AN INVESTIGATION ON CORROSION OF DUAL PHASE STEEL WELDED PLATE IN 5% CONCENTRATION OF SODIUM CHLORIDE

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This report is submitted
in fulfillment of the requirement for the degree of
Bachelor of Mechanical Engineering (Structure and Material)

Faculty of Mechanical Engineering

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DECLARATION

I declare that this project report entitled "An Investigation on Corrosion of Dual Phase Steel Welded Plate in 5% Concentration of Sodium Chloride" is the result of my own work except as cited in the references

Signature : .....

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APPROVAL

I hereby declare that I have read this project report 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 & Materials).

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DEDICATION

To my beloved mother and father

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ABSTRACT

Protection against corrosion is a major industrial problem that has been studied with numerous inquiries. Because of that, dual phase steel has been used as an alternative to low carbon steel. Dual phase steel is high quality steel that can be developed from low carbon steel by heat treatment. Therefore, the aim of this project is to investigate the corrosion of welded dual phase steel with different percentage of martensite in 5% concentration of sodium chloride to look at the effect of microstructural changes that occurs during heat treatment and its relationship with dual phase susceptibility to corrosion. Dual phase steel was successfully developed from low carbon steel by heat treatment at 800°C and 850°C and joint by the process of shielded metal arc welding (SMAW). The specimen were exposed to NaCl for 7, 14, 21 and 28 days. The discontinuities on welded and non-welded dual phase steel and the microstructure of the specimens were inspected before and after corrosion test using Optical Microscope (OM) and Confocal Microscope (CM) while severe corrosion were inspected using scanning electron microscope (SEM) and energy dispersive x-ray spectroscopy (EDS). The results show that with longer exposure time, the corrosion rate, weight loss and hardness loss of the specimens increase. Weight loss method was used to determine the corrosion rate. Generally, welded specimens loss most of its weight whereas the non-welded specimen loss most of its hardness. The corrosion rate for welded specimens is higher than non-welded specimens.

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ABSTRAK

Perlindungan terhadap kakisan adalah masalah utama industri yang telah dikaji dengan banyak persoalan. Untuk itu, keluli dua fasa banyak digunakan sebagai alternatif keluli berkarbon rendah. Keluli dua fasa adalah keluli yang berkualiti tinggi yang terhasil daripada keluli berkarbon rendah. Tujuan projek ini dijalankan adalah menyiasat kakisan keluli dua fasa yang dikimpal dengan peratusan martensit yang berbeza dalam 5% kepekatan natrium klorida yang untuk melihat kesan perubahan mikrostruktur yang berlaku semasa rawatan haba dan hubungannya dengan kecenderungan dua fasa kepada hakisan. Keluli dwi fasa telah berjaya dibentuk daripada keluli berkarbon rendah oleh rawatan haba pada 800 ° C dan 850 ° C dan dikimpal melalui proses kimpalan arka logam berperisai (SMAW). Specimen telah didedahkan kepada natrium klorida selama 7, 14, 21, dan 28 hari. Ketidakselanjaran pada keluli dua fasa yang dikimpal dan tidak dikimpal dan mikrostruktur spesimen telah diperiksa sebelum dan selepas ujian kakisan menggunakan mikroskop optik (OM) dan Confocal Mikroskop (CM);manakala hakisan teruk telah diperiksa menggunakan pengimbas elektron mikroskop (SEM) dan tenaga serakan spektroskopi x-ray (EDS).Keputusan menunjukkan bahawa dengan masa pendedahan yang lebih lama kepada natrium klorida, kadar hakisan, kehilangan berat dan kehilangan kekerasan spesimen meningkat. Kaedah penurunan berat telah digunakan untuk menentukan kadar hakisan. Untuk penurunan berat, specimen yang dikimpal kehilangan kebanyakan beratnya sedangkan spesimen yang tidak dikimpal kehilangan kebanyakan kekerasannya. Kadar kakisan untuk spesimen yang dikimpal adalah lebih tinggi berbanding dengan spesimen yang tidak dikimpal.

