EFFECT OF TYPE AND CHARACTER OF QUENCHING MEDIUM ON HARDNESS OF STEEL THROUGH HEAT TREATMENT

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This thesis is submitted to Faculty of Mechanical Engineering as Partial Fulfillment of Requirement for Award of the Degree of Bachelor of Mechanical Engineering (Structure & Material)

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November 2008

"I declare that I have already read this thesis entitle effect of type & character of quenching medium on hardness of steel through heat treatment and the point of my view that this report is qualify for this scope & quality to fulfill the award for Bachelor Degree of Mechanical Engineering (Structure & Material)"

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To my lovely parents, brothers and sisters, my supervisors and all my friends

ACKNOWLEDGEMENT

First and foremost, ALHAMDULILLAH I am grateful to ALLAH SWT on His blessing in completing this project. I am also thankful to Him because through my studying at Universiti Teknikal Malaysia Melaka (UTeM), it is easier for me to get knowledgement by Him and all resistances and obstacles is faced can be resolved with diligent and patiently.

I would like to take this opportunity to thanks my project supervisor, Puan Zakiah bt Abd Halim for her invaluable guidance, assistance and support throughout this research. Under her supervision, many aspects regarding on this project has been explored, and with knowledge, idea and support received from her, this thesis can be represented in the given time.

Not forget I wish to acknowledge the technicians especially Materials Science and Technology Lab's technician, En Mahader for his help and assistance on the experiment during finishing this thesis. Without his guidance maybe this project cannot be completed succesfully.

Finally, I would like to dedicate my gratitude to all my lectures involved and teaching my course, thanks for the lesson that been delivered. Not forget to my lovely parents, Encik Musa bin Ngah and Semek@Aishah bt Awang and also all my friends.

ABSTRAK

Kajian ini dijalankan menggunakan keluli karbon sederhana, AISI 1040. Melalui prosess rawatan haba, tesis ini menyiasat tentang kesan kekerasan pada jenis dan karakteristik medium penyejukan. Objektif utama kajian ini dilakukan adalah untuk meningkatkan mutu ekperimen rawatan haba yang telah sedia ada untuk subjek Sains Bahan dan bertujuan untuk menyediakan satu set baru eksperimen yang lebih efisyen dan berjaya. Set ini hanya untuk eksperimen yang fokus pada jenis-jenis dan karakter medium penyejukan tersebut. Tesis ini meliputi proses yang pertama iaitu penyediaan bahan dari bahan mentah hinggalah kepada analisis data. Selain perbezaan jenis medium penyejukan yang digunakan sperti minyak, air dan larutan garam, sifat-sifat medium penyejukan ini juga di ambil kira bagaimana ia memberi kesan kepada kekerasan keluli. Antara parameter sifat-sifat media penyejukan yang dikaji termasuklah perbezaan tahap kocakan (kacauan), perbezaan suhu awal medium penyejukan dan perbezaan teknik penyejukan selepas kocakan (kacauan).

ABSTRACT

The research is carried on specimen of medium carbon steel, AISI 1040. Through heat treatment process, the effect of type and character of quenching medium on hardness are investigated. The main objective of this research is to improve the existing heat treatment in Material Science subject by recommending a new set of experiment that can successfully heat treated steels by focusing on type and character of quenching medium. This thesis had covered from the first process, which is material preparation until the data analysis. Beside differences in type of quenching medium used which are oil, water and brine, the character of this quenching medium also considered how it will give effect to steel hardness. The parameter of character that investigated in this project includes the differences of mode of agitation, the initial quenching medium temperature and the technique of quenching after agitation.

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CHAPTER 1

INTRODUCTION

3.10Overview

University Teknikal Malaysia Melaka's (UTeM) student especially second year students from Faculty of Mechanical are studying Science Material as a core subject. Heat treatment of steel is one of the experiments that carried out in this subject. This research is about the types and character of quenching medium affects the hardness of steel through heat treatment.

