"Saya akui bahawa saya telah membaca karya ini dan pada pandangan saya karya ini adalah memadai dari segi skop dan kualiti untuk tujuan penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal (Struktur & Bahan)"

Tandatangan : .....

Nama Penyelia : MR. WAN MOHD FARID BIN WAN MOHAMAD

Tarikh : MEI 2006

A STUDY ON END-QUENCH PROCESS OF CARBON STEEL, LOW ALLOY STEEL AND STAINLESS STEEL

YOONG THIAM LONG

Laporan ini diserahkan kepada Fakulti Kejuruteraan Mekanikal
sebagai memenuhi sebahagian daripada syarat penganugerahan
Ijazah Sarjana Muda Kejuruteraaan Mekanikal (Struktur & Bahan)

Fakulti Kejuruteraan Mekanikal
Kolej Universiti Teknikal Kebangsaaan Malaysia

MEI 2006

"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya jelaskan sumbernya"

Tandatangan : .....

Nama Penulis : YOONG THIAM LONG

Tarikh : MEI 2006

ACKNOWLEDGEMENT

Since the thesis of studying the Jominy end-quenching process based on carbon steel, low alloy steel and stainless steel was appeared in 2005, many lecturers, friends and reviews have provided a helpful feedback and suggestion in developing this thesis. I wish to thank to:

1. Mr. Wan Mohd Farid Bin Wan Mohamad, supervisor (FKM) *Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM).*
2. Mr. Ahmad Rivai, lecturer (FKM) *Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM).*
3. Mr. Mahader Bin Muhamad, technician (FKM) *Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM).*
4. Mr. Azhar, technician (FKP) *Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM).*

Finally, I need to thank again for the people above due to their assistance and cooperation and also my beloved family to success my thesis.

ABSTRACT

The purpose of this study was identifying the effect of quenching process bases on their hardenability, microstructure and distortion profile of three different steels. Three experiments have carried out involving hardness test, distortion examination and microstructure analyze. Where the samples hardness profile across the bars uniformly show hardness decrease towards the center, which was due to the decrease in the cooling rate towards the center. Sample with fast cooling rate, the transformation from austenite to pearlite cannot occur and the new phase obtained by quenching was called martensite. Martensite was a supersaturated metastable phase and has body centered tetragonal lettice (bct) instead of bcc. After sample was quenched, it was usually very hard and strong but brittle. Martensite looks needle-like under microscope due to its fine lamellar structure. Therefore the quenched end with high cooling rate will have high hardness profile. The microstructural changes from martensite at the quenched end to ferrite-pearlite where far from quenched end were depend to the cooling rate. Each quench medium has different cooling rate, therefore different quench medium will showed a different results to the samples.

ABSTRAK

Tujuan bagi kajian ini adalah untuk mengenalpastikan kesan proses penyejukan kejut terhadap kekerasan, mikrostruktur dan keherotan bagi tiga jenis besi yang berlainan. Tiga ujian telah dijalankan iaitu ujian kekerasan, pemeriksaan keherotan dan menganlisiskan perubahan mikrostruktur. Di mana kekerasan sampel menunjukkan kadar pengurangan yang serata apabila merentasi ke bahagian tengah bar yang disebabkan oleh pengurangan kadar penyejukan ke bahagian tengah. Sampel yang mempunyai kadar penyejukan yang cepat, perubahan austenite kepada pearlite tidak dapat dilakukan dan ia akan menjanakan satu fasa yang baru yang dikenali sebagai martensite. Martensiti adalah fasa yang lampau tepu. Selepas sampel disejukan, biasanya ia sangat keras dan kuat tetapi rapuh. Dibawah permerhatian mikroskop, mikrostruktur martensiti kelihatan berbentuk jarum yang disebabkan keunikan lapisan strukturnya. Oleh demikian, bahagian hujung yang mempunyai kadar penyejukan yang tinggi akan menunjukkan kekerasan yang maksimum. Mikrostruktur akan berubah dari Martensiti pada bahagian hujung sample ke bentuk ferriti-pearliti dimana jauh dari bahagian hujung sample. Setiap jenis medium penyejukan kejut mempunyai kadar penyejukan yang berlainan. Oleh demikian, ia akan membawa hasil keputusan yang berlainan kepada sample yang diuji.

