THE MECHANICAL PROPERTIES & MICROSTRUCTURAL ANALYSIS OF WELDED DPS IN COMPLIANCE TO A SELECTED INTERNATIONAL STANDARD

MUHAMMAD NAQUIB BIN NOORAZMI

This report is submitted
In fulfilment of the requirement for the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

DECLARATION

I declare that this project report entitle "The mechanical properties & microstructural analysis of welded DPS in compliance to a selected international standard" is the result of my own except as cited in the references

Signature : ....

Name : ....

Date : ....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in term of scope and quality for award of the degree of Bachelor of Mechanical Engineering (with Honours)

Signature	:	....
Supervisor’s Name	:	....
Date	:	....

SUPERVISOR'S DECLARATION

I have checked this report and the report can now be submitted to JK-PSM to be delivered back to supervisor and to the second examiner.

Signature : ....

Name of Supervisor : ....

Date : ....

DEDICATION

This report is dedicated to my beloved mother and father

Norainah binti Mat Yusoff

Noorazmi bin Yahya

ABSTRACT

This researches is to characterize the effect of annealing temperature to the mechanical properties and microstructure of Dual Phase Steel (DPS) produced through heat treatment of mild steel and also to determine the suitable Dual Phase Steel (DPS) that is in compliance to a selected international standard for welding. High ductility, affordability, weld ability and good machinability characteristics of mild steel has put mild steel into the popular choice of steel for consumers. However, due to lack of alloying elements compared to those found in stainless steel means that mild steel is more prone to corrosion. On the top of that, mild steel also being in the low hit when it comes to strength capability and it restrict the usage of mild steel in applications where load bearing and strength is essential. Even though, mild steel has found its own territory in various industries, some other application needs the material used to be harder, without reducing the formability and stronger while keeping the price affordable and competitive. Dual phase steel (DPS) has been introduced to fill in the gap left by mild steel and provide better strength steel by heat treatment process. The selected for this particular project occurs in the inter critical temperature which is 740°C, 760°C, 780°C and 800°C within the α-ferrite and γ-austenite phase region from Fe-Fe_3C phase diagram. Quenching was done right after austenitizing in order to produced martensite through diffusionless transformation. The volume fraction of martensite (%) was then analyze for each temperature. Characterization of the samples were done by Rockwell Hardness Test (ASTM A370-14) , morphological observation using light microscope and tensile testing is carried out using universal testing machine (UTM) of 500 KN capacity as

per ASTM code E8-09 after shielded metal arc welding SMAW process of mild steel and Dual Phase Steel. In the observation the higher intercritical temperature of annealing, the higher the percentage of the martensite volume fraction. For the hardness more volume fraction of martensite, more hardening occur in specimen. Eventhough hardness increase with the higher annealing temperature due to formation of martensite. However, at certain point it already reduces the weldability of Dual Phase Steel. The overall objective of this project has been achieved. Dual phase steel mechanical properties and microstructure analysis had been analyzed and studied, and also shielded metal arc welding. The hardness of the steel was determined from the experiment result.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my greatest gratitude and fully sincere to my best supervisor Mrs. Anita Akmar binti Kamarolzaman from Faculty of Mechanical Engineering of Universiti Teknikal Malaysia Melaka (UTeM) for his guidance, knowledge and essential support towards the completion of this project.

I would like to give special thanks to technician and my friend which always helped and shared their knowledge throughout completion of this project. Last but not least, thank you so much to my beloved mother, father and supportive siblings for their countless support in completing this project.

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DPS	Dual Phase Steel
SMAW	Shielded Metal Arc Welding
GMAW	Gas Metal Arc Welding
GTAW	Gas Tungsten Arc Welding
FCAW	Flux Core Arc Welding
SAW	Submerged Arc Welding
ESW	Electro Slag Welding
CCT	Continuous cooling Transformation
SEM	Scanning Electron Microscope
TEM	Transmission Electron Microscope
MCS	Medium Carbon Steel
HCS	High Carbon Steel
HSLA	High Steel Low Alloy

LIST OF SYMBOL

T	=	Temperature
°C	=	Degree Celsius
α	=	Alpha
γ	=	gamma

CHAPTER 1

INTRODUCTION

1.1 Background

Mild steel is considered a type of steel with the amount of carbon content typically around 0.05% to 0.25% by weight. Although mild steel relatively has low tensile strength compared to other steel with higher percentage of carbon, the usage of mild steel has become very competitive in various industries due to its affordable price. Sectors where vast usage of mild steel can be found includes structural applications, automotive industry and pipelines for oil and gas.