Heat treatment of steels is a heat-treating process whereby the steel are exposed to an elevated temperature for a period time and cooled of which transforms or changes the mechanical properties without changing the specimen shape. Heat treatment can be define as an operation or set of operations in a metal involving heating and controlled cooling. Transformation in the solid state can be obtained using heat treatment procedures, which cause changes in microstructure resulting in materials with a wide range of hardness and mechanical properties. Although an exact relationship between hardness and wear performance does not exist, hardness has traditionally been the properly used for quality control, selection of steel, and heat treatment and performance evaluation (Totten. G.E. and Liang. H, 2004).

Quenching is one of the important processes of the heat treatment to improve the performance of steel. During quenching, the steel is rapidly cooled in a quenching medium from the austenitising temperature typically in the range 845-870 ºC. Quenching is performed to prevent ferrite or pearlite formation and allow bainite or martensite to be formed. The selection of a quenching medium depends on the hardenability of particular alloy, the section thickness and shape involved, and the cooling rates needed to achieve desired microstructure. The most common quenching media used include oil that may contain a variety of additives, water, aqueous polymer solution and water may contain salt or caustic additives.

As can know, steels are among the most important engineering materials because without them, the machinery and tools are required to establish any industrial activity would be difficult to imagine. A very important property of steel is the ability to alter its hardness by simple heat treatments. Carbon steel can be classified according to various deoxidation process. Deoxidation practice and steelmaking process will have an effect on the characteristics and properties of the steel. Generally, carbon steels contain up to 2% total alloying elements and can be subdivided into low-carbon,medium-carbon, high-carbon, and ultrahigh-carbon (UHC) steels.

3.11Problem statement

Heat treatment of steel is already done in laboratory session for Material Science subject by students. The existing heat treatment experiment focus on the study of effects of different quenching medium but at the same austenization temperature and soaking time. The other problems are from the research, it is noted that usually the existing heat treatment experiment almost take more than lab session hour, which is usually three hours. But usually extend until a few hours and give effect for the others session. Besides that, the material used for this project different with the exits material in heat

treatment experiment. Cause of that, study on the type of these material properties, and also for different type and characteristic of quenching medium is needed.

3.12Problem Identifications

In order to study the effect of type and character of quenching medium to specimen properties, the different types of mediums used which are oil, water and brine. Different quench character such as agitation mode, initial temperature of quenching medium and the technique of quenching after agitation are raised.

To make sure the three hours lab session is enough for heat treatment experiment, a new set experiment as these parameters affect the hardness of specimen will be recommended. In order to achieve the objective, medium carbon steel is used as specimen as replacement to plain carbon steel that already used in heat treatment experiment. To measure the hardenability of the specimen, the Brinell Hardness Test is suitable to use.

1.4 Objectives

For any research, the objective is the main element that must have. So, in this research, the main objectives are to improve the existing heat treatment experiment in Material Science subject at Univesity Technical Malaysia Melaka (UTeM). Medium-carbon steel is used as specimen as already in the experiment. A new set of heat teatment experiment will be recommended after all analysis is done. This will be take new set of heat experiment with update procedure and steps that can successfully heat treated steels.

AISI-SAE 1040 Plain Carbon Steel is used in this experiment which is in standard size and shape; diameter and thickness. The specimen used is ∅20mm in diameter and 10mm thickness in cylinder shape. Not same as previously heat treatment in Material Science subject, which have use AISI-SAE 1080 Plain Carbon Steel for the experiment as specimen.

The other objective in this research is to focus on type and character of quenching medium. Quenching medium use in this experiment are brine, water, and oil. This research wills analysis the type of these media that will give effect to the specimen and also the character of it. The size, composition and initial temperature of the specimen and the final properties are deciding factors in selecting the quenching medium. All parameter will be considered in this analysis.

