

‘Saya/Kami\* akui bahawa telah membaca  
karya ini dan pada pandangan saya/kami\* karya ini  
adalah memadai dari segi skop dan kualiti untuk tujuan penganugerahan  
Ijazah Sarjana Muda Kejuruteraan Mekanikal (Struktur & Bahan)’

Tandatangan : .....

Nama Penyelia : .....

Tarikh : .....

*\* Potong yang tidak berkenaan*

EFFECT OF SIZE AND SHAPE OF SPECIMEN  
ON HARDNESS OF STEEL  
THROUGH HEAT TREATMENT

NOR SHAUFINA BT MD JA'AFAR

Laporan ini dikemukakan sebagai  
Memenuhi sebahagian daripada syarat penganugerahan  
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“Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya telah jelaskan sumbernya”

Tandatangan : .....

Nama Penulis : .....

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I dedicate this thesis to my parents whose always giving me a warm support as I really need it.

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## ABSTRAK

Kajian sains bahan yang sedia ada hanyalah tertumpu kepada kesan suhu, masa dan medium lindap kejut terhadap tahap kekerasan besi melalui process rawatan haba. Oleh itu, kajian eksperimen ini diilhamkan bertujuan untuk memperbaiki eksperimen berkaitan proses rawatan haba yang telah sedia ada. Kajian eksperimen ini bertujuan untuk membuat penyelidikan dan mengesahkan samada saiz dan bentuk mempengaruhi tahap kekerasan besi setelah menjalani proses rawatan haba. Tahap kekerasan besi diukur pada permukaan besi untuk menghasilkan data bagi analisis. Walaubagaimanapun, kajian ini lebih menekankan pengukuran tahap kekerasan besi dengan menggunakan keluli karbon rendah sebagai bahan ujikaji. Dengan menggunakan proses lindap kejut dan proses pembajaan, besi dikenakan rawatan haba. Manakala ujian tahap kekerasan besi pula dilakukan dengan menggunakan Ujian Kekerasan Rockwell dengan menggunakan alat pelekuk jenis bebola 1/16” dan skala B sebagai rujukan. Setelah analisis dijalankan dalam kajian eksperimen ini, kajian samada saiz dan bentuk besi mempengaruhi tahap kekerasan besi dapat disahkan. Hal ini kerana, saiz dan bentuk besi yang berbeza memberikan nilai kekerasan yang berbeza kepada besi, dan ini menunjukkan adanya kesan oleh saiz dan bentuk bahan ujikaji terhadap kekerasan besi yang telah dikenakan rawatan haba. Oleh itu, tujuan kajian ini untuk memperbaiki dan menginovasikan eksperimen akan tercapai.

## ABSTRACT

The present material analysis experiment is only focused on the effect of temperature, time and quenching media in order to investigate the hardness of steel. Thus, this experimental study comes with the aims of improving the existing experiment of heat treatment. This experimental study wants to investigate and verify whether the size and shape affect the hardness of steel. The hardness is measured on the surface of steel using the repetitive measurement in order to construct the statistical analysis. This experimental study also includes the achievement of the design of experiment. The emphasis of this study is to measure the hardness characteristics using the specimen of low carbon steel. By using the quenching process, the steel was heat-treated to the austenite temperature. The hardness testing is performed using the Rockwell hardness test with the diamond indenter and the D-scale. As the investigation and statistical analysis is done in this experimental study, the verification of size and shape were affecting the hardness of steel is identified. The different of size and shape gives the different hardness value, thus indicate the effect on hardness of steel. So the aim of improving and designing the existing heat treatment experiment is achieved and the details study is made of this findings.



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**LIST OF SYMBOL**

mm	=	millimeter
AISI	=	American Iron and Steel Institutes
BE	=	Barkhausen emission
DW	=	Domain Walls
ELC	=	Extra Lo Carbon
ULC	=	Ultra Low Carbon
Rpm	=	Revolution per minute
HI	=	High
LO	=	Low
CNC	=	Computer Numerical Control
°	=	Degree
%	=	Percent
C	=	Carbon
Mn	=	Mangan
P	=	Phosphorus
S	=	Sulphur
HB	=	Brinell hardness
MPa	=	Mega Pascal
GPa	=	Giga Pascal
m	=	meter

## ATTACHMENTS

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## **CHAPTER I**

### **INTRODUCTION**

This chapter will be discussed about the introduction of experimental study on hardness of steel through heat treatment. This chapter will cover the objective for the experimental study, the problem statement, the scope covered by this experimental study and the background of study.

