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Effect of Carburizing Temperature and Size Schleichera Oleosa Carbonized Chorcoal on the Mechanical Properties of Low Carbon Steel

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***Abstract*—Steel contain a considerable concentration of iron alloy and carbon when compared to other elements. Furthermore, carburzing process is used to improve mechanical properties of this metal through the addition of an activated carbon. This study used rough and smooth sizes of schleichera oleosa wood charcoal in the carburizing process to diffuse into low carbon steel surface. Furthermore, low carbon steel were heated in a furnace with temperature variations of 800°C, 850°C, 900°C and holding time of 60 and 90 minutes then submerged into a water medium to cool. The results of this process showed an increase in steel hardness using smooth charcoal with increased temperature and a roughness value of 551 HV. Meanwhile, rough charcoal size has a higher hardness value than smooth charcoal, but declines when heated up to 900°C. However, the highest hardness value for rough charcoal size is 682.6 HV.**

Keywords—carburizing, temperature, size schleichera oleosa, low carbon steel introduction

I. INTRODUCTION

Low carbon steel is a structural steel produced in large quantities for construction of buildings, bridges, cranes, ships, towers and vehicles. This steel contains a carbon element of 0.2% with relatively large ductility and low mechanical properties, in a way it shows permanent strains before failure. However, presence of low carbon content renders it inferior for certain end product applications, in material engineering this metal is given special treatment to increase presence of carbon content. Meanwhile, hardening process is carried out to obtain a harder surface while maintaining ductility of the inside.

Abdulrazzaq examined the surface hardening process of low carbon steel by cooling oil. Furthermore, mechanical properties discovered through carburizing process are microstructure, hardness in addition to wear resistance at various temperatures between 850°C, 900°C, and 950 °C with holding time of 2 hours. The result of this experiment reveled at 850°C, specimen hardness increased from 102 to 250 HV, while increase in temperature from 900°C to 950°C hardness of this metal equally augmented from 105 to 272 HV and from 115 to 192 HV respectively. Meanwhile, for high wear resistance, the 950°C carburizing sample was maintained for 2, 4 and 6 hours with results as follows, at 2 hours the wear rate was 9.99 * 10-6g /m for 4 hoursit increased to 12.7 * 10 6g /m and finally became 15.13 * 10-6g /m at 6 hours [1].

According to Betan et al., improved mechanical properties of low carbon steel carries out the carbonization process of schleichera oleosa charcoal with a holding time of 1, 1.5 and 2 hours using a temperature variation of 800°C, 850°C, 900°C in water and oil quenching. Furthermore, results of the experiment indicate best shear strength occurs at a temperature of 800°C [2].

Ihom et al. conducted experiments on various organic waste to increase the surface hardness of mild steel. These materials include sugarcane, rice husks, eggshells, melon shells, arecaceae flower dung, plastic, polyethylene, and charcoal. Meanwhile, before the experiment it becomes necessary to prepare materials in various shapes and sizes before been mixed with mild steel specimens, and heated in a furnace at 920°C for 5 hours then cooled in water. The specimens were tested for hardness using a Rockwell hardness testing machine. Furthermore, outcome of this investigation identified organic waste also increases surface hardness of steel. Moreover, organic wastes used shows an increase in hardness value of mild steel specimens exceeding 30 HRC hardness values of the previous mild steel specimens [3].

Furthermore, variations in carburizing temperature and holding time against the mechanical properties of AISI/SAE1020 steels were examined. Meanwhile, specimens were produced based on standard tests, then a hardening process was carried out using a carbon palm shell with a temperature of 800°C, 850°C, 900°C and 950°C with about 60 to 120 minutes holding time, then cooled in oil and tempered at 500°C for 60 minute. Also, after the carburizing process, samples were tested for tensile, impact and hardness. These data were then calculated as ultimate tensile strength (UTS), impact strength and core hardness of carburizing samples taken through an optical microscope to observe shapes of the microstructure. The results shows at 800°C, 850°C and 900°C, UTS together with micro hardness initially decreased but later increased with growing carburizing temperature at 950°C. This experiment was conclude by noting optimum mechanical properties only occurs at a carburizing temperature of 950°C and hold for 120 minutes followed by oil quench and temper at a temperature of 500°C for 60 minutes [4].

