REPAIR WELDING ON STAINLESS STEEL TO CARBON STEEL ORBITAL PIPE JOINT

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This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering

by

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DECLARATION

I hereby, declared this report entitled "Repair Welding on Stainless Steel to Carbon Steel Orbital Pipe Joint" is the result of my own research except as cited in references.

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Date	: 3 July 2018

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee are as follow:

……………………..................................

(Prof Madya Dr Nur Izan Syahriah Binti Hussien)

……………………….................

(Encik Mohammad Nizam Bin Ayof)

ABSTRACT

The purpose of this research is to investigate the effect of repair welding process on stainless steel to carbon steel orbital pipes joint generally, repair welding is applied to meet the requirement of conversion in mechanical properties and variance in working conditions. In this study stainless steel grade AISI 304L and carbon steel grade BS1387 are used as a research materials due to their difference in properties and applications. Repair welding is performed in order to extend the service life of the steel made structure when there is a failure happen caused by service deterioration during fabrication stage. However the repetitive heat input on the same weldment during the repair welding process will cause the change in the structure and mechanical properties of the materials. In this study the weld is repaired by using Gas Metal Arc Welding (GMAW) and the welding parameters were welding current, voltage and speed. This research will investigate the effect of welding performance on tensile strength and the height of the weld bead were analyzed by using DOE Taguchi Method. The results of the testing showed that the height of weld bead increases with the increasing of current and speed but decreasing with the increasing of voltage. The tensile strength of the welded material decreases as the increasing of welding current, voltage and speed. So, it can be concluded that the welding parameters give important impact towards mechanical properties of stainless steel to carbon steel orbital pipe joints.

ABSTRAK

Tujuan kajian ini adalah untuk mengkaji kesan kimpalan pembaikan terhadap keluli tahan karat keatas keluli karbon. Secara umumnya, kimpalan pembaikan digunakan untuk memenuhi keperluan penukaran dalam sifat mekanik dan varians dalam keadaan kerja. Dalam kajian ini gred keluli tahan karat AISI 304L dan gred keluli karbon BS1387 digunakan sebagai bahan kajian kerana perbezaan sifat dan aplikasinya. Kimpalan pembaikan dilakukan untuk memanjangkan hayat perkhidmatan struktur keluli apabila terdapat kegagalan berlaku disebabkan oleh kemerosotan perkhidmatan semasa tahap fabrikasi. Walau bagaimanapun input haba berulang pada kimpalan yang sama semasa proses kimpalan pembaikan akan menyebabkan perubahan dalam struktur dan sifat mekanik bahan. Dalam kajian ini kimpalan akan dibaiki dengan menggunakan Gas Metal Arc Welding (GMAW) dan parameter kimpalan akan menjadi kimpalan semasa, voltan dan kelajuan. Dalam kajian ini, kesan prestasi kimpalan pada kekuatan tegangan dan ketinggian manik kimpal akan dianalisis menggunakan kaedah DOE Taguchi. Keputusan ujian menunjukkan bahawa ketinggian manik kimpal bertambah dengan peningkatan arus dan kelajuan tetapi berkurang dengan peningkatan voltan. Kekuatan tegangan bahan yang dikimpal berkurang apabila meningkatnya arus kimpalan, voltan dan kelajuan. Kesimpulanya, parameter kimpalan memberikan kesan yang penting terhadap sifat mekanik keluli tahan karat untuk sendi paip orbital keluli karbon.

DEDICATION

To all those who have supported, encouraged, challenged, and inspired us. Especially dedicated to my beloved parents, family, honorable lectures and friends for all their guidance, love and attention has made it possible for me to make it up to this point and as well as my dear supervisor who always showed the best possible route by their unmatchable style and by best possible techniques.

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CHAPTER 1

INTRODUCTION

1.1 Background

Welding is a process of joining similar or dissimilar materials at their contacting surface by means of heat or pressure or both and with or without added metal. There are various types of welding process than have been introduced in the industry including Metal Arc, Tungsten Arc, Resistance and etc. Among of these processes Inert Gas Welding is the most popular welding process due to its ability to produce clearer and longer continuous welds (N. Arunkumar, 2012). Inert Gas Welding can be divided by two major processes which are Metal Inert Gas (MIG) and Tungsten Inert Gas (TIG). MIG has become the most influential arc welding process because it can produce higher productivity and good quality of weldments (Ibrahim, Mohamat, Amir, & Ghalib, 2012).

Most of welding process is important role in petroleum and manufacturing industries. This process has been applied extensively in piping system for transporting of gas and liquid from one place to another. This pipeline system need to work in critical conditions such as in high temperature or pressure and harsh working environment which is the leakage must be avoided (Zeinoddini, Arnavaz, Zandi, & Vaghasloo, 2013). Besides, dissimilar metal welding also need to be performed in these industry in order to satisfy the needs in transition of mechanical properties and variation of service environment (Hussein, Ayof, & Kean, 2015) . This is because different properties of joined metals plays an important role on the strength of joint. Besides, it is necessary to form dissimilar joint of metals in some application to fulfill the requirement of the system (Chaudhari, Ingle, & Kalita, 2015).

