UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF DIFFERENT HEAT SENSITIZATION TEMPERATURE ON TYPE 304 STAINLESS STEEL

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) with Honours.

By

TAY SHIN YOON

FACULTY OF MANUFACTURING ENGINEERING

2010

EVALUATION ON THE EFFECT OF VARYING MANGANESE (Mn) COMPOSITION TOWARDS AISI 304 AND 316 MICROSTRUCTURE AND HARDNESS

TAY SHIN YOON

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Effect of Different Heat Sensitizaton Temperature on type 304 Stainless Steel**

SESI PENGAJIAN: 2009/2010

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I hereby, declared this thesis entitled " Effect of Different Sensitization Temperature on type 304 Stainless Steel" is the results of my own research except as cited in references.

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ABSTRACT

Nowadays, stainless steel is one of the most important materials. Stainless steel resistance to corrosion and staining, low maintenance, relatively low cost and familiar luster make it an ideal base material for a host of commercial applications. The material usage in this project is type 304 stainless steel. This project will present the effect of different heat sensitization temperature toward microstructure, corrosion and hardness of stainless steel. Type 304 stainless steel is suit to make all types of dairy equipment such as Kitchen sink, storage tank and piping. So it always use in industry equipment that has corrosive or chemical process. Sodium chloride solution was used in cyclic polarization test. The microstructure was determined by Optical Microscope and the hardness was determined by Vicker's Hardness Tester. Besides that, the present of some elements in the stainless steel was determined by x-ray diffraction machine. In addition, the corrosion test used was cyclic polarization. Next, a discussion, conclusion and recommendation were constructed from the result obtained. The microstructure was showed the precipitation of chromium carbide and precipitation of chromium carbide was proved by x-ray diffraction results. The hardness of the specimens was not had much different although corrosion was reduced the strength of the specimens. This is because chromium carbide is a hard phase. Lastly, the effect of sensitization was reduced the corrosion resistance of type 304 stainless steel.

ABSTRAK

Kini, “Stainless steel” adalah satu bahan yang penting. “Stainless steel” penentangan karat, tahan lama, harga murah dan permukaan yang kilat telah manjadi bahan ini sebagai bahan asas kegunaan. Bahan yang mangunakan dalam projek ini ialah jenis 304 “Stainless steel”. Projek ini akan manunjukkan kesan-kesan pelbagai mikrostruktur, kekakisan dan kekerasan dengan pelbagai suhu “sensitization” proses. 304 “Stainless steel” adalah sesuai digunakan untuk manbuat benda harian. Pelbagai unsur dalam “Stainless steel” akan ditentukan dengan mangunakan “X-ray Diffraction” analisis. Selain itu, mikrostrutur akan ditentukan dengan “Optical Microscope dan kekerasan akan ditentukan dengan “Vicker’s hardness machine”. Selepas itu, perbincangan, kesimpulan dan cadangan akan dibuat dengan merujukkan data. Mikrostruktur akan menunjukan kemunculan “chromium carbide” dan kemunculan itu dapat ditentukan dengan “X-ray diffraction” keputusan. Kekerasan bahan itu akan kekal lebih kurang sama kerana “chromium carbide” adalah keras fasa. Akhirnys, “sensitization” proses akan membawa keturunan kakisan rintanga kepada bahan.

DEDICATION

To my beloved family and friends

ACKNOWLEDGEMENT

First of all, I would like to express my gratitude to Universiti Teknikal Malaysia Melaka (UTeM) for the opportunity to pursue study in Bachelor of Manufacturing Engineering (Manufacturing Material) and to conduct and complete this "Projek Sarjana Muda". UTeM has provided many facilities such as machines and equipments to aid the success of this project.

Very special thanks to my supervisor Dr. Zulkifli Mohd. Rosli for his guidance, encouragement and contribution in this project. He has given me useful advices and motivation when I encountered problems and willingly shares the knowledge regarding this project.

Last but no least, I would like to thank my family for their continuous support and courage throughout the study and the project. Not forgettable, thanks to my friends that have been working side by side in completing this project.

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LIST OF ABBREVIATIONS

SEM	-	Scanning Electron Microscope
EDX	-	Energy Dispersive X-ray
SS	-	Stainless steel
ASTM	-	American Society for Testing and Materials International
ASM		American Society for Metals
Mn	-	Manganese
MnS	-	Manganese sulphide

CHAPTER 1
INTRODUCTION

1.1 Project overview

This project is to obtain the effect of different sensitization temperature on corrosion, microstructure and hardness of type 304 stainless steel. The heat treatment processes is sensitizing process. The specimens are heat in different sensitizing temperature. The whole project is focus on how the different heat treatment processes affect the corrosion, microstructure and hardness of type 304 stainless steel. In this project, understanding the effect of sensitizing temperature is the main thing need to be done. Sensitizing heat treatment is whether accidental intentional or incidental. Corrosion is the chemical transformation of metal due to chemical reactions. Stainless steel is susceptible to intergranular corrosion if heat treating is not performed correctly. Intergranular corrosion is a selective attack of a metal at or adjacent to grain boundaries. There are three mechanisms that have been identified as causing intergranular corrosion in various situations. One of the mechanism causes intergranular corrosion is due to the local depletion of an alloying element. This form of attack can occur in many stainless steel. It is called sensitization. Many stainless steels rely on a combination of nickel and chromium for their corrosion resistance. Nickel and chromium are expensive so they are added only in amounts necessary to obtain the necessary corrosion resistance. Another element which is commonly present in stainless steel is carbon. In stainless steels, carbon atoms tend to concentrate at the grain boundaries as an impurity during solidification. Chromium carbides can form adjacent to the grain boundaries during heat treatment. When these compounds form, the chromium is