Oluwa Femi et al., conducted an experiment using a mixture of palm and coconut shells as carburetor for low carbon steel at a temperature of 950°C geared towards tensile and hardness properties. Prior to use, these materials were cleaned, dried, ground and sieved to a particle size of 150 µm, then was later mixed with various compositions including calcium carbonate (CaCO3) weighed 20% as an energizer. The research included seven tensile and hardness samples carburized with different carburetor composition, then quenched and forged at a temperature of 450°C for forty-five minutes in a heat treatment furnace. Furthermore, obtained properties shows better with the carburetor mixture than with a single substance [5].

Carburizing involves changing the carbon content of the surface followed by quenching to convert the surface layer into martensite. The process is normally carried out on steel containing less than 0.2% C. The carburizing treatment is used to raise the carbon content of the surface layer by about 0.7 and 0.8% C. A large difference in carbon content is required, because quenching is followed by carburizing which affects both the core in the surface layer and the surface layer are converted to martensite, but the core remains soft and ductile. The usual carburizing method is pack carburizing steel components heated to a certain temperature in a closed metal box containing carburizing media, namely carbon-rich materials such as charcoal and an energiser as barium carbonate. Gas carburizing is a process carried out by heating the components in a furnace in a carbon-rich gas rich atmosphere which results in diffusion of carbon into the surface austenitic layer.

This study emphasized on use of schleichera oleosa charcoal as a carbon element to improve the hardness and microstructure of low carbon steels. Meanwhile, to increase the hardness of this metal a certain amount of carbon was added depending on temperature, holding time and charcoal used.

II. Research Methodology

A. Material Preparation

Carbon steel used for the hardening process is low carbon steel (ST 37) with a chemical composition of 0.10% C, 0.50% Mn, 0.009% S, 0.056% Cr and 0.025% N. In addition, specimens for hardness testing were produced with a diameter of 20 mm and 10 mm height. Furthermore, charcoal mashed in form of smooth and rough powder was used as an activation carbon. The material were then put into a stainless steel box ready for carburizing at 800°C, 850°C, 900°C with holding times of 60 and 90 minutes respectively, then slowly cooled in water media. Figure 1 below shows the Carburizing process.

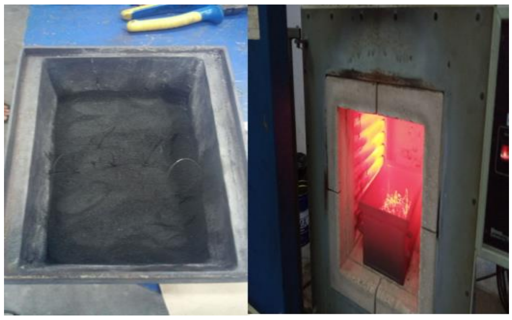

Fig. 1. Lion elektro therm.

Low carbon steel resulting from carburization were tested for hardness, beginning with a surface polishing process then etched. Furthermore, this test was carried out on a Mitutoyo HM-200 Machine using the Vickers method. Figure2 shows the Mitutoyo Hardness Testing Machine used.

Fig. 2. Mitutoyo hardness testing machine.

Meanwhile, data on of hardness tests carried out are represented in the table below. Moreover, outcomes displayed have gone through calculations for the average of each treatment with 4 samples each. Table 1. Vikers hardness test results data.

III. Results and Discussion

A. Hardness Value Analysis

The vickers hardness value of samples from carburizing process are detailed in table 1. In addition, values for the sample carburizing process used 2 sizes of schleichera oleosa charcoal, specifically fine and coarse particles at 800°C, 850°C, 900°C with different coal measurements and a constant holding time then cooled in water. The outcome of this experiment showed in fine charcoal sizes, each increase in temperature equally raises the hardness value and therefore the highest point occurred at a temperature of 900°C with 551 HV.