Generally, after a long time operation the weldments will experience some defects due to the critical working conditions of this structure which is in extremely high temperature and pressure.in addition to that, this will increase the possibility of the weldments to experience cracking, corrosion, ruptures and pitting that will lead to the components failure. So, repair welding is often carried out in order to prolong the service life of these steel-made structural component. Besides, repetitive welding also can extend the performance of the component as well as saving the cost and minimizing the breakdown time. Repair welding is more economical process compared to replacing the deteriorate part because it may cause some loss to a company(Hussein et al., 2015).

1.2 Problem Statement

Pipeline system plays a vital role in transporting liquid or gaseous from one place to another. This system is important especially in manufacturing plants and offshore industries since they need to transport liquid and gaseous in a long distance (Zeinoddini et al., 2013).Nowadays, almost all steel pipeline system is joined by full penetration welding. This welding will develop a number of cracks if it is exposed with critical condition and harsh working environment for a certain time. The cracked area will cause defects that can lead to leakage which can be dangerous to human and environment (Zeinoddini et al., 2013).

Welding of dissimilar material between stainless steel to other materials commonly used in fossil fuel and nuclear power plant (Chaudhari et al., 2015). This type of welding has been performed in order to provide the requirement of conversion in mechanical properties or difference in service environment (Hussein et al., 2015). Although the dissimilar joining will enhance properties of the materials it also has caused some defect to the welded area that can harm human and environment. The research of failure of dissimilar joint in piping system between carbon steel pipe and stainless steel grade 304 by Ul-Hamid, Tawancy and Abbas (2005) shows that there are some cracks appeared on the surface of weld joints after a relatively short period of usage resulting in leakage of gaseous.

Therefore, in this study repair welding was introduced to the welded area of stainless steel to carbon steel orbital pipe joints in order prolong their service life. Repair welding will enable the part to be return to its normal lifecycle when there is a weld failure due to the service deterioration or failings during fabrication stage. This process is more economical compared to replacing a new piping system that will increase the production cost of the company. This cost includes the delay time of waiting the replaced part that may cause loss to the company (Hussein et al., 2015). So, repair welding plays a significant role in extending the component service cycle, saving the production cost and minimizing the break that can lead the increasing of production performance.

1.3 Objectives

The aim of this study is to understand welding parameter and properties of stainless steel to carbon steel pipe joints after repetitive welds. Therefore, the objectives of this study are:

i The study the process of repair welding on stainless steel to carbon steel orbital pipe joints.

ii To investigate the effect of repetitive welding parameters on the mechanical properties of stainless steel to carbon steel weldment.

iii To propose the optimum welding parameters for repair welding process.

1.4 Scopes of the Research

This project will cover the scopes as follows:

a. Materials:

   This research used stainless steel grade AISI 304L with dimension of 60mm and carbon steel BS 1387 with dimension of 57mm as a research materials. Both materials will be cut in the length of 100mm

b. Welding Process.

   The welding process that will be applied is GMAW by using Trans Synergic 400 C MIG Welding Machine.

c. Welding Design.

   The type of welding that will be performed is an orbital welding by using a specific jig.

d. Welding Parameters.

   The welding parameters are welding current, welding voltage and welding speed

e. Welding Response.

   This study will investigate the effect of repair welding on weldment size and height, and tensile strength.

1.5 Significance of Study

The significant of this research are as follows:

(a) Welding process between stainless steel and carbon steel need to achieve full penetration in order to avoid welding defects. This study is developed to extend the service life of the component and minimize the production cost of the company.

(c) Generate technical information and deep understanding for the student on the role of repair welding on the performance of the orbital pipes joint.

(d) Enable student to gain new knowledge behind the experimental research by applying fundamental of welding process and bringing the engineering knowledge to higher level especially in repair welding technology. Student will able to develop a new idea to increase the number of repair welding process in order to prolong the service cycle of the pipes.

1.6 Project Planning

Project planning is important in this study in order to make a plan so that the objectives of this study can be achieved within the prescribed time. A wise planning will ensure the consistency of the project. Gantt chart is the most suitable method that can be used to illustrate the progress of project implementation. Appendix A and B shows a Gantt chart for PSM 1 and 2 that need to be followed in order to achieve the aim of the study

CHAPTER 2

LITERATURE REVIEW

This chapter views the theory and research which have been defined and conducted by various researchers years ago. Related information of previous studies were extracted as references and reviewed based on the research in regards to the effect of welding performance in repair welding of dissimilar materials.

