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Study on Mechanical Properties of Carburized Mild Steel Subjected to Heat Treatment

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Abstract

Carburizing is one of the known cases hardening method that encouraged formation of carbon layer on the surface of a substance in order to improve the strength and hardness properties. The aim of present work is to improve the mechanical properties of the mild steels samples by using pack carburizing technique. In the present investigation the mechanical behaviors of mild steel carburized at different temperature range of 900^0 C and 1000^0 C are studied. The aim is to examine the effect of these different carburization temperatures and conditions on the mechanical properties of the carburized mild steel. The results of these experiment show that the process of carburization greatly improves the mechanical properties (case depth). Mechanical 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 show that the mild steel carburized under different temperature range as stated above, with in which the mild steel carburized at the temperature of 1000^0 C gives the best results.

1. INTRODUCTION

Agriculture is the spine of economy for most of the developing nations including India and a source of income for more than 60% of their population. Most commonly used ranch equipment used in agriculture are ploughs, harrows, cultivators, peddlers, furor opener, Kodaly, etc. Indian agro industries and village artisans usually use economically and in abundance available low carbon and mild steels for the manufacture of these farm equipment to suit every farmer, either rich or poor. Carburizing is one of the most generally used surface hardening processes. The method involves diffusing carbon into a low carbon steel alloy to form a high carbon steel surface. Carburizing steel is generally used as a material of automobiles, form implements, machines, gears, springs and high strength wires etc. which are vital to have the excellent power, toughness, hardness and wear resistance, etc. because these parts are normally 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 keep soft. 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 system of surface hardening of high chromium steels required to produce the desired combination of wear resistance and bulk strength properties. The results of an experimental investigation carried out by Akdemir et al. [2] on Impact toughness and microstructure of continuous steel wire-reinforced cast iron composite and reported that absorbed energy of the gray cast iron increases mainly with adding the Ductile reinforcement and also absorbed energy of the composite decreases with decreasing test temperature since the steel wire in the composite loses its ductility and behaves as a brittle material as the test temperature was decreased. He also reported that impact toughness of the gray cast iron was not improved with the increasing normalization temperature as there is no change in the morphology of graphite flakes in the gray cast iron with normalizing heat treatment. Normalizing heat treatment does not affect impact toughness of the cast composite significantly, because the partially dissolved region is very narrow due to inadequate volume fraction for the current work condition.

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. 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 harden ability was found to increase with increase of austenite grain size and with extent of carbon penetration in carburized steel. Izciler and Tabur [5] on his study of abrasive wear behavior of different case depth gas carburized AISI 8620 gear steel concluded that in respect with microstructures, samples subjected to longer periods of gas carburizing show greater case depth The samples having greater case depth and surface hardness are more wear resistant than that with low case depth. Celik et al. [10] studied the high temperature abrasive wear behavior of an as-cast ductile iron and reported that the high temperature tensile properties were affected by dynamic strain aging. Serrated flow was observed in the temperature range between 100^0 C and 300^0 C. In this temperature system, tensile strength values were almost invariable.

The present work aims to improve mechanical properties of mild steel by developing an economically possible carburization technique. Also the present work is valid not only for the farm implements but also for the applications like material of automobiles, machines, gears, springs and high strength wires etc.

2. MATERIAL AND EXPERIMENTAL DETAILS

Mild steel of the dimensions were taken from the workshop and the test specimens were prepared from it [6]. Specimen for toughness test:-A toughness test specimen as per ASTM standard is primed for the same purpose having the following dimensions. Length (5.5 cm), Width (1 cm), Thickness (0.5 cm), Notch depth (0.25 cm).

Toughness (Charpy impact) test: The test is conducted for the three different samples carburized under the two different temperatures of 900^0C and 1000^0C . The test consist of measuring the energy absorbed in breaking a ASTM standard U – notched specimen by giving a single blow by fluctuation 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 [9].

The ability of material to absorbed energy and deform plastically previous to fracture is called toughness. It is usually measured by the energy absorbed in a notched impact test like charpy izod tests. In current 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 [9].

Figure 2.1: Charpy impact tester for toughness

The oxidized layer of the as received sample was removed by polishing both upper and lower surfaces of the sample by doing its Pack Carburization [7].

Arrange the composition of charcoal and barium carbonate (as energizer) in 4:1 ratio for the pack carburizing of the mild steel samples at different temperatures for different holding time.

The First 3 samples were heat treated (Pack Carburization) in the Muffle Furnace at 900^0C for 1hr, 3hr and 5hr incessantly.

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Carburization Cycle – Sample were kept in the furnace and the furnace was switched on. After the furnace reached the requisite holding temperature (900^{0}C for each sample) the samples were allowed to be get soaked in the furnace for 1hr, 3hr and 5hr and then the furnace was switched off and samples were allowed to Air cool till the samples acquired the room temperature.

Then next 3 samples were heat treated (Pack Carburization) in the Muffle Furnace at 1000^{0}C for 1hr, 3hr and 5hr incessantly and follow the carburization cycle as mention in step (7).
Now for measuring the case depth highlight the end point of the sample by using the whitener and measure the diffusion distance of carbon at 100X magnification in all carburized samples and evaluate.

