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Improvement in Hardness of Mild Steel with Methane Carburization

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Abstract: In the present process the hardness behaviors of mild steels carburized at different temperature range of 860, 900 and 940°C have been studied and it is found that the simple heat treatments greatly improves hardness of the mild steels. The aim has been to examine the effects of these different gaseous carburization temperatures and conditions on the hardness 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 180°C for half an hour after these carburized and tempered mild steels are subjected for hardness test. The results of these experiment shows that the process of carburization greatly improves the hardness and this property increase with increase in the carburization temperature but apart from this if we increase temperature further then deformation in specimen dimensions occur. Therefore, experimental results shows that the mild steels carburized under different temperature range as stated above, with in which the mild steels carburized at the temperature of 940°C gives the best results for hardness because at this temperature it gives highest hardness, so it must be preferred for the required applications.

Keywords: Carburized Mild Steel, Hardness Test.

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 properties. The heat treatment and carburization increases the hardness. Carburizing is the addition of carbon to the surface of low-carbon steels at temperatures generally between 860°C and 940°C 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 martensite 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 martensite. 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.

Effect on Hardness

The hardness of the abrasives in relation with the applied loads and wear distances had affected the wear resistance significantly. Comparing Al_2O_3 and SiC abrasive papers, Al_2O_3 abrasive papers lose their sharpness more than SiC papers do, especially under higher loads.

Khusid et al [1] on his work studied the Wear of carburized high chromium steels and reported that Carburization raises the abrasive wear resistance and allows significant suppression of the adhesion phenomena under dry sliding. The results obtained determine the regime of surface hardening of high chromium steels required to produce the desired combination of wear resistance and bulk strength properties.

Baldissera and Delprete [3] studied effects of deep cryogenic treatment (DCT) on static mechanical properties of 18NiCrMo5 carburized steel and concluded that The soaking time parameter shows a strong influence on the hardness increase induced by the pre-tempering DCT and, under the assumption that the micro structural mechanism involves the entire process further improvements could be possible with a prolonged DCT exposure. The unchanged tensile strength

of the pre-tempering DCT groups could be related to a compensation effects due to the loss in residual stress, as it is reported by literature.

Carburization Temperature

The authors found that the hardness and abrasion resistance of carburized mild steels increased considerably with increase of carburization temperature up to 940°C and soak time up to 2 hours; use of coal tar pitch and quenching oil on mild steel surface and its subsequent carburization in charcoal greatly Improved the wear resistance of carburized mild steel; the highest abrasion resistance was observed in the steel samples carburized in partially burnt charcoal and the hardness and wear resistance values of mild steels carburized by using coal tar pitch were comparable with those of heat treated high carbon low Cr steels.

Bepari et al. [4] studied the effects of Cr and Ni addition on the structure and properties of carburized low carbon steels and found that both Cr and Ni promote the formation of retained austenite in carburized and hardened steel, Cr being more effective. Both were found to refine the martensite platelets, with Ni being more effective the hardenability was found to increase with increase of austenite grain size and with extent of carbon penetration in carburized steel materials, but very little attention has been paid in reducing the wear of farm implements materials. Thus, there is an urgent need to substantially upgrade the mechanical properties and wear resistance of low carbon and mild steels in actual soil conditions.

Methodology

In our investigation we follow heat treatment process in which gaseous carburization process we choose for our experiment. During the process, austenite transforms into martensite the hard layer of carbon surfaced up to 0.03 to 0.09mm. The specimen of given dimension are put into the furnace and methane gas (in which CO carbon mono oxide gas is in unstable state in furnace) is pass in appropriate proportion into the furnace chamber where specimen soak carbon for 2 hours at fixed temperature 860,900 and 940° C respectively. Then quenched in water and after that tempered in the furnace for half an hour at 180°C.

Materials Selection

Mild steels of the required dimensions were purchased from the local market and the test specimens were prepared from it. The chemical composition of mild steel by (wt %) is given as follows C-0.16, Si-0.03, Mn-0.32, S-0.05, P-0.2, Ni-0.01, Cu-0.01, Cr-0.01 and Fe.

Preparation of test specimens

The test specimen for analysis of hardness was prepared as per ASTM standard and its description is given below.
Specimen for hardness test:- The hardness is determined from the same specimen. A standard specimen of dimensions (4cm x 2.5cm x 0.5cm) of mild steel is prepared for the same purpose.

Figure 1. Specimen for Hardness Test

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 reach, 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 860, 900 and 940°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.

Results and Discussion

Hardness Test Results

In general heat treatment and carburization of mild steels resulted in an increase in hardness, tensile strength and wear resistance and decreases the weight loss during abrasion and toughness values. The tests results of different mechanical characteristics like tensile strength, toughness and hardness under the different carburization temperature of 860, 900 and 940°C is shown in Table 1. and summarized under the following points.

1. The hardness values varied between range of 52 HRC – 56 HRC and it is highest for the mild steel carburized at temperature of 940°C and is lowest for the mild steels carburized at 860°C, so with increase of carburization temperature the hardness values increases.
2. Finally the net results is that the mild steels carburized at 940°C is giving the best results for hardness.

Table 1. Rockwell hardness of carburized mild steel, at load 150 kg

Carburization condition		Tempering condition		Hardness(R_c)
Temp (°C)	Soak Time (Hrs)	Temp (°C)	Soak Time (Hrs)	
Simple Mild steel	-	-	-	20
860°C	2	200°C	0.5	52
900°C	2	200°C	0.5	55
940°C	2	200°C	0.5	56

Conclusions

From the present studies on "Hardness of carburized mild steels samples" the following conclusion have been drawn:

1. The carburization treatment followed by the water quenching appreciably improved the hardness of mild steels.
2. The carburization process decreases the toughness of the mild steels. And the toughness is decreases with increase in the carburization temperature.
3. Hardness increases with increase in the carburization temperature.
4. As comparing for different carburization temperature. The mild steels carburized at the temperature of 940°C shows the highest hardness. Finally the net conclusion is that the mild steel carburized under the different temperature range of 860, 900, and 940°C with in which the mild steel carburized at the temperature of 940°C is giving the best results.

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