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LIST OF ABBEREVATIONS

CM	Confocal Microscope
DPS	Dual Phase Steel
EDS	Electron Dispersive Spectroscopy
GMAW	Gas Metal Arc Welding
OM	Optical Microscope
SEM	Scanning Electron Microscope
SMAW	Shielded Metal Arc Welding

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LIST OF SYMBOL

NaCl	Sodium Chloride
Fe3C	Cementite

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

During the 70's energy crisis, a new kind of steels called "Dual phase steels" (DPS) was discovered. This kind of steels showed a microstructure made generally of ferrite and martensite. (Campillo, 2010). In dual phase steel, the existence of martensite plays an important role towards the corrosion resistance of dual phase steel compared to ferrite and pearlite microstructure in low carbon steel. Martensite is shaped in carbon steels by the rapid cooling (quenching) of austenite at such a high rate to the point that carbon particles do not have time to diffuse out of the crystal structure in large enough amounts to form cementite (Fe3C). Therefore, to improve their corrosion resistance characteristics, heat treatment is used to change the physical and sometimes chemical properties of a material. (Ayodele & Nenuwa, 2013). Dual phase steel is widely used for automotive applications such as body panels, bicycles, and bumpers as they combine high durability and good permeability at low production prices.

Most of these steels in application are fabricated by the technique of welding which is an efficient metal joining process that is normally practiced in the manufacture and shielded metal arc welding (SMAW) is an example of the commonly used welding methods. (Welding, 2015). However, during the welding process, due to the different amount of heat input as well as the quality of the weldments, numerous issues emerge from the process including those related to corrosion and the joint area is always considered as the weakest part in the components. (N.A.A. Razak et al, 2014).

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When a welded structure is exposed to water containing corrosion-aggressive ions such as chloride ions, corrosion gets to be extreme, even in a short period of exposure. Therefore, the sodium chloride environment has been known as a corrosive environment condition of steels. The effect of sodium chloride concentration on the corrosion of iron in air immersed water at room temperature was found to increase the corrosion rate. Chlorides increase the electrical conductivity of the water so that the stream of corrosion currents will be facilitated. (Hasan et al, 2010). Marine atmosphere is highly corrosive because of the presence of sodium chloride. Seawater contains predominantly sodium chloride, and in addition a few minerals and organic matters. It is also commonly more corrosive than freshwater, frequently producing pitting and crevice corrosion. (Ayodele & Nenuwa, 2013)

In this study, corrosion of welded dual phase steel with an adjustment percentage of martensite in different concentration of sodium chloride will be investigated to look at the effect of microstructural changes that occurs during heat treatment and its relationship with dual phase susceptibility to corrosion.

1.2 PROBLEM STATEMENT

Protection against corrosion is a major industrial problem that has been studied with numerous inquiries. For example, the parts under the body of the car and the interior surface of body panels are easily damaged from corrosive attacks caused by sodium chloride solution deposited on roads to melt snow. (Acarer, Ahlatci, & Hayat, 2013). Therefore, dual phase steel has been used as an alternative for low carbon steel to avoid corrosion. This project will investigate the corrosion of welded dual phase steel with different percentage of martensite in 5% concentration of sodium chloride to look at the effect of microstructural changes that occurs during heat treatment and its relationship with dual phase susceptibility to corrosion.

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1.3 OBJECTIVE

The objectives of this project are as follows:

1. To conduct heat treatment process to produce dual phase steel from low carbon steel.
2. To conduct the immersion corrosion test of dual phase steel in 5% concentration of sodium chloride.
3. To conduct hardness test of dual phase steel before and after the corrosion test.
4. To investigate the corrosion product on dual phase steel after the corrosion test.

1.4 SCOPE OF PROJECT

The scopes of this project are:

1. Use SMAW on butt joint to weld two pieces of specimen.
2. Use different of heating temperatures to get different of martensite percentage.
3. Check, compare and record the weight loss of the specimens before and after the corrosion test.
4. Conduct a corrosion test by immersing the specimens in 5% concentration of Sodium Chloride, NaCl for a period of time.
5. Use Optical Microscope (OM) and Confocal Microscope (CM) to study the microstructure of the specimens after the corrosion test.

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6. Use Scanning Electron Microscope (SEM) and Electron Dispersive Spectroscopy (EDS) to investigate the specimens further in terms of specific elements and its chemical composition after the corrosion test.