3. RESULT AND DISCUSSION

It is obtained from the table 3.1 that at the constant temperature when we are increasing the holding time increasing the carbon penetration. At 900^0 C the holding time varies from 1hr to 3hr and carbon penetration varies from 184.4544 µm to 1352.5866 µm and at 1000^0 C the holding time varies from 1hr to 3hr and carbon penetration varies from 798.8668 µm to 1547.3859 µm. Finally the figure 1 and 2 show the variation of carbon penetration with respect to holding time and It is obtained from the figure 3.1 and 3.2 that at the constant temperature when we are increasing the holding time increasing the carbon penetration.

Table 3.1: Carbon penetration in carburized sample at different temperature

Temperature and Time	Average Carbon Penetration (μm)	Value of "k" (μm/ s$^{1/2}$)
Sample at 900°C and 1hr	184.4544	3.0743
Sample at 900°C and 3hr	264.6418	2.5466
Sample at 900°C and 5hr	1352.5866	10.0816
Sample at 1000°C and 1hr	798.8668	13.3145
Sample at 1000°C and 3hr	901.6798	8.6764
Sample at 1000°C and 5hr	1547.3859	11.5335

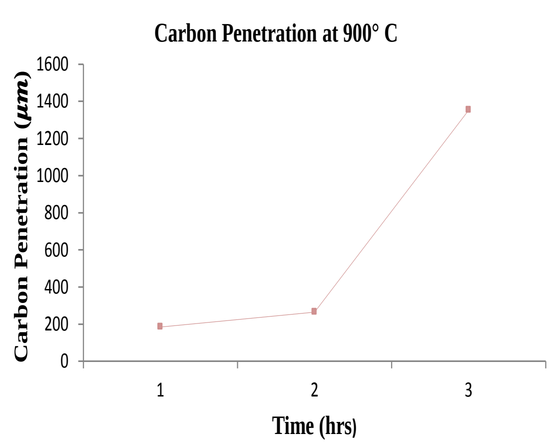

Figure 3.1: Carbon penetration at 900oC

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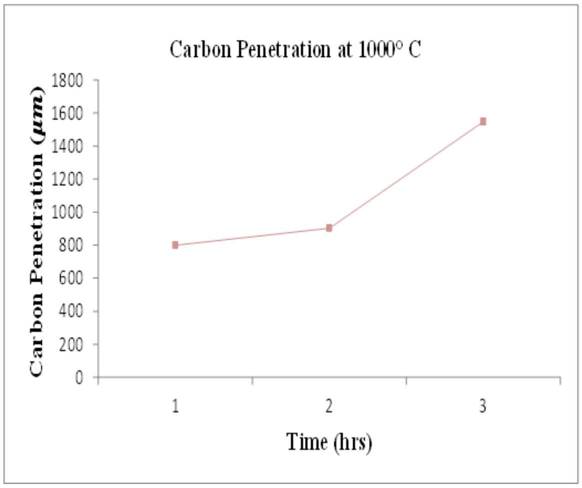

Figure 3.2: Carbon penetration at 1000Oc

It is also obtained from the toughness test results that. As the carburization temperature increases from value of 900^{0}C – 1000^{0}C, there is a small decrease in the toughness values from 37J – 32 J, so it is concluded from the results that with increase of carburization temperature, the toughness values decreases.

Table 3.2: Result of toughness test of carburized mild steel

Carburization condition		Tempering condition		Toughness , Joule (Nm)
Temp (^{o}C)	Soak time (Hrs)	Temp (^{o}C)	Soak time Time (Hrs)	
Room temperature	-	-	-	54
900^{o}C	2	200^{o}C	0.5	35
1000^{o}C	2	200^{o}C	0.5	32

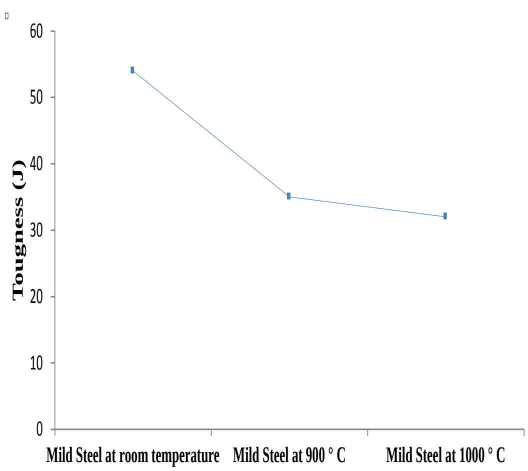

Figure 3.3: Variation of toughness with carburizing temperature

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4. CONCLUSION

From the present studies on "Mechanical properties of carburized mild steel samples" the following conclusions have been drawn.

1. Case depth in the carburization process increases with increasing the holding time and temperature.

2. The carburization process decreases the toughness of the mild steel and the toughness is decreases with increase in the carburization temperature.

3. Finally the net conclusion is that the mild steel carburized under the different temperature range of 900^0C, and 1000^0C with in which the mild steel carburized at the temperature of 1000^0C is giving the best results for the mechanical and wear properties like hardness and wear resistance.

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