High ductility, affordability, weld ability and good machinability characteristics of mild steel has put mild steel into the popular choice of steel for consumers. However, due to lack of alloying elements compared to those found in stainless steel means that mild steel is more prone to corrosion. On the top of that, mild steel also being in the low hit when it comes to strength capability and it restrict the usage of mild steel in applications where load bearing and strength is essential.

Even though, mild steel has found its own territory in various industries, some other application needs the material used to be harder and stronger while keeping the price fordable and competitive. Dual phase steel (DPS) has been introduced driven to fill in the gap left by mild steel and provide better strength steel without reducing the formability or reducing the costs.

Dual phase steel can be produced either by continuous annealing with the inter critical temperature range or by hot rolling. Dual phase steel produced by the continuous annealing process is considered important due to less requirement of Mn and give less variation in mechanical properties. Dual phase steel also known to have properties such as high work hardening rate and uniform total elongation that makes it a very good candidate in automotive industry for weight saving and improving fuel economy due to the good formability characteristics.

A common property that all steels should have is weld ability during the application and assembly of dual phase steel, fusion welding process such as SMAW is used as pail its joining technique. However, heat input from fusion welding can cause the martensite island to decompose into softer island of tempered martensite.

1.2 Problem Statement

Event though, the formability of high strength dual phase steel is superior to that of mild steel, higher percentage of martensite and possibility of it decomposing into tempered martensite with the application of heat during welding might introduced certain issues for the welded part. The effect of the percentage of martensite which directly relates to the intercritical annealing temperature is expected to play an important role towards a good weldability characteristic of the dual phase steel produced. The study will be looking into this aspect an analysis of the welded pail as well as its weldability performance will be done.

1.3 Objective

The objectives of this project are as follows:

I. To characterize the effect of annealing temperature to the mechanical properties and microstructure of Dual Phase Steel (DPS) produced through heat treatment of mild steel.

II. To determine the suitable Dual Phase Steel (DPS) that is in compliance to a selected international standard for welding.

