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International Journal for Scientific Research in Modern Engineering and Science

International Journal for Scientific Research in Modern Engineering and Science, 2(4): 14-18 (2021)

CARBURIZATION EFFECTS ON THE MECHANICAL AND WEAR PROPERTIES OF MILD STEEL - A REVIEW

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Abstract

The mechanical and wear properties of steel and iron component can be altered using the heat treatment process. The type of heat treatment process that are applied generally are carburizing, quenching and tempering. This paper discusses about the carburization process, then some research works related to carburization of the mild steel and then finally the conclusions are discussed followed by the suggestions for the future work.

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1. Introduction

Carburization is a type of heat treatment process in which heating the steel or iron component by packing in the carburizing medium and increasing the temperature, there is improvement of mechanical and wear properties of the component. Earlier, low carbon wrought iron parts were packed with charcoal and then the packaging was heated at high temperatures for several hours. After that the entire heated parts was put into water for cooling. This whole process was done to make the outer part of the iron more harder and to improve the mechanical properties of the inside or core part. Carburizing process is shown in fig.

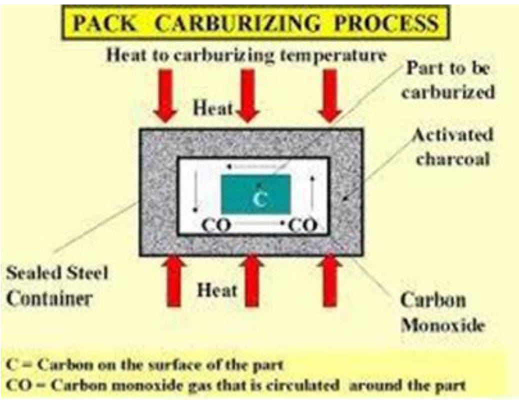

fig. 1 Pack carburizing process

Manufactures and producers used this carburizing heat treatment method to improve the mechanical and wear properties of the steel parts and components. Mechanical and wear properties include tensile strength, ultimate strength toughness, hardness, impact resistance, ductility, machinability, etc. The improvement of these properties largely depend on a number of parameters of carburizing, such as carburization temperature, carburizing medium, carburizing time, soaking time, carbon potential, cooling medium and cooling time.

2. Some research works with the application of Carburizing heat treatment of mild steel

Kharia et al. performed the comparative investigation of different carburizing medium and their effect on the wear properties of mild steel. Carburizing medium taken were charcoal, cow bone , CaCO3. Cylindrical specimen of 10x20 mm dimensions were prepared for the adhesion wear test, according to ASTM (G99-04) specifications. Carburizing, then quenching followed by tempering process were performed. For that, firstly the specimen of mild steel was carburized at 925oC for soaking time of 2 hours and left for cooling in furnace. The carburized specimen were further reheated at 870oC for half hour and the left for water quenching followed by tempering at 160oC for 1 hour and then left to cool in air. These carburized and tempered mild steels were subjected to adhesive wear test and hardness test. From that they obtained the results that the carburization process contributed in increase of wear resistance. Cow bone compound having CaCO3 energizer had 2.32 mm of carburizing case depth and gave the highest wear resistance, while charcoal compound had 1.1 mm of case depth. The process shows increase in the hardness of mild steel.

Hesham et al. studied the changes in the mechanical properties of mild steel in the temperature range of 850°C to 950°C during carburization and subsequent tempering for 30 minutes. An improvement in hardness and tensile strength was observed during the hardening process. The strength and hardness of mild steel increased with the increase of carburizing temperature. The results also show that the toughness of mild steel decreases with increasing temperature and further decreases. The highest tensile strength and hardness were achieved at a carburizing temperature of 950°C. Therefore, this temperature should be the first choice for carburizing applications.