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CHAPTER 2

LITERATURE REVIEW

2.1 CORROSION

In engineering, metals and alloys are utilized as development and manufacture materials.(Fadare, Fadara, & others, 2013) The metal or combination debilitate gradually on the off chance that they are not appropriately maintained by the action of atmospheric gases, moisture and other chemicals. Corrosion is known as the phenomenon of metals and alloys to experience damage by the act of environment. (Metals, n.d.).

Corrosion can be well-defined as the corruption of a material because of a response with its environment. Corruption implies weakening of physical properties of the material. This can be a weakening of the material because of a loss of cross-sectional area, it can be the shattering of a metal because of hydrogen embrittlement, or it can be the cracking of a polymer because of sunlight exposure.

Corrosion comes in an extensive variety of structure and can be arranged by the reason for the compound disintegration of a metal. There are many types of corrosion, for example, atmospheric corrosion, galvanic corrosion, general corrosion and others. As indicated by (Badea, Cret, Lolea, & Setel, n.d.), one of the most frequently corrosion type takes place in existence of the humidity surface layer after the electrochemical corrosion mechanism is atmospheric corrosion. Around 80% from all corruptions produced by corrosion in the metallic structures are due to the atmospheric corrosion. The atmospheric corrosion is suitably classified into three types which are dry oxidation, damp corrosion and wet corrosion. Dry oxidation happens in the environment with all metal that have a negative free vitality of oxide development. The damp atmospheric corrosion is categorized by the

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existence of thin, invisible film of electrolyte solution on the metal surface, whereas the wet atmospheric corrosion is characterized by visible deposits of dew, rain, sea-spray and others. (Corrosion Doctors, 2000) expressed that there are four types of atmosphere that may vary with the wind pattern, particularly where corrosive pollutants are present, or with local conditions which are:

a) **Industrial**

These climates are associated with substantial modern handling offices and can contain of sulphur dioxide, chlorides, phosphates, and nitrates. **Figure 2.1** demonstrates the corrosion of nut in industrial.

Figure 2.1 Rusty metal square nuts

(Source: Bolts, 2015)

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b) Marine

Fine windswept chloride particles that get stored on surfaces portray this kind of environment. Marine environments are generally highly corrosive, and the corrosivity tends to be significantly reliant on wind direction, wind velocity, and distance from the seashore. The corrosion because of salt can be seen in **Figure 2.2**. It should to be said that a proportionally corrosive environment is created by the use of de-icing salts on the streets of numerous cold regions of the planet.

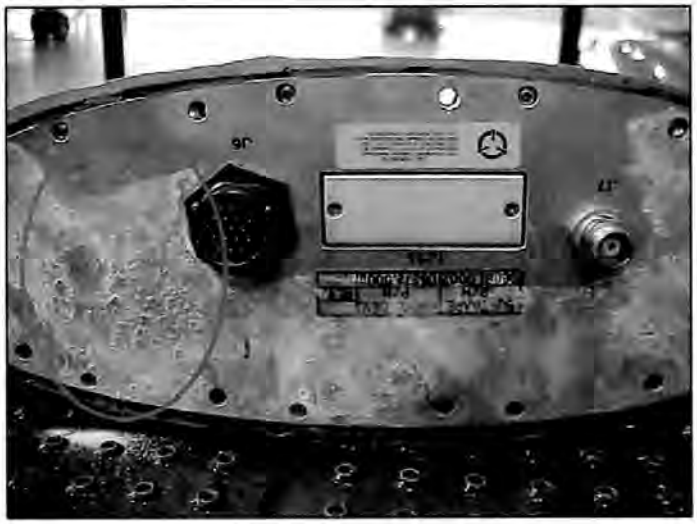

Figure 2.2 Salt causing corrosion to the antenna internal components because of a broken seal.

(Source: Corrosion-doctors.org, 2015)

c) Rural

Usually, this sort of atmosphere is the slightest corrosive and contain organic and inorganic particulates but does not have chemical pollutants. The basic corrodes are moisture, oxygen, and carbon dioxide. Dry and tropical sorts are exceptional compelling cases in the rural category.

