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STUDY ON TEMPERING EFFECTS IN GAS CARBURIZED LOW CARBON STEEL

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

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ABSTRACT

The hardness and compression stress of AISI 1020 steel surface improved by various heat treatments such as carburizing and tempering were tested. Samples prepared from the test materials were treated at gases carburizing medium and then tempered. The hardness and compression distribution were measured. According to ASTM E9-89a standard, the specimen was fabricated with length to diameter ratio of 2.0 and the surface must be flattening to proceed the compression test. The hardness and compression strength of AISI 1020 were determined and compared with other treated steel samples. Rockwell hardness testing machine was used to obtain the hardness value based on ASTM E18-03 standard and compression testing was conducted using Universal Testing Machine (UTM) to measure the compression strength based on ASTM E9-89a standard. The hardness of carburized steel was not as expected. Compression strength results are increased after the treatment with very minimal values.

ABSTRAK

Kekerasan dan tekanan mampatan pada permukaan AISI 1020 ditingkatkan oleh pelbagai rawatan haba sepeti penyusukkarbonan dan pewajaan. Bahan-bahan ujian disediakan untuk dirawat di dalam penyusukkarbonan mengunakan gas dan pewajaan. Kekerasan dan pengedaran mampatan diukur. Berdasarkan piawaian ASTM E9-89a, spesimen difabrikasi mengikut nisbah panjang kepada diameter 2.0 dan permukaan mestilah diratakan untuk meneruskan ujian mampatan. Kekerasan dan kekuatan mampatan AISI 1020 yang diukur dan dibandingkan antara keluli lain yang dirawat. Mesin ujian kekerasan Rockwell digunakan untuk memperoleh nilai kekerasan berdasarkan piawaian ASTM E18-03 dan ujian mampatan menggunakan Mesin Ujian Universal (UTM) untuk mengukur kekuatan mampatan berdasarkan piawaian E9-89a. Kekerasan keluli yang telah ditusuk karbon tidak mengikut keputusan yang dijangka. Keputusan kekuatan mampatan adalah bertambah selepas menjalani rawatan dengan nilai yang minima.

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LIST OF ABBREVIATIONS

AISI	=	American Iron and Steel Institute
ASTM	=	American Standard Test Method
BHN	=	Brinell Hardness Number
C	=	Carbon
CH_4	=	Methane
CNC	=	Computer Numerical Control
CO	=	Carbon monoxide
CO_2	=	Carbon dioxide
C_3H_8	=	Propane
Fe	=	Ferum
HRB	=	Rockwell B
HRC	=	Rockwell C
H_2	=	Hydrogen
H_2O	=	Water
Mn	=	Manganese
SAE	=	Society of Automotive Engineering
UTM	=	Universal Testing Machine

CHAPTER 1

INTRODUCTION

1.1 Background

In many applications it is necessary to develop high surface hardness on a steel part that can resist wear and abrasion. So, the poor ductility and toughness cannot be tolerated throughout the entire part. Many rotating or sliding steel parts such as gears and shaft must have a hard outside case for wear resistance and tough inner core for fracture resistance. So the surface hardening method is one of the methods to overcome the problem.

Heat treatment defines as an operation or combination of operations, involving heating and cooling of a metal or alloy in its solid sate with the object of changing the characteristics of the material (Rajput, R.K. 2000). There are several of the heat treatment processes. Some of the processes are surface hardening, tempering, quenching and normalizing.

Surface hardening processes may be divided into two specifications, those in which the composition of the surface materials must be changed and those in which the composition of the surface materials is not changed. Carburizing, nitriding, carbonitriding, and cyaniding process are used to satisfy the first specification (Chapman, W. W. 2004).

Carburizing is most widely used as a surface hardening process in general engineering and has been practiced for many years. Carburizing is a process in which an austenitized ferrous material is bought into contact with a carbonaceous atmosphere of sufficient carbon potential to cause absorption of carbon at the surface and, by diffusion, create a concentration gradient (Tomsic, J.L. and Hodder, R. 2000). The three basics methods of carburizing steel: pack carburizing, liquid carburizing and gas carburizing.