Fatai Olufemi et al. used pulverized bones as the carburizing medium during the carburization process of mild steel, to determine the effect of this method on the mechanical properties of mild steel. The carburizing temperature was selected as 850°C, 900°C and 950°C, followed by soaking treatment. The mild steel was then cooled in oil at the carburizing temperature for 15 minutes and 30 minutes, and tempered at 550°C. Before the carburization process, the standard samples prepared from the as-received specimen were subjected to tensile and impact tests and the data obtained were used to calculate the maximum tensile strength, engineering strain, impact strength and elastic modulus. The hardness of the case and core of the hardened sample was measured, and it was observed that the mechanical properties of mild steel depend to a large extent on the carburizing process, the carburizing temperature and the soaking time at the carburizing temperature. Carburizing at 900°C, soaking for 15 minutes, carburizing at 850°C, soaking for 30 minutes, then oil quenching and tempering at 550°C is better because they have a harder shell and softer core.

Mahmoud Adly et al. studied the impact of using different coke sizes on the mechanical properties of carburized mild steel. For this purpose, 5 sets of samples were prepared, and then carburization treatment was done at distinctive temperatures and times. Three sets were carburized at 850, 900, and 950oC for 120 minutes, and the alternative was carburized at 1000 and 1050°C for 120 minutes. All sets were carburized with 3 distinctive sizes of coke, particularly A (< 0.4 mm), B (1: 1.6 mm), and C (4:5 mm). After carburizing, all sets were cooled in water followed through temper treatment at 200°C for 15 minutes. After tempering, microstructure test, hardness test, Charpy effect test, tensile test, and adhesive wear test were accomplished on various mild steel samples. The evaluation of the experimental consequences suggests that the mild steel carburized at 1050∘C with the common coke particle size B (1-1.6 mm) gave great results for the mechanical and wear properties, which may be The final result of the microstructure (core of martensite and bainite) obtained at this temperature. The results suggest that the coke size B affords the great mixture of surface area and porosity required for reaction kinetics, in addition to the highest wear resistance after carburization treatment at distinctive temperatures.

A. Oyetunjiet al. used palm kernel shells, animal bones (bones of cattle and mammals) and mussels (oyster shells) as carburizing medium to carburize 0.078% C mild steel. Samples were prepared for hardness and tensile tests. They are crushed into a fine powder and barium trioxycarbonate (BaCO3) as an activator was used for the carburizing process. Three rectangular boxes made of stainless steel plates were made to contain each steel sample. The steel box is mixed with 20% by weight of BaCO3. The sample is completely covered by each box, and the carbohydrate mixture is added to the oven. The carburizing temperature is 700 ~ 1100℃, and the holding time is 1 ~ 1100℃, 5 hours. After carburizing in the oven, cool the box and its contents to room temperature. After holding at this temperature for 30 minutes, all samples were heated to 850°C and cooled in oil. This is to increase the hardness of the case. Fifteen (15) of these samples were further heated to 350°C and kept for 2 hours to reduce the stress accumulated during tempering. This is done to increase the hardness of the watch case. Five (15) of the samples were heated to an additional 350°C and kept for 2 hours to reduce the stress accumulated during cooling. Display durability test, tensile test and chemical analysis. The hardness value of the untempered sample is higher than that of the tempered sample at the carburizing temperature of 700℃, 800℃ and 900℃. On the other hand, the tensile strength of the tempered sample is higher than that of the untempered sample. Samples with carburizing temperatures of 700°C, 1000°C and 1100°C. The results of carbon analysis show that palm kernels and animal bone shells are suitable as high temperature (above 10,00°C) carburizing media, with a holding time of more than 1 hour.

3. Conclusion

1. Carburization heat treatment process and carburization temperature has a great impact on mechanical and wear properties of mild steel.
2. The increase in carbuzisation temperature decreases the toughness of mild steel.

3. Carburization process increases the stiffness, but with the increase in carburizing temperature, stiffness is decreased.
4. Tensile strength and hardness increase with the increase in carburization temperature.
5. An increase in soaking time results in increase in hardness and tensile strength.
6. As the hardness increases, wear resistance increases but due to abrasion and wear rate, there is decrease in weight loss.
7. With the increase in the applied load, there is increase in wear volume, wear rate and weight loss due to abrasion.
8. With increase in the carburization temperature, wear volume, wear rate, toughness and weight loss due to abrasion decreases.

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