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d) Indoor

Generally, normal indoor atmospheres are considered to be quite mild when ambient humidity and other corrosive components are under control. However, severe corrosion problem may be bring out by some combinations of conditions as can be seen in **Figure 2.3**. While there is no typical contaminant or set of conditions associated with an indoor atmosphere, any enclosed space which is not emptied or filled with a liquid can be considered an indoor atmosphere. Such an environment may contain fumes if not ventilated, which in the presence of condensation or high humidity could prove to be highly corrosive.

Figure 2.3 Electric junction box badly corroded only four years after a new residence was completed.

(Source: Corrosion-doctors.org, 2015)

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2.1.1 Corrosive Environment

Corrosive environments include the air, aqueous solutions, soils, acids, bases, inorganic solvents, molten salts and liquid metals. (Ayodele & Nenuwa, 2013). A corrosive environment can consist of a wide range of corrosive elements, yet not every corrosive pollutants are found in a single corrosive environment. It is likewise phenomenal for a corrosive environment to hold only one corrosive pollutant in its climate. (Tullmin & Roberge, 2000) give some examples of corrosive pollutant such as:

a) Hydrogen sulfide

Corrosion may occur where stale sewage generates hydrogen sulfide gas in an atmosphere containing oxygen gas and high relative humidity. At that place must be an underlying anaerobic aquatic habitat containing sulfates and an overlying aerobic aquatic habitat separated by a gas phase containing both oxygen and hydrogen sulfide at concentrations in excess of 2 ppm.

b) Ammonia

Materials of construction for ammonia are dependent on the operating temperature. Whilst mild steel may be used at ambient temperature special steels are required at low temperatures to avoid embrittlement. Debasements in liquid ammonia such as air or carbon dioxide can bring about corrosion cracking of mild steel. Ammonia is highly corrosive towards copper and zinc.

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c) Carbon dioxide

Carbon dioxide (CO2) is found in petroleum and gas fields in varying concentrations. Dry CO2, be it in the gas stage or a supercritical liquid is non corrosive to metals and alloys. Nevertheless, in the presence of water-containing produced fluids, severe erosion of the infrastructure may result due to the formation of carbonic acid.

d) Sodium chloride

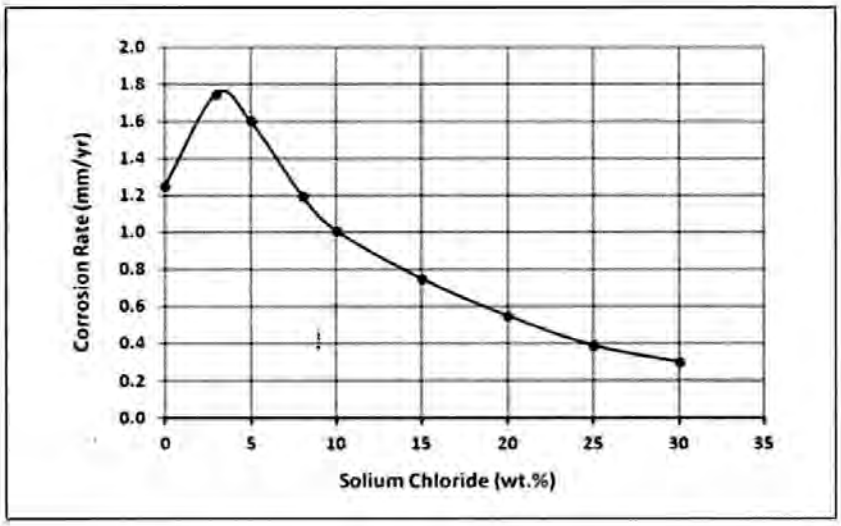

Figure 2.4 Graph of effect of sodium chloride against corrosion rate

(Source: Yari, 2015)

Marine atmosphere is highly corrosive because of the presence of sodium chloride. (Ayodele & Nenuwa, 2013). Seawater typically contains around 3.5% sodium chloride, although the salt may be broken in some areas by dilution with clean water or concentrated by solar evaporation in others. Seawater is ordinarily more corrosive than fresh water due to the higher conductivity and the soaking in force of the chloride ion through surface films on a metal. (Corrosion Doctors, 2000). The rate of corrosion is kept in line by the chloride

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