#### **1.1 PROBLEM STATEMENT**

Hardness test is used to measure the hardness properties of material. Many methods can be used to conduct the hardness test. One most frequently used is the Rockwell hardness test. To indicate the hardness is using the measurement of depth or area of indentation left with a specific force applied in a specific time. The heat treatment process used also influenced the hardness level of material by the time consumed to heat the material or the quenching medium used in a heat treatment process. But the present material analysis in Material Science subject on the hardness was only focusing on the study of effects on temperature, time and types of quenching medium to the hardness of material. Rarely to find out the study that analyzes other specifications used to verify the hardness of steel such as the size or shape particularly in Faculty of Mechanical in University of Technical Malaysia Melaka. The size and shape might influence the

hardness of material particularly after it was heated by the heat treatment process using quenching method. Thus, the need of this study is to analyze the effect of size and shape on hardness of steel through heat treatment method. In order to achieve the objective of this experimental study, low carbon steel will be used to be the specimen. Besides, this experimental study can improved the current exist experiment of hardness measurement and verify whether the heat treatment effect the size and shape of specimen. Additionally, this experimental study can be used to modify the hardness properties of low carbon to be hardened and strengthened due to the various application of low carbon steel in manufacturing industry.

## **1.2 BACKGROUND**

The study of material properties is widely applied in engineering, mainly in mechanical engineering side. The material properties are also known as mechanical properties. The common types of mechanical properties are the density, Poisson's ratio, elastic modulus, tensile strength, yield strength, elongation, and reduction in area, impact strength and hardness. It has been used as measurements of how metals behave under a load. These properties are described in terms of the types of force or stress that the material must withstand and how these could be resisted.

The study on hardness of material was conduct for various standard type of steel. For this study, the material used is tested the hardness characteristic involving the heat treatment process.

The hardness is one of the indications of quality of the steel to resist the permanent indention mainly when it is applied in the tooling and manufacturing. This is because, the tools made of steel should be high resistance of force subjected to it. Therefore the hardness of steel should be analyzed in various specifications so that it will truly prove the toughness of the material. Because there are several methods of measuring

hardness, the hardness of a material is always specified in terms of the particular test that was used to measure this property. Rockwell, Vickers, or Brinell are the methods of hardness testing. Among these tests, Rockwell is the most frequently used.

The hardness experiment in one of the common test used to investigate the hardness properties of steel. This experimental study also will utilize the Rockwell hardness test as the equipment to determine of hardness properties.

This experimental study need to analyze other specification to indicate the hardness of steel; the size and shape. Various size and shape stated of specimens firstly is hardened by quenching process to change the grain structure and produce the brittle structure. Then, the size and shape will be investigated by the effects on the hardness, focusing on the surface of specimen. So, the hardness test was conducted on the flat surface of specimen, not at the curve and edge of specimen.

Low Carbon Steel will be used as the experimental specimen. To carry out this experimental study, the specimens used are the low carbon steel was chosen as three different sizes and similar shape of cylindrical bar. The three different size of specimen was selected which are 20 mm, 23mm and 25 mm in diameter. These types of specimen used to analyze the size effect to the hardness of steel. While two different shapes with similar edge of 17 mm of low carbon steel used to analyze the effect of shape to the hardness. The two different shapes were stated as round, square and triangle shape. The differences of the size and shape will prove the targets of this experimental study.

Before the specimen undergoes the hardness test; it will be treated by the heat treatment process which is quenching process. Quenching process is conducted using the oil medium. Then the hardness test is done to the quenched specimen to measure the hardness of the specimen. The heat treating process to the specimen will make the specimen harden as the fully hardened and tempered of specimen will develop the best combination of strength and notch-ductility.

In spite of improving the existing heat treatment experiment which only investigating the effect of time, temperature and quenching medium to steel, this experimental study will also improve and enhance the quality of low carbon steel through heat treatment instead of many application of the low carbon steel with variety of shape and size in industry.

### **1.3 OBJECTIVE**

The objective of this experimental study is to improve the existing heat treatment experiment in the Material Science subject by recommending the new set of experiment of heat treatment. This experimental study also wants to investigate and verify whether the size and shape affects the hardness of low carbon steel. Three different size and shape of low carbon steel with the stated dimension will be used in this hardness investigation.

### **1.4 SCOPE**

The emphasis of this experimental study is on the observation the hardness properties of low carbon steel after it was heat-treated. The investigation includes the laboratory test on different size and shape of low carbon steel with the Rockwell hardness test. The Rockwell hardness test was used with the diamond indenter and the D-scale. The hardness property that measured in this experimental study was the hardness affect at the flat surface of specimen after the heat treatment process.

## 1.5 ORGANIZATION

The first part of this report is collecting all the related information of the experimental study about heat treatment, hardness test and low carbon steel. From the related information, a literature review for this experimental study can be generated. At the same time, the specimen for the experiment, which is the low carbon steel, is prepared according to the standard dimension and shape that was stated. Then, the experiment is started with the heat treatment process on the specimen and then the Rockwell hardness was tested on the specimen after the heat treating process. The hardness test is done by repetitively measurement as the hardness measurement was done at different location of the specimen surface. This followed by data collection and analysis of the finding results. The consequences from this experimental study were prepared in the analysis result. Finally, the verification of the size and shape were affecting the hardness of steel are identified and detailed study about the related factor to the steel's hardness is made of these.