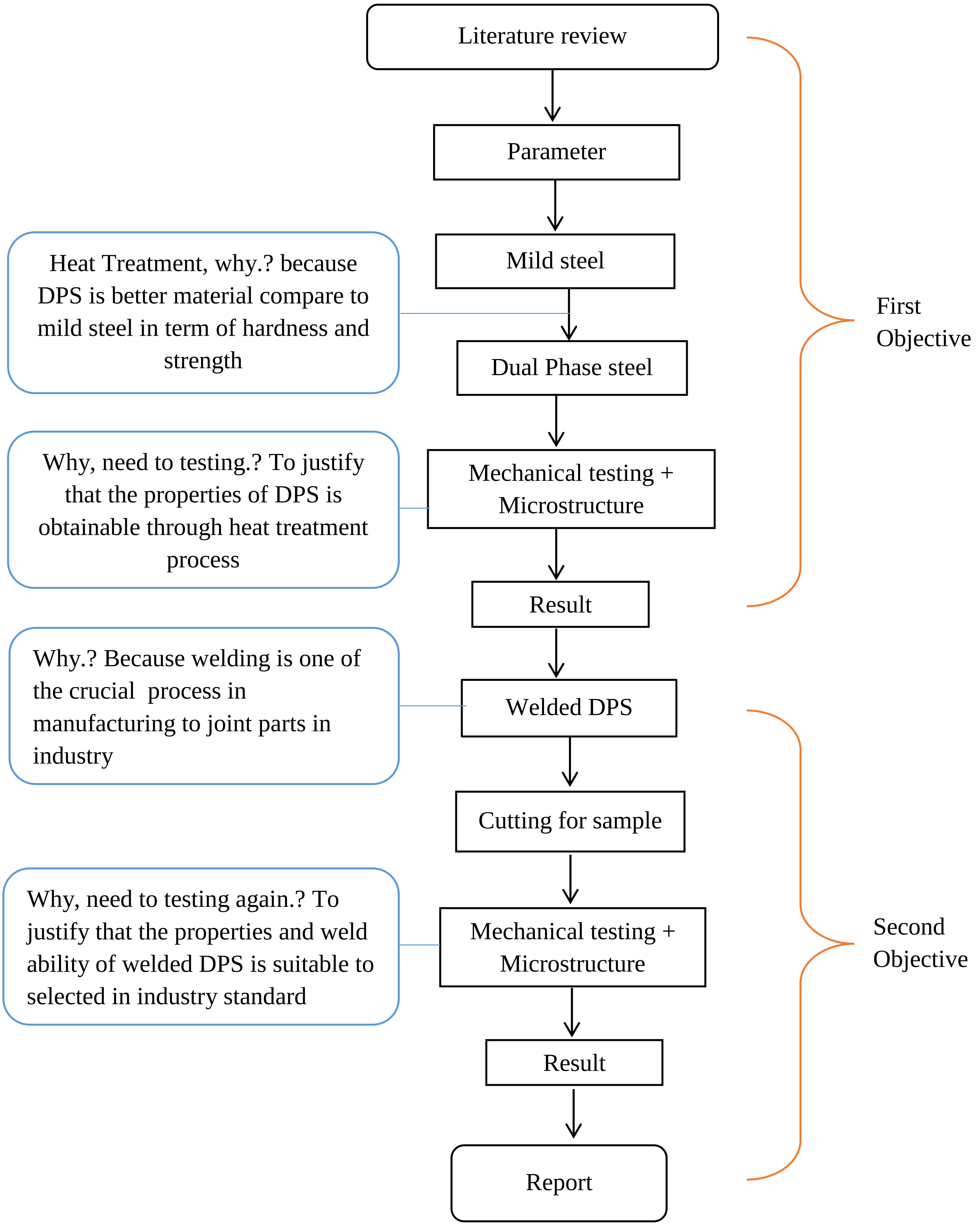
1.4 Scope

The scopes of this project are:

I. Mechanical testing to see the strength of mild steel and after transform to Dual Phase Steel (DPS) by using tensile test.

II. Development of microstructure transformation to martensite in annealing temperature.

1.5 General Methodology



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter intended to review the literature of the most about Dual Phase Steel and apply it in welding process. Microstructure view and mechanical testing which was hardness test on dual phase steel forms one of the main reasons for this project. In the previous study, research or journalism due to dual phase steel characterized by good cool-forming properties and suitable as pressed and welding parts. Great, in this study dual phase steel is the stuff where the welding will labor on.

2.2 Steel Definition

Steel is an alloy with the majority of iron and carbon between 0.2% and 2.1% by weight, rely on the grade. Carbon is most common iron alloy, but different from the used alloy element, such as manganese, chromium, vanadium and tungsten. Carbon and other element act as a hardening element, preventing dislocation in the iron crystal grid moving past each other.

The varying quantity and shape of the alloy elements in the steel (solute components, precipitated segment) direct behaviours such as hardness, ductility and tensile strength of the steel resulting. Steel with a boosted carbon content can be harder and stronger than iron, but its ductility is less than iron as well. Alloys with a carbon element higher than 2.1 percent are known as cast iron due to their low melting point and good cast capacity.

Additional steel fine tuning has been developed such as basic oxygen steel production (BOS), lower production costs while increasing metal quality. Today, with more than 1.3 billion tons formed annually, steel is one of the most common material in the world. It is a key component in buildings, infrastructure, tools, ships, automobile, machine appliance, and weapon.

2.2.1 Type Of Carbon Steel

Carbon steel also called plain carbon steel, where carbon is the main interstitial alloy element. The American iron and steel institute (AISI) derive carbon steel as: “steel is considered to be carbon steel when minimum for chromium, cobalt, molybdenum, nickel, niobium, titanium, tungsten, vanadium or zirconium, or any other element to be added to obtain a desired alloying effect. Carbon steel is divided into four classes based on carbon content.

Low carbon steel – Mild steel is the most common form of steel because it has a relatively low value while offering material properties that can be used in many applications. Low carbon steel has an approximate carbon content of 0.05-0.25 percent and mild steel contains 0.16-0.29 percent carbon; it is therefore fragile or ductile. The tensile strength of mild steel is virtually low, but it is cheap and bendy; surface hardness can be increased by carburizing. It is often the case that large quantities of steel, such as structural steel is approximately 7.85 g/cm^3 (7850 kg/m^3) and the young’s modulus is 210 GPa (30,000,000 psi). The experience of low carbon steels from yield point runs out where the material has two yield points. The first point (top yield) is greater than the second point and yield decreases dramatically after the upper yield point.

Medium carbon steel – The carbon content is approximately 0.30 – 0.59 percent. Balance ductility and strength and good wear confrontation for larger components, forging and automotive components.

High carbon steel – The carbon content is approximately 0.6 – 0.99 percent. Very powerful physically, used in springs and high - strength wires.

Ultra high carbon steel – The carbon content is approximately 1.0 – 2.0 percent. To great stiffness, steel can be raged. Used for specific purposes, such as axles and punches.

2.3 Mild Steel

Mild steel is type of carbon steel with a low the quantity of carbon, it also called as "low carbon steel". Although degrees range depending on the source, the quantity of carbon generally discovered within slight metal mild steel is 0.05% to 0.25% by weight. (McHenry and Laughlin, 2014) whereas the content of higher carbon steel are usually described as having a carbon content from 0.30% to 2.00%. If any extra of carbon than to that amount is added, the steel would stand labelled as cast iron. Mild steel is not an alloy steel and consequently does not contain large amounts of other elements besides iron. The calculated average industry grade mild steel density is 7861.093 kg/m3. Its Young's modulus, a measure of its stiffness is around 210,000 MPa.