TABLE OF CONTENT

CHAPTER	ITEM		PAGE
	4.2.1.4	Different Steel Samples with Water Quenched	50
4.2.2	Sample Steels with Oil Quenched		52
	4.2.2.1	Hardness Test Analysis For AISI 1045 Carbon Steel	52
	4.2.2.2	Hardness Test Analysis For AISI 4130 Low Alloy Steel	56
	4.2.2.3	Hardness Test Analysis For AISI 304 Stainless Steel	60
	4.2.2.4	Different Steel Samples with Oil Quenched	64
4.2.3	Sample Steels with Air Quenched		66
	4.2.3.1	Hardness Test Analysis For AISI 1045 Carbon Steel	66

LIST OF TABLE

LIST OF FIGURE

LIST OF SYMBOLS

SYMBOL	DEFINITION
A1-W	AISI 1045 Carbon Steel with Water Quenched
A2-W	AISI 4130 Low Alloy Steel with Water Quenched
A3-W	AISI 304 Stainless Steel with Water Quenched
A1-O	AISI 1045 Carbon Steel with Oil Quenched
A2-O	AISI 4130 Low Alloy Steel with Oil Quenched
A3-O	AISI 304 Stainless Steel with Oil Quenched
A1-A	AISI 1045 Carbon Steel with Air Quenched
A2-A	AISI 4130 Low Alloy Steel with Air Quenched
A3-A	AISI 304 Stainless Steel with Air Quenched

CHAPTER I

INTRODUCTION

Quenching is the most basic and widely practiced steel heat treatment processes. It allows the base properties and performance of the steel to be significantly enhanced, such that a relatively inexpensive and simple starting material can be used for a wide range of demanding applications. Apart from the widely used immersion quenching techniques, the fundamental and latest development of other quenching techniques such as spray quenching, gas quenching in vacuum furnaces and hot salt bath quenching.

Quenching refers to rapid cooling of metal parts from the solution-treating temperature, typically in the range of 845-870 ^{o}C (1550 to 1600 ^{o}F) for steel alloys. Quenching is performed to prevent ferrite or pearlite formation and allow bainite or martensite to be formed. Martensite is the most commonly desired transformation product; refer to Figure 1.1. Quenching of steel in liquid medium consists of three distinct stages of cooling: vapor phase, nucleate boiling, and convective stage. Quenching is the most critical part of the hardening process. The quenching process has to be designed so as to extract heat from the hot work piece at such a rate as to produce the microstructure, hardness and residual stresses desired. There is much type of quenching techniques such as spray quenching, gas quenching in vacuum furnaces, intensive quenching, hot salt bath quenching, and Jominy end-quenching and so on.

When steel is heated to a temperature above the upper limit of its critical range and is then rapidly cooled in a suitable medium such as water or oil, it is hardened. An increase in hardness is obtained. The increase in hardness is greater as the cooling rate is increased. The ultimate tensile strength of mild steel is greatly improved by water quenching instead of air cooled. The hardened article is usually too brittle for use, and is therefore tempered in order to reduce its hardness and increase its toughness. By tempering is meant reheating steel (however previously treated) to a temperature of tempering, the more does the treated steel approach its condition of minimum hardness.

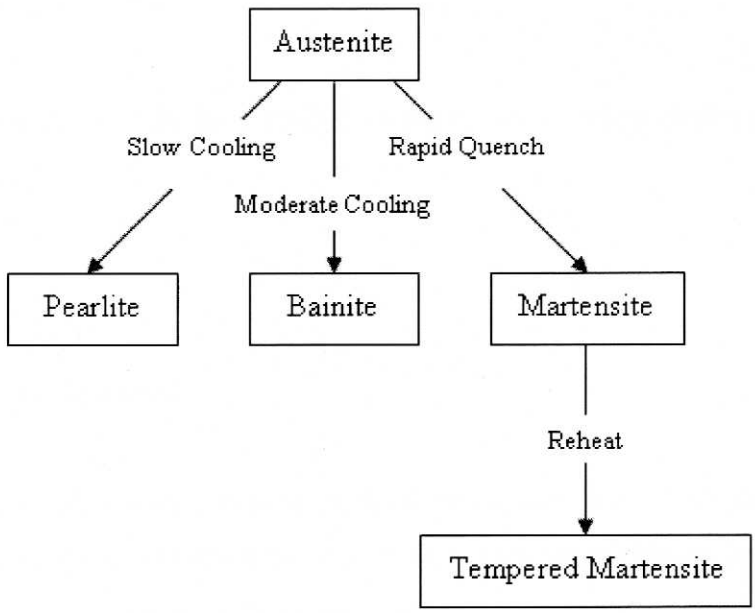

Figure 1.1 Possible transformations involving the decomposition of austenite. Solid arrows, transformations involving diffusion: dashed arrow, diffusion less transformation.

1.1 Objective

The project is concerned with effect of end quenching process based on their hardenability, microstructure and distortion profile. The objectives are as follows:

1) To obtain experiment data for AISI 1045 carbon steel, AISI 4130 low alloy steel and AISI 304 stainless steel in three difference quenching medium such as water, quench oil and air;

2) To investigate the resultant microstructure of steel when subjected to type of heat treatment; and

3) To observe the microstructural changes occur when different parameters involved.

1.2 Scope of Research

a) Conduct laboratory work on AISI 1045 carbon steel, AISI 4130 low alloy steel and AISI 304 stainless steel with heated austenitizing temperature and cooled in different quenching medium.

b) The microstructure analyses, hardness and distortion profile will be done after undergoing the end quenching process.