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QUENCHING-TEMPERING EFFECTS ON FRACTURE PROPERTIES IN CARBURIZED LOW CARBON STEEL

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THIS REPORT WAS SUBMITTED IN ACCORDANCE WITH THE PARTIAL REQUIREMENT FOR THE HONOR OF DEGREE OF MECHANICAL ENGINEERING (MATERIAL AND STRUCTURE)

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For my beloved parent and siblings

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ABSTRACT

Quenching and tempering process are two common processes that are used in the industrial. Quenching is the process where the steel is rapidly cooled after carburizing by using quenching medium such as oil while tempering is the process where the steel is heated at certain temperature between 400^{o}C to 600^{o}C. In this research, 20 specimens of low carbon steel specimens with dimension of 100mm x 19mm x 10mm are used for heat treatment process such as carburizing, quenching, tempering and normalizing. Then the specimens were fracture by using fracture toughness test as per ASTM E399. The effect of this heat treatment process on the fracture properties were analyzed by doing statistical analysis which is hypothesis test. As for data comparison, 4 set of specimens were treated with different heat treatment process. The results from this research showed that the fracture toughness become higher when the specimen undergo quenching and tempering process. This is due to the change of microstructure in the material which it increases the ductility and strength of the specimen therefore making it tougher and durable. Furthermore, the carburizing process diffused more carbon on the specimens which resulted in a higher wear resistance and hardness surface. As a conclusion, this research gives important information and helps the industry to increase the production of steel with higher strength and longer life span.

ABSTRAK

Proses pelindapkejutan dan pembajaan merupakan dua proses yang biasa digunakan di dalam industri. Proses pelindapkejutan merupakan proses menyejukkan keluli secara mengejut menggunakan medium pelindapkejutan seperti minyak selepas penyusukkarbonan manakala proses pembajaan merupakan proses memanaskan kembali keluli pada suhu tertentu diantara 400^{o}C dan 600^{o}C. Dalam kajian ini, 20 keluli karbon rendah yang berukuran 100mm x 19mm x 10mm telah digunakan untuk proses rawatan haba seperti penyusukkarbonan, pelindapkejutan, pembajaan dan penormalan. Selepas itu keluli dipatahkan menggunakan ujian keliatan patah seperti dalam ASTM E399. Kesan daripada proses rawatan haba ini keatas ciri-ciri patah dianalisis menggunakan statistik analisis iaitu ujian hipotesis. Sebagai perbandingan, 4 set specimen dirawat menggunakan proses rawatan haba yang berbeza. Keputusan daripada kajian ini menunjukkan peningkatan keatas keliatan patah apabila specimen menjalani proses pelindapkejutan dan pembajaan. Ini disebabkan berlakunya perubahan keatas struktur mikro dalam keluli tersebut yang meningkat kemuluran dan kekuatan yang menyebabkannya lebih liat dan tahan lama. Tambahan pula proses penyusukkarbonan menyebarkan lebih karbon untuk meningkatkan ketahanan haus dan kekuatan permukaan specimen. Sebagai kesimpulannya, kajian ini memberi lebih informasi dan membantu industri untuk meningkatkan pengeluaran keluli yang lebih tahan lama dan mempunyai jangka hayat yang panjang.

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W	=	Width (cm)
a	=	Crack length (cm)
B	=	Thickness (cm)
S	=	Span (cm)
P	=	Force (kN)
Kq	=	Fracture toughness (MPa.√m)
σ^2	=	Variance
n	=	No of sample
$\bar{x}$	=	Mean of sample

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CHAPTER I

INTRODUCTION

1.0 Introduction

Quenching process and tempering process are two of the most basic and widely practiced steel heat treatment processes. Each 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 application.

These technological developments within these two processes are often ignored in favor of high tech surface treatments. Many research studies are involved in area of surface treatments to increase the material friction and wear resistance. One of the surface treatments is quenching process which is technically developed and widely used in industry to produce extremely hard and wear resistant surface layer on metallic substrate (Selcuk *et al*, 1999).

Certainly the technology of quenching has changed as well as the kind of workpieces being quenched from axes and swords to gears and automotive components to the development of gas turbine blade that has been quenched in a hot isostatic pressing (HIP) quenching unit in argon under 2000 bars of pressure (Liscic *et al*, 1993). Even more important is the fact the simultaneously quenching has changed from an empirical skill to a scientifically founded and

controlled process which now belongs to the area of intelligent processing of materials (Persampieri *et al*, 1984).

In this research, the material used in this process is low carbon steel (AISI 1020). Low carbon steel in other name called plain carbon steel is a metal alloy that has been combined by two elements iron and carbon, where other elements are present in such a small quantities to affect the properties. Steel with low carbon content has the same properties as iron and soft but it is easily to form. This is due to the carbon content rises the metal becomes harder and stronger but less ductile and more difficult to weld. The most important characteristics is the carbon content influences the yield strength of steel because they fit into the interstitial crystal lattice sites of the body-centered cubic arrangement of the iron molecules. The interstitial carbon reduces the mobility of dislocations which in turn has a hardening effect on the iron. To get dislocations to move, a high enough stress level must be applied in order to break way the dislocation (internet reference, 13/9/07). In this research, effect of quenching and tempering process on fracture properties of carburized low carbon steel was studied. This can provide reference data on fracture properties of the steel. Therefore this finding can be beneficial to expand the application of low carbon steel in industries.

1.1 Objectives

The objectives of this research are to study and discuss the effects of quenching-tempering processes on fracture properties of carburized low carbon steel by using statistical analysis.