2.1 Stainless Steel

2.1.1 Properties of Stainless Steel

Stainless steel are alloys that is composed from iron with low composition of carbon, 10.5% of chromium and 30% of nickel. To increase corrosion resistance for manufacturing supplies, the volume of chromium may be increased and some elements will be added such as manganese, aluminum, titanium and molybdenum. The excess chromium in the stainless steel properties will form a tenacious, refractory oxide protective film on any exposed layer that act as a corrosion barrier. This film will broke and repair itself naturally when exposing to an oxidizing agent such as air or nitric acid. Stainless steel also known as corrosion-resisting steel due to its properties which is less staining and high resistance to corrosive attack (Holliday, 2005)

2.1.2 Type of Stainless Steel

There are four basic type of stainless steel which are duplex, austenitic, ferritic and martensitic. This group is characterized based on their metallurgical structure that forms when they are cooled from elevated temperature (AK Steel, 2007). This research will only focused on Austenitic Stainless Steel (ASS) since it is widely used in pipeline system. Austenitic Stainless Steel (ASS) consist of 18% of chromium and 8% of nickel. There are various grade of austenitic stainless steel which are 301, 304, 304L, 316, 316L, 321 and 310. Austenitic type of stainless steel are commonly used in the industry which is more than 70% and grade 304 is the most frequent. The characteristic of Austenitic Stainless Steel are it can be reinforced by cold working up until 4 times, easily welded and has high ductility. Besides, ASS also has greater corrosion resistance and can operate in high and con temperature (AK Steel, 2007). Table 2.1 shows the commonly used ASS in manufacturing industry.

Table 2.1: Commonly Used Austenitic Stainless Steel (AK Steel, 2007).

Grade	Application	Properties
304	Suitable for architecture, food processing, handling and serving equipment, domestic sinks and laundry toughs, general deep drawing application, barrels, heat exchangers and refrigerator parts.	This grade is resistance to corrosion like its general purpose. It can give and excellent quality of deep drawing and cold forming in annealed condition. This grade of stainless steel also can be polished to a high finish. It can be readily weldable to use in moderate corrosion resistant applications. 304 grade can be welded by using suitable techniques in thickness up to 12mm without any heat treatment unless it is needed for stress purpose.
304L	Chemical plant, food processing equipment and for use in coal and petroleum industry	This grade has corrosion resistance similar to 304 but with greater resistance to inter granular corrosion. This grade also known as extra-low carbon austenitic stainless steel. This grade has a weldability factor that greater than 304 and can be heated for appreciable of time above 500°C without needing any heat treatment. It is recommended to fabricate a materials that have a thickness more than 12mm.

310	Furnace parts and equipment, baffles, heat treatment, boxes, retorts, furnace lining, heat exchangers.	This grade contain 25:20 chromium to nickel steel which offer excellent resistance to scaling at elevated temperatures. It has superior mechanical properties in the higher temperature compared to other resisting steels. This grade can work for continuos service within temperature that range from 900/950 °C- 110 °C
316	Exterior applications to severe industrial or marine atmospheres, chemical, textile, photographic and paper making equipment, wine vats.	This type has greater resistivity to corrosion compared to typical non-molybdenum bearing austenitic stainless steel.it is suitable to use to protect a material from highly corrosive non-oxidizing acids. It is commonly used for plant and equipment in chemical manufacture. This type has a weldability in thickness up to 12mm for most application without needing heat treatment
316L	Chemical plant and food processing equipment.	This grade is a modification of 316 with low carbon but have a similar corrosion resistance. This grade is suitable for heavier sheet or plate fabrication where there is a demand of welding without requiring heat treatment. There is no effect of inter-granular corrosion when this type of stainless steel is welded in heavy section. It also can be used for polishing to a bright finish.

2.2 Carbon Steel

2.2.1 Properties of Carbon Steel

Carbon Steel is the most frequently used type of steel in various kind of industries. Generally, carbon steel will have a carbon content of less than 1% and this carbon content will affect the properties of carbon steel. There are numerous type of product that can be made from carbon steel such as structural beams, car bodies, kitchen appliances and cans. Plain carbon steel can be characterized in three types which are low carbon steel, medium carbon steel and high carbon steel. All of these types of carbon steel term have different amount of carbon content in their proportion. So, it can be confirmed that plain carbon steel is the type of steel that have maximum amount of carbon content which is 1.5% with low percentage of silica, Sulphur, phosphorus and manganese.

Low carbon steel contain the percentage of carbon content less than 0.30%. It is the most commonly used grade because it can be machined and welded nicely and has higher ductility than higher-carbon steel. Medium-carbon steels have carbon content ranging from 0.30% - 0.45%. The increase in carbon content will increase the hardness and tensile strength of steel but it will decrease the ductility causing the steel become harder to be machined. The grade of carbon steel that have carbon content from 0.45%-0.75% is known as high carbon steel. This type of steel is difficult to be weld as it need a heat treatment to produce a good weld in order to control the mechanical properties of steel after welding process. Last but not least, very high carbon steel contains a percentage of carbon up to 1.50%. Usually, very high carbon steel is used in hard steel work such as metal cutting tools and truck springs. This grade of steel need a heat treatment before, during, and after welding to maintain its mechanical properties (Capudean, 2003).