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Date :……………………

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Name of 2nd Supervisor :…………………....

Date :……………………

QUENCHING-TEMPERING EFFECTS ON HARDNESS AND COMPRESSION STRENGTH OF CARBURIZED LOW ALLOY STEEL

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"I declare that this report is done by my own exclude the citation with the mentioned references for each."

Signature:…………………….

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ABSTRACT

Nowadays, the major challenge in engineering field is to improve the properties of steels in order to meet the entire engineering requirement. A better toughness, strength and ductility of steels can be achieved by applying several types of heat treatments and surface treatments. In this study, the effects of quenching and tempering of carburized low alloy steel on hardness and compression strength are investigated. There are two conditions of specimens; carburized and uncarburized low alloy steels. The carburized specimens then face different phases of heat treatments. The phases of heat treatments are carburizing and normalizing; carburizing, quenching and normalizing; and carburizing, quenching, tempering and normalizing. Then, the specimens are tested by using Rockwell hardness test and compression test. The data obtained will be analyzed and a comparison will be carried out by using statistical analysis.

ABSTRAK

Kini, cabaran yang paling utama dalam bidang kejuruteraan adalah untuk meningkatkan sifat-sifat keluli supaya dapat diaplikasikan untuk seluruh keperluan bidang ini. Kekerasan, keliatan dan kemuluran yang lebih baik dapat dicapai dengan menggunakan beberapa jenis rawatan haba dan rawatan permukaan. Dalam kajian ini, kesan-kesan rawatan sepuh lindap dan pembajaan ke atas kekerasan dan kekuatan mampatan keluli beraloi rendah yang ditusukkarbon dikaji. Terdapat dua keadaan spesimen; ditusukkarbon dan tidak ditusukkarbon. Spesimen yang ditusukkarbon kemudiannya melalui rawatan haba yang berlainan fasa. Fasa-fasa rawatan haba adalah penusukkarbonan dan penormalan; penusukkarbonan, sepuh lindap dan penormalan dan penusukkarbonan, sepuh indap, pembajaan dan penormalan. Kemudian, specimen-spesimen tersebut diuji dengan menggunakan ujian kekerasan Rockwell dan ujian kekuatan mampatan. Data yang diperolehi akan dianalisis dan satu perbandingan dapat dilakukan daripada analisis statistik.

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LIST OF ABBREVIATIONS

ASTM	=	American Society of Testing and Material
AISI	=	American Iron and Steel Institute
UNS	=	Unified Numbering System
BHN	=	Brinell Hardness Number
HRB	=	Rockwell B Hardness
HRC	=	Rockwell C Hardness
EN	=	Euro Norm
CO	=	Carbon monoxide
CO_2	=	Carbon dioxide
Fe	=	Ferum

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CHAPTER 1

INTRODUCTION

1.1 Background

Low alloy steels have been developed to overcome the deficiencies of plain carbon steels that contain alloying elements to improve their properties. The principle alloying elements added to make alloy steel are manganese, nickel, chromium, molybdenum and tungsten. Alloy steels are expensive than plain carbon steel but for many applications, they are the only materials that can be used to meet engineering requirements especially in the manufacture of automobiles and trucks parts. Beside that, low alloy steels also have better combination of strength, toughness and ductility than plain carbon steel. They contain about 0.2 percent C which commonly carburized or surface heat-treated to produce a hard, wear resistance surface while maintaining a tough inner core (Smith, 2004).

Carburizing is a thermal diffusion of an adequate quantity of atomic carbon on to the surface layer of steel and it takes place in its atomic state (Prabhudev, 2000). Basically, there are three most important methods of carburizing; pack carburizing, gas carburizing and liquid carburizing. For this project, pack carburizing method was elected due to simplify of experimental set up. Pack carburizing or powder carburizing process consists of packing the component in a solid carburizing compound in a suitable box and heating it slowly in a furnace to attain a temperature of about 900° to 950°C (Prabhudev, 2000). In this project, three types of heat treatment processes were carried out in order to compare the effect of quenching, tempering and normalizing after carburizing.

For the experimental set up, the heat treatment were divided into three phases, the first phase consists of carburizing then followed by normalizing, while for the second phase is carburizing, quenching and normalizing and the last phase consists of carburizing, quenching, tempering and normalizing. Quenching is a method of rapid cooling of a metal in a bath of liquid during heat treatment (Rajput, 2000) while the definition of tempering is a reheating of previously quenched alloy to a temperature below the critical range, holding the alloy for a specified time at that temperature, and then cooling it at a controlled rate, usually by immediate rapid quenching, to room temperature (Tomsic and Hodder, 2000). The final treatment is normalizing which it is the term applied to the process of heating the steel approximately 4°C above the critical temperature followed by cooling below this range in still air (Rajput, 2000).

After the heat treatment processes, hardness and compression strength test were carried out to study the effects of those heat treatments on low alloy steel specimens. Hardness is a material's ability to resist surface abrasion while the compression strength is defined as malleability which it is a measure of the extent to which a material can withstand deformation in compression before failure occurs (Chapman, 2004). The data obtained from these test were compared to each other and the effects on low alloy steel were evaluated and analyzed after the three phases of heat treatments.