1.5 Scope

The main scope in this project are handling and conducting the experiment using all heat treatment equipments in Materials Science and Technology Lab at UTeM. The specimen comes as raw material in a roll of steel with 1 meter long. The steel is cut properly with bandsaw machine as 15mm each. After that, using CNC machine, the specimen machined to get 10mm thickness. The gas furnace is use for heat treatment process. After quenching process, all specimens are grinded and polished before tested the hardness using Brinell Hardnes Test.

As previously, it was state that the plain carbon AISI 1040 is the material used compared to existing heat treatment using AISI 1080. The standard specimen for this experiment is in round shape with dimension 20 mm and 10 mm length.

Based on cost effectiveness, it refers to power consumption requirements. For example the heating process by Gas Furnace, how much lot of the power (kilowatt per hour) used to heat the specimen for a period of time.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

Chapter 2 discusses about studies on steel, classification of steel through its composition, the review of past research by others scientist and also the assessment of mechanical properties.

2.2 Studies on steel

2.2.1 Classification of steel

According to *Anil Kumar Sinha et.al* (*2006)*, steel can be classified by different systems depending on:

1 Compositions, such as carbon (or nonalloy), low-alloy, and alloy steel
2 Manufacturing methods, such as converter, electric furnace, or elecrtroslag remelting method

3	Application or main characteristic, such as structural, tool, stainless steel or heat-resistant steels
4	Finishing methods such as hot rolling, cold rolling, casting, or controlled rolling and controlled cooling
5	Product shape, such as bar, plate, strip, tubing, or structural shape
6	Oxidation practice employed, such as rimmed, killed, semikilled, and chapped steels
7	Microstructure, such as ferritic, pearlitic, martensitic, and austenitic
8	Required strength level, as specified in the American Society for Testing and Materials (ASTM) standards
9	Heat treatment, such as annealing, quenching and tempering, air cooling (normalization), and thermo mechanical processing
10	Quality descriptors and classifications, such as forging quality and commercial quality

Steels are commonly made from iron ore, coal, and limestone. When these raw materials are put into the blast furnace, the result is a pig iron which has a composition of iron, carbon, manganese, sulfur, phosphorus, and silicon. As pig iron is hard and brittle, steelmakers must refine the material by purifying it and then adding other elements to strengthen the material. The steel is next deoxidized by a carbon and oxygen reaction.

2.2.2 The hardenibility heat treatment of steel

Bhadeshia and *Robert Honeycombe (2006),* introduced the traditional route to high strength in steels is by quenching to form martensite which is subsequently reheated or tempered at an intermediate temperature, increasing the toughness of the steel without too great a loss in strength. Therefore, for optimum development of strength, a steel must first be fully converted to martensite. To achive this situation, the

steel must be quenched at a rate sufficiently rapid to avoid the decomposition of austenite during cooling to such products as ferrite, pearlite and bainite. The effectiveness of the quench will depend primarily on two factors; the geometry of the specimen, and the composition of the steel.

2.2.3 Carbon Steel

According to *Efunda Engineering Fundamentals*, carbon steels are steels whose alloying elements do not exceed the following limits:

Table 2.1 : Composition of Carbon Steel

(http://www.efunda.eng.com)

Element	Max weight (%)
C	1.00
Cu	0.60
Mn	1.65
P	0.40
Si	0.60
S	0.005

Wikipedia mentioned that Carbon steel also called plain carbon steel, is a metal alloy, a combination of two elements, iron and carbon, where other elements are present in quantities too small to affect the properties. The only other alloying elements allowed in plain-carbon steel are manganese (1.65% max), silicon (0.60% max), and copper (0.60% max). As general, Carbon steel classified to three groups, which are Mild or Low carbon steel, Medium carbon steel and High Carbon steel. Low carbon steel has approximately 0.05% to 0.29% carbon content. Steel with low carbon content has the same properties as iron, soft but easily formed. Besides that, it has low tensile strength, but it is cheap and malleable, and surface hardness can be increased through carburizing.