Gas carburizing is a surface hardening process in which steel or alloy suitable alternative composition is exposed at elevated temperature to a gaseous atmosphere with a high carbon potential; hardening of the resulting carbon-rich surface layer is accomplished by quenching the part from the carburizing the temperature or by reheating and quenching (Tomsic, J.L. and Hodder, R. 2000).

Low carbon steel AISI 1020 is a cheap material, easy to find and widely used in manufacturing of simple construction and machine elements. Percentage of carbon contain in this steel is 18 to 23 percent. The surface properties of these steel are usually improved by carburizing (Selcuk, B., Ipek, R. and Karamis, M. B. 2003). It can used as the automotive component as gear drives, pump shafts, guide bar and others.

In this study, gas carburizing process using carbon monoxide gases of the low carbon steel AISI 1020 will be carried out. Result of each testing is compared to define the differential strength of tempering effect using statistical analysis.

1.2 Objective

The objective of this research is to study and discuss the effects of tempering process on hardness and compression strength of gas carburized low carbon steel using statistical analysis.

1.3 Scope

The scope of this study is:

a) To carry out carburizing treatment which is carburizing and normalizing, carburizing than proceed tempering and normalizing on low carbon steel using carbon monoxide gas.
b) To carry out hardness and compression test on the material before and after treatment.
c) To compare the data using statistical analysis in order to propose a better gas carburizing treatment process.

1.4 Problem statement

The problem statement in this study is:

a) By the time moving, price of steel become increased. So, the machine and structural component become expensive.
b) To produce cheaper component, low carbon steel are proposed to be used as its component. However, it requires good strength for safety.
c) Heat treatment using gas carburizing is suggested to be the better way on increasing the hardness and strength of low carbon steels.

CHAPTER 2

LITERATURE REVIEW

2.1 Heat treatment

Heat treatment defines as an operation or combination of operations, involving heating and cooling of a metal or alloy in its solid state with the object of changing the characteristics of the material. The purpose of the heat treatment are to improve the machinability, change or refine grain size, relieve the stress of the metal induced during cold or hot working, produce a hard surface on a ductile interior and improve mechanical properties like tensile strength, hardness, ductility, shock resistance and more. It also can improve the mechanical and electrical properties and increase resistance to wear, heat and corrosion (Rajput, R.K. 2000).

Heat treatment also can define as an operation or series of operation of heating and cooling a metal or alloy in the solid state to develop a specific desired properties or characteristics (Chapman, W. W. 2004).

There are two categories of thermal treatment which is those that increase the strength, hardness and toughness of steel by rapidly from above the transformation range and those that decrease hardness and promote uniformity either by cooling slowly from above the transformation range. Quenching and tempering was satisfied the first specification (Chapman, W. W. 2004).

2.2 Surface hardening

Surface hardening also referred as to case hardening. Surface hardening of carbon steel and iron is the most common form of introduction heat treatment because the heating can be localize to the areas where the metallurgical changes are desired (Totten, G. E. 2007).

The apparatus under consideration is used in the surface hardening of iron and steel part such as balls ad races of ball bearings, similar parts of roller bearing, many parts of automobiles, sewing machines and agricultural implements; links pins, bushings of silent chains, similar part as roller drive chains, automobile skid chains, cap screws, nuts, set screws and many such parts which in use are required to have a hard surface to resist wear (Totten, G. E. 2007).

Surface hardening involves one of four different method; carburizing, nitriding, cyaniding or carbonitriding. Surface hardening also know as case hardening. Case hardening is a term used to describe one or more process of hardening steel in which the outer portion or care is made substantially harder than the inner portion or core (Horath, L. 2001).

