

A Study of Optimization and Improvement of Mechanical Properties of Low Carbon Steel by the Process of Carburization

B.U. Said¹, I. Umar² and N.S. Sharif³

^{1,3}Postgraduate Student, (Dept. of Mechanical Eng.) Sharda University India

²Graduate Student (Dept. of Mathematics) KUST Wudil

E-mail: ¹bashirnahaske@gmail.com, ³calsaeed12@gmail.com

Abstract—The heat treatment and carburization has been acknowledged by some means of improving the various properties of metals and alloys. In the present investigation the mechanical and wear behaviours of mild steels carburized at different temperature range of 850, 900 and 950°C have been studied and it is found that the simple heat treatment greatly improves the hardness, tensile strength and wears resistance of the mild steels. The aim has been to examine the effects of these different carburization temperatures and conditions on the mechanical and wear properties of the carburized mild steels. For above purpose firstly the mild steels are carburized under the different temperature range as stated above and then it is tempered at 200°C for half an hour after this the carburized and tempered mild steels are subjected for different kind of test such as abrasive wear test, hardness test, tensile test and the toughness test. The results of these experiment shows that the process of carburization greatly improves the mechanical and wear properties like hardness, tensile strength and wear resistance and these properties increases with increase in the carburization temperature but apart from this the toughness property decreases and it is further decreases with increase in carburization temperature. The experimental results also shows that the mild steels carburized under different temperature range as stated above, with in which the mild steels carburized at the temperature of 950°C gives the best results for the different kinds of mechanical and wear properties because at this temperature it gives highest tensile strength, hardness and wear resistance, so it must be preferred for the required applications.

Keywords: Carburization, Hardness, Toughness, tensile

1. INTRODUCTION

The carburization provides a gradual change in carbon content and carbide volume from the surface to the bulk, resulting in a gradual alteration of mechanical and wear properties. The heat treatment and carburization increases the mechanical and wear resistance. Carburizing is the addition of carbon to the surface of low-carbon steels at temperatures generally between 850 and 950°C (1560 and 1740°F), at which austenite, with its high solubility for carbon, is the stable crystal structure. Hardening is accomplished when the high-carbon surface layer is quenched to form marten site so that a high-carbon martensitic case with good wear and fatigue resistance is

superimposed on a tough, low-carbon steel core. Carburizing steels for case hardening usually have base-carbon contents of about 0.2%, with the carbon content of the carburized layer generally being controlled at between 0.8 and 1% C. However, surface carbon is often limited to 0.9% because too high a carbon content can result in retained austenite and brittle marten site.

Carburizing is one of the most widely used surface hardening processes. The process involves diffusing carbon into a low carbon steel alloy to form a high carbon steel surface. Carburizing steel is widely used as a material of automobiles, form implements, machines, gears, springs and high strength wires etc. which are required to have the excellent strength, toughness, hardness and wear resistance, etc. Because these parts are generally subjected to high load and impact. Such mechanical properties and wear resistance can be obtained from the carburization and quenching processes. This manufacturing process can be characterized by the key points such as: it is applied to low carbon work pieces, work pieces are in contact with high carbon gas, liquid or solid, it produces hard work piece surface, work piece cores retain soft.

2. CARBURATION PROCESS

Carburization is simply defined as the addition of carbon to the surface of low carbon steel at temperature generally between 850-950 degree Celsius. Carburization is the most widely used method of surface hardening. It consist of enrichment of surface layers of low carbon / mild steel (c less than equal to 0.30%) with carbon up to 0.8 % to 1% by this way the good wear and fatigue resistance is superimposed on a tough low carbon steel core. usually have base-carbon contents of about 0.2%, with the carbon content of the carburized layer generally being controlled at between 0.8 and 1% C. However, surface carbon is often limited to 0.9% because too high a carbon content can result in retained austenite and brittle marten site.

There are following types of carburization processes exist

1. Solid carburization
2. Gaseous carburization
3. Vacuum carburization
4. Plasma carburization
5. Salt bath carburization

3. MATERIAL AND METHODOLOGY

This work aims to determine to study the mechanical properties of low carbon steel by the process of carburization using the hardness test and toughness test.

Mechanical properties are strength, hardness, toughness, elasticity, plasticity, brittleness, and ductility and malleability are mechanical properties 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 metal must withstand and how these are resisted.

3.1 Hardness test

Rockwell hardness testing is a general method for measuring the bulk hardness of metallic and polymer materials. Although hardness testing does not give a direct measurement of any performance properties, hardness correlates with strength, wear resistance, and other properties. Hardness testing is widely used for material evaluation due to its simplicity and low cost relative to direct measurement of many properties.