removed from the alloy adjacent to the grain boundaries and the resulting alloy does not have enough chromium content to remain passive. There is a very unfavourable anode/cathode area ratio and rapid attack can occur. Besides that, understanding the applications and properties of type 304 stainless steel is also needed in order to be more understand the purpose of this project. Stainless steel is high alloy steel which has been added by some elements in order to improve its properties such as resistance to corrosion. Stainless steel can be divided into three groups which are austenitic, ferritic and martensitic. The names of these classes reflect the microstructure of which the steel is normally composed. Type 304 stainless steel is austenitic grade. Austenitic stainless steels are non-magnetic non heat-treatable steels and FCC metal. In austenitic steels the grain boundaries are narrow straight lines. Grade 304 is the basic 18-8 alloy (18% chromium, 8% nickel) and most common of the 300 series with the excellent corrosion resistance in most applications. 304 stainless steel is especially suited for all types of dairy equipment such as milking machines, containers, homogenizer, sterilizers, storage tanks, piping, milk truck and railroad cars.

1.2 Problem statement

Austenitic stainless steel with excellent corrosion resistance and good weldability has used in various scientific and engineering applications like chemical and pharmaceutical industry such as food and beverage industry, petrochemical industry, oil and water pipe lines, ship and naval structures, architectural applications, water supply and desalination. Type 304 stainless steel is the basic 18Cr8Ni austenitic stainless steel and is so widely used that it accounts for about 50% of all stainless steel production. Corrosion can weakening the material and may lead to crack growth or failure. Hence it is critical importance to any engineer designing components or structure that use metal. Atmospheric contaminants often responsible for the rusting of structural stainless steels are the chlorides and metallic rust. Chlorine can be introduced into a piping system in

many ways but most common seen in food industry applications are as sodium chloride. The structure of a material is related to its composition, properties, processing history and performance. Therefore, studying the microstructure of a material will provides information linking with its composition to its properties and performance. Hardness is the property of a material that enables it to resist plastic deformation, penetration, indentation and scratching. Therefore, hardness is important properties for a material because resistance to wear by either friction or erosion by steam, oil and water. Besides that, the hardness value also can determine the brittleness of the material. Moreover, hardness value can be converting to tensile strength. So, raw material can be save due to small quality of material needed for hardness test if compare with tensile test.

1.3 Objective

I. To study the effect of different sensitizing heat treatment process for type 304 stainless steel on microstructure.
II. To study the effect of different sensitizing heat treatment process for type 304 stainless steel on hardness.
III. To study the effect of different sensitizing heat treatment process for type 304 stainless steel on corrosion.

1.4 Scope

I. The microstructures of the specimens are obtained by optical microscope.
II. The hardness of the specimens is test by Vicker hardness test machine.
III. Use XRD to determine the characteristic and crystal structure of that metal.
IV. Cyclic potential dynamic is use to obtain the corrosion level of the specimen.

1.5 Organization of report

This report is divided into six chapters which are Introduction, Literature Review, Methodology, Results, Discussion, and Conclusion.

I. Introduction

This chapter contains the background and problem statement of this project. Besides that, the understanding of this project will also be shown in this chapter.

II. Literature Review

This chapter contains the sources find out from book, journal, articles and internet source. Any information which is related to this project is studied and summarized.

III. Methodology

This chapter contains the experimental procedure of this project. A flow chart of this project will be shown in this chapter.

IV. Results & Discussion

This chapter contains some table, figure and graph which is plotted base on the result obtained during lab session. Besides that, this chapter also presents the most important results and commenting on results. Moreover, the result obtained from the lab session and the theoretical results are compared. In addition, the results obtained are concluded.

V. Conclusion

This chapter summary all the finding from this project and give some suggestion or recommendation for the further study. Besides that, this chapter will also review the significant findings and explain the significant for the findings.

CHAPTER 2
LITERATURES REVIEW

2.1 Introduction

This literature review is to find out all the necessary information and unknown knowledge in the research of the effect of different sensitization temperature towards AISI 304 stainless steel microstructure, corrosion and hardness. The objective of literature review is to use the sources found out to support the research. The sources found out will explain the properties and the effect of different sensitizing temperature toward microstructure, corrosion and hardness of AISI 304 stainless steel. The sources include book, journal, articles and internet sources.

2.2 Stainless Steel

Stainless means non-corrosion. Stainless steels are considered as ferrous alloys which containing more than 12% to 30% of chromium. The corrosion resistance of the stainless steel is due to the formation of chromium rich oxide passive film on the surface in oxidized environment. The stainless steel can be classified into three types that are ferritic stainless steel, martensitic stainless steel and austenitic stainless steel (Chen, M.L. 2006).