If a hard steel surface is desired, high carbon steel can be used or much cheaper low carbon steel can be heated in a carbonaceous atmosphere to increase the carbon content of the surface layers (Henkel, D. and Pense, A. W. 2002).

According to Akita, M. and Tokaji, K. (2006) study, he used modified gas carburizing which called pionite treatment at temperature below 773K for 35 hours in CO and H_2 gas mixture, and AISI 316 as the raw material. He found that hardness rapidly decreases with increasing the distance from the surface and then reaches a constant value of the hardness of the core material. It is also can be seen that the carburized specimen, tensile strength increases and ductility decreases compared with the untreated specimen, but the differences in tensile properties between the untreated and carburized specimens are small.

Most of the processes involve either enriching the surface layer with carbon and/or nitrogen, usually followed by quenching and tempering, or the selective hardening of the surface layer means of flame or induction hardening (Chapman, W. W. 2004). These case hardened pieces represent a compromise between the hard, wear resistance brittleness of high carbon steel and the softer, more ductile, less wear resistant low carbon steel (Rajput, R. K. 2000).

The objectives of the case hardening are to obtain a hard and wear resistance surface in machine part with enrichment of the surface layer with carbon to concentration of 0.75 percent to 1.2 percent. It also used to obtain tough core and close tolerances in machining part. Lastly, the objective of the case hardening is to obtain a higher fatigue limit and high mechanical properties in the core (Rajput, R. K. 2000).

2.3 Carburizing

Carburizing is a process in which an austenitized ferrous material is bought into contact with a carbonaceous atmosphere of sufficient carbon potential to cause absorption of carbon at the surface and, by diffusion, create concentration gradient (Tomsic, J. L. and Hodder, R. 2000). Carburizing is a heat treatment process to increase the surface hardness and wear resistance of components which are required to possess fairly good impact strength and resistance to wear service (Askeland, D. R. 1994).

Carburizing is accomplished by crowding considerable amounts of carbon into the outer surface of the steel as shown in figure 2.1. This can be done by placing the low carbon steel in a high carbon atmosphere and heating it into the red heat range 766 to 878°C (Horath, L. 2001).

As a result the carbon atoms are being absorbed on the steel surface and next diffuse into the core. The ability of carburizing atmosphere to release the carbon atoms as a result of thermal decomposition of the components of the atmosphere is very high and so is the carbon potential (Kula, P., Pietrasik, R. and Dybowski, K. 2005).

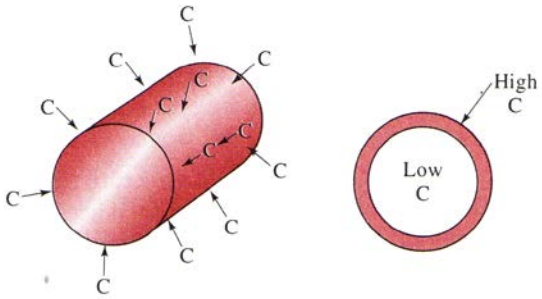

Figure 2.1: Carburizing of low carbon steel to produce a high resistance surface (Sources: Askeland, D. R. (1994))

During carburizing, three important changes take place. First, the atomic carbon is liberated from carbonaceous medium. This takes place due to the decomposition of carbon monoxide into carbon dioxide and atomic carbon. The reaction of the carbon monoxide is shown in equation 2.1.

$$2CO \rightarrow CO_2 + C_{at} \qquad \text{Equation 2.1}$$

Secondly, the carbon atom from the carburizing agent is transferred to the surface of the steel. Thirdly, the carbon so absorbed by the surface of steel is diffused deep to it (Prabhudev, K. H. 2000).

The carbon diffusion process start once the carbon atoms reach the steel surface and diffuse interstitially into the low carbon content region. As the actual carbon concentration profile is formed by the diffusion of carbon atoms into the treated component (Li, S. and Manory, R. R. 1995). There are three basics methods of carburizing steel: pack carburizing, liquid carburizing and gas carburizing.