This method consists of indenting the test material with a diamond cone or hardened steel ball indenter. The indenter is forced into the test material under a preliminary minor load F_0 usually 150kg. When equilibrium has been reached, an indicating device, which follows the movements of the indenter and so responds to changes in depth of penetration of the indenter, is set to a datum position. While the preliminary minor load is still applied an additional major load is applied with resulting increase in penetration. When equilibrium has again been reached, the additional major load is removed but the preliminary minor load is still maintained. Removal of the additional major load allows a partial recovery, so reducing the depth of penetration. The permanent increase in depth of penetration, resulting from the application and removal of the additional major load is used to calculate the Rockwell hardness number.

In present experimental work Rockwell hardness was measured on carburized and tempered mild steel samples which are carburized under different temperature range of 850, 900 and 950 °C. For each of the sample, test was conducted for 5 times and the average of all the samples was taken as the observed values in each case. The Fig.1 shows the Rockwell hardness test.



Fig. 1: Rock well hardness test

3.2 Toughness (Charpy impact) test

The test is conducted for the three different samples carburized under the three different temperatures of 850, 900 and 950 °C. The test consist of measuring the energy absorbed in breaking a ASTM standard U-notched specimen by giving a single blow by swinging hammer. The specimen is simply supported at its ends. As the velocity of striking body is changed, there must occur a transfer of energy; work is done on the parts receiving the blow. The mechanics of impact involves not only the question of stresses induced, but also a consideration of energy transfer and of energy absorption and dissipation.

The ability of material to absorbed energy and deform plastically before fracture is called “toughness”. It is usually measured by the energy absorbed in a notched impact test like charpy or izod tests. In present work for each of the sample, test was conducted for 3times and the average of all the samples was taken as the observed values in each case. As shown in Fig. 2.0 below.

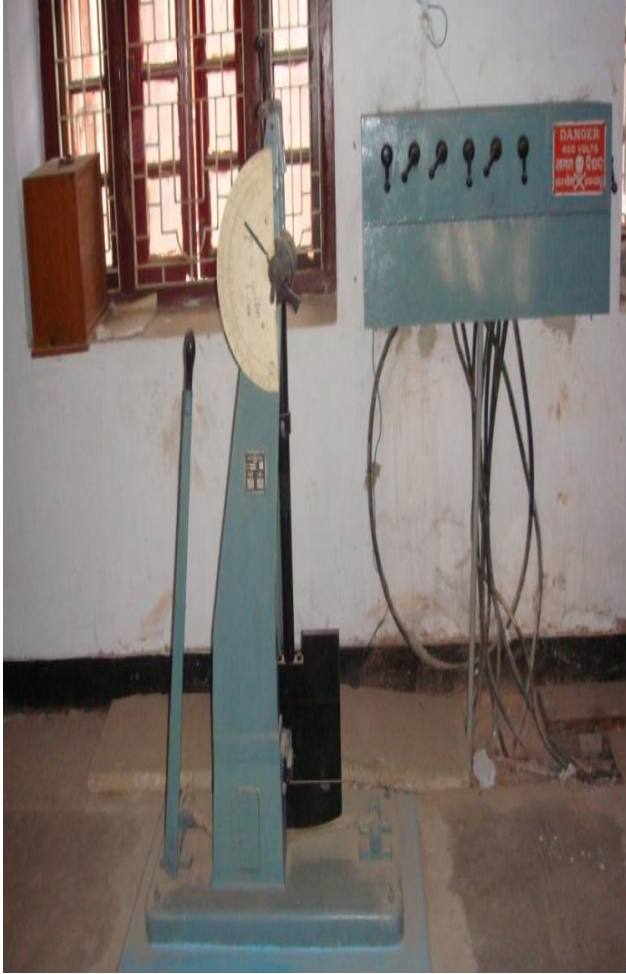


Fig. 2: Toughness (charpy impact) test

4. RESULT AND DISCUSSION

The result of hardness and toughness (charpy) can be summary in table one and two below in which their hardness numbers were found at different temperature that is 850,900,and 950⁰C.

Table 1: Hardness test Result

TEMP	I	II	III	AVERAGE
850	39	45	39	41
900	68	54	54	59
950	50	61	52	54

Table 2: Charpy impact test Result

TEM	I	ii	iii	AVERAGE
850	240	270	260	257
900	250	242	270	254
950	278	238	115	233

5. CONCLUSION OF THE RESULT

The mechanical and wear properties of mild steels were found to be strongly influenced by the process of carburization and carburizing temperature. The carburization process decreases the toughness of the mild steels. And the toughness is decreases with increase in the carburization temperature. Finally the net conclusion is that the mild steel carburized under the different temperature range of 850, 900, and 950⁰C with in which the mild steel carburized at the temperature of 950⁰C is giving the best results for the mechanical and wear properties like tensile strength, hardness and wear resistance.

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