Less carbon means that mild steel is usually more ductile, machine able, and welding able than high carbon steel and other steel. However, that additional capability such is nearly not possible with to harden and strengthen through heating and quenching. The low carbon content also means it has very little carbon and other alloying elements to block dislocations in its crystal structure, typically resulting of much less tensile strength than high carbon and alloy steel. Mild steel also has a high iron and ferrite content, which makes it magnetic. Lack of alloying elements such as those found in stainless steels means that the iron in mild steel is subject to oxidation (rust) if not properly coated. However, the negligible amount of alloy elements also makes mild steel relatively affordable compared to other steels. The affordability, weldability, and machinability make it a popular consumer choice of steel. Such as it provides high surface hardness and a soft core to parts that include worms, dogs, pins, liners, machinery parts, special bolts, ratchets, chain pins, oil tool slips, tie rods, anchor pins, studs, and others (Covered and Composition, 2012).

However, due to the lack of alloy elements like in stainless steel, mild steel is more susceptible to corrosion. In addition, mild steel is also low in strength and restricts the use of mild steel in applications where load bearing and strength are essential. Therefore, dual phase steel (DPS) has been introduced, where DPS offer higher strength without reduced formability compared to conventional high steel low alloy (HSLA).

2.4 Dual Phase Steel (DPS)

Dual phase steel (DPS) steel urbanized in the mid-seventies (Granbom, 2010) in order to gratify the increasing weight reduction and improved crash performance and keeping the manufacturing costs at easing levels. Dual phase steel grades having a more range of chemical compositions and being produced with various processing methods.

Based on the report by Hayami and Furukawa, DPS essentially contained ferrite and martensite as its major microstructure. However, other microstructure such as bainite, pearlite and retained austenite might also exist in a smaller amount. Regardless of the exact composition of the mild steel, dual phase ferrite martensite microstructure occurs in the inter critical temperature within the $\alpha + \gamma$ two phase region from the Fe-Fe_3C phase diagram. Accompanied by rapid cooling (quenching) in order to allow martensite conversion. (Ghosh *et al.*, 1991)

Soaking time of steel in the inter critical temperature was normally keep around 3 hours to ensure homogeneity before being followed by quenching. The term "dual phase" steel or DPS, refers to a class of high strength steel which is composed concerning of two phase; normally a ferrite matrix and a dispersed second phase of martensite, retained austenite and bainite. The driving force for the development of DPS was due to the urge of producing new high strength steel without reducing its formability and at a relatively low cost compared to other steels such as MCS or HCS. The automotive industry, in particular, has demanded steel grades with excessive tensile elongation in conformity with assure formability, high tensile strength. DPS show superior properties as shown in **Figure 2.1**.

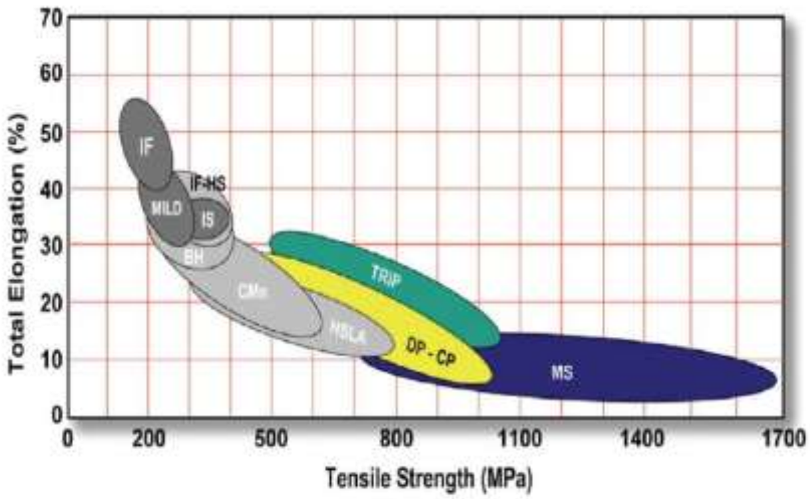


Figure 2.1 : Schematic picture showing advanced high strength steels (shown in colour) compared to low strength steels (dark grey) and traditional HS steels (grey)

Source : (Granbom, 2010)

The Continuous Cooling Transformation (CCT) are determined by measuring some physical properties during continuous cooling. Normally these are specific volume and magnetic permeability. However, the precedence about the work has been done through specific volume change by dilatometric method. This method is supplemented by using