1.2 Objective

The objective of this research is to study and discuss the effects of quenching-tempering processes on hardness and compression strength of carburized low alloy steel using statistical analysis.

1.3 Scopes

The scopes of this study are:

(a) To do literature study on carburizing process.

(b) To carry out carburizing treatment, carburizing-normalizing, carburizing-quenching-normalizing, carburizing-quenching-tempering-normalizing on low alloy steel.

(c) To carry out hardness and compression test on the material, before and after treatments.

(d) To compare the data using statistical analysis in order to propose a better carburizing treatment process.

1.4 Problem Statement

In advance engineering, low alloy steels are widely used for some applications due to better combination of strength, toughness and ductility than plain carbon steel. In order to obtain the superior strength and toughness properties, there are some heat treatments that should be going through. Low alloy steels are commonly carburized to produce hard, high wear-resistant of the outer surface.

In previous study of FKM student, hardness of carburized low alloy steel was investigated but the result was against the prediction. Supposedly, hardness of carburized low alloy steel should be better than uncarburized low alloy steel. This research is carried out to make some enhancement with further heat treatment processes. After carburizing process, it was followed by other heat treatments like quenching, tempering and normalizing. Each process will presents different effects on the mechanical properties of low alloy steels. These desired properties are depending on how crucial the engineering works are. The effects of these surface hardening and heat treatments on low alloy steels will be investigated.

CHAPTER 2

LITERATURE REVIEW

2.1 Alloy Steel

Smith (2004), said alloy steels have been developed to overcome the limitations of plain carbon steel which are used widely in engineering application. Some of the limitations of carbon steels are:

(a) Plain carbon steels cannot be strengthened beyond about 100,000 psi (690MPa) without a substantial loss in ductility and impact resistance.
(b) Large-section thickness of plain carbon steels can not be produced with a martensitic structure throughout. That is, they are not deep hardenable.
(c) Plain carbon steels have low corrosion and oxidation resistance.
(d) Medium-carbon plain carbon steels must be quenched rapidly to obtain a fully martensitic structure. Rapid quenching leads to possible distortion and cracking of the heat-treated part.
(e) Plain carbon steels have poor impact resistance at low temperature.

In order to improve the properties of plain carbon steels, alloying elements added such as manganese, nickel, chromium, molybdenum, and tungsten to make alloy steels. Other elements that are added include vanadium, cobalt, boron, copper, aluminum, lead, titanium, and columbium (niobium).

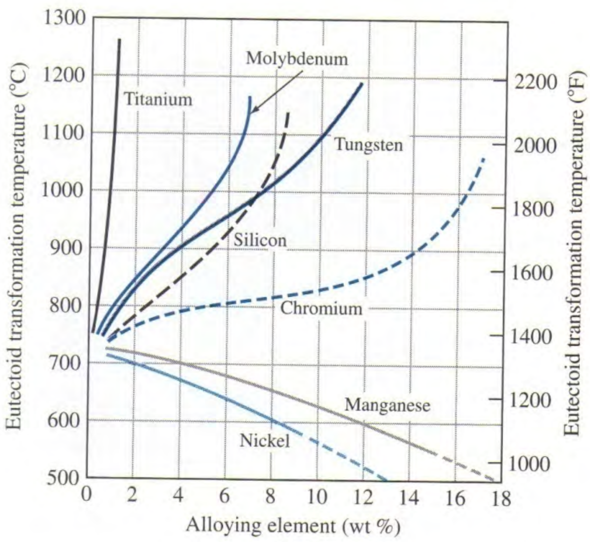

Figure 2.1: The effect of the percentage of alloying elements on the eutectoid temperature of the transformation of austenite to pearlite in the Fe-Fe_3C phase diagram (Source: Smith, 2004).

Beside that, according to Askeland (1994), the alloying elements are added to steels to provide solution strengthening of ferrite, cause the eutectoid temperature of the Fe-Fe^3C phase diagram to be raised or lowered (as shown in Figure 2.1), improve corrosion resistance and other special characteristics of the steel, and improve hardenability. Improving the hardenability is the most important in alloy and tool steels and the general effectiveness is shown in Figure 2.2:

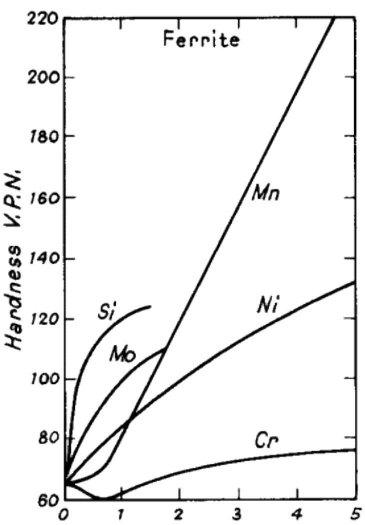

Figure 1.2: Hardening effects of alloying elements in solid solution in fully annealed ferrite (Source: *Internet reference* 22th July 2007).