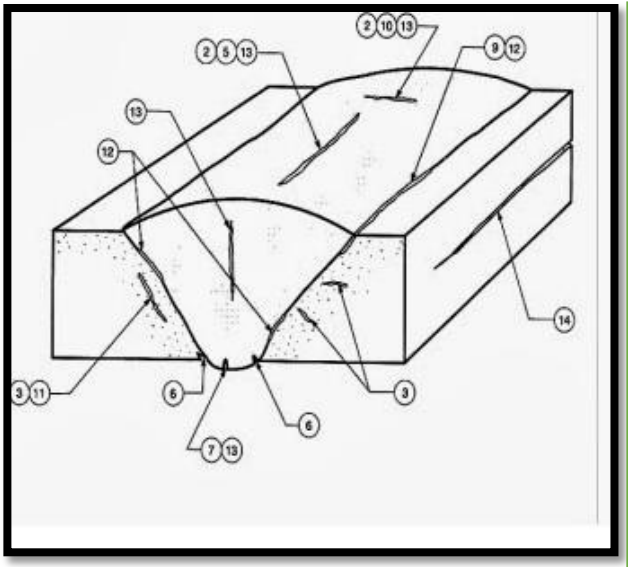
2.1.3 Heat-affected Zone (HAZ)

Heat-affected zone are define as the area of base metal which is has had its microstructure and properties altered by welding. The heat from the welding process and subsequent re-cooling causes this change in the area surrounding the weld (Dr. Paul Scott, n.d).

The properties and microstructure of the HAZ depend on the rate heat input and cooling rate. It also depending on temperature to which this zone was raised. In addition to metallurgical factors (such as the original grain size, grain orientation, and degree of prior cold work), physical properties influence the size and characteristic of the HAZ. The weld HAZ contains potentially crack susceptible metallurgical structure, hardness variation and residual stresses.

2.1.4 Welding defect

Defect or discontinuity is a flow or flaws that by nature or accumulated effect render a part or product unable to meet minimum applicable, acceptance standards or specification. Welding defect can affect the quality of the weld. Defect can be reduce by using a right technique and do the proper weld preparation such as use proper welding amperages and voltages, clean the joint fusion faces, pre-heat weld or re-dry the base metal and electrode. Early detection is important to ensure the quality of the welding and to avoid the crack become worse.



1. Crater crack
2. Face crack
3. HAZ crack
4. Lamellar tear
5. Longitudinal crack
6. Root crack
7. Root surface crack
8. Throat crack
9. Toe crack
10. Transverse crack
11. Under bead crack
12. Weld interface crack
13. Weld metal crack
14. lamination

Figure2.3: welding defect
(http://wiki.iploca.com/download/attachments)

2.1.5 Steel

Steel is a material that generally strong, durable, malleable containing alloying element such as manganese, chromium, nickel and carbon. When carbon is the primary alloying element, its content in the steel is between 0.45 to 0.75 percent carbon, these