TABLE I. Vickers Hardness Test Result

Temperature	**Holding Time**	**Size Schleichera Oleosa**	**Vickers Hardness**

			(HV)
800 °C	60	Smooth Size	198
850 °C	60	Smooth Size	250,6
900 °C	60	Smooth Size	551
800 °C	90	Rough Size	368,8
850 °C	90	Rough Size	682,6
900 °C	90	Rough Size	677,8

Furthermore, by increasing the hardness of Vickers, carbon charcoals were able to diffuse and bind well to steel surface when cooled slowly in water according to the instructions in (Figure 3). However, this is different from rough charcoal size where with higher emperature, hardness of the vickers decreases at 900°C. This therefore shows larger carbon charcoal sizes processed at high temperatures, will increase diffusion processes to the metal surface.

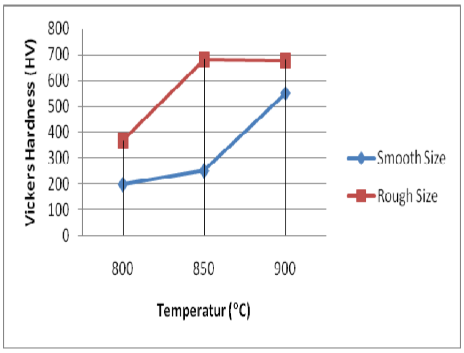

Fig. 3. Effect of carburizing temperature and size schleichera oleosa on vickers hardness.

B. Microstructure Analysis

From observations carried out, samples processed by carburing at 800°C with a 60 minutes holding time using fine carbon charcoal show a small martensite, pearlite and most of the ferrite structure as shown in Figure 4.

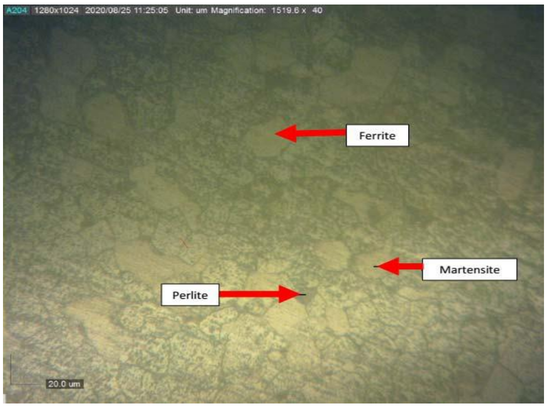

Fig. 4. Microstructure photo at 800°C with holding for 60 minutes.

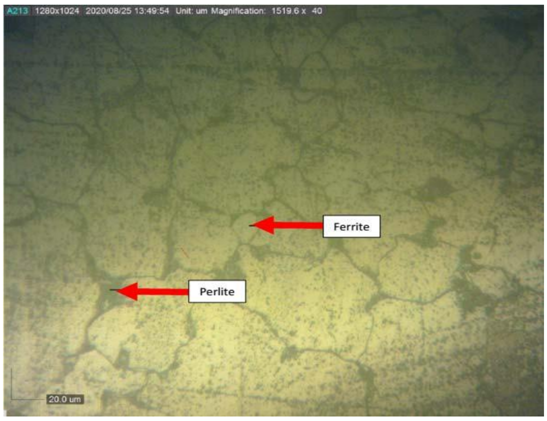

Fig. 5. Microstructure photo at 850°C with holding for 60 minutes.

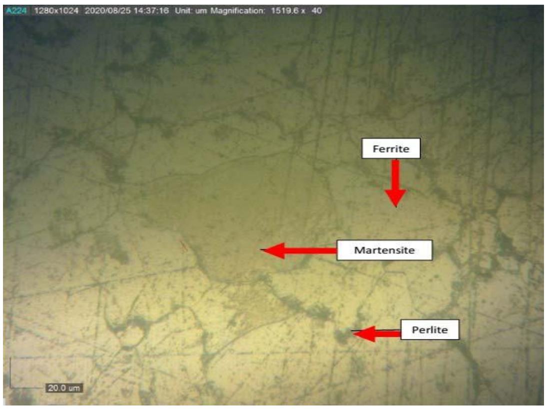

Fig. 6. Microstructure photo at 900°C with holding for 60 minutes.

Furthermore, for specimens with carburizing process at 850°C and holding time of 60 minutes, shows the ferrite microstructure has begun to decrease and a more dominant pearlite structure appears therefore increasing the hardness as shown in Figure 5.

The specimen microstructure for carburizing process at 9000C with a 60 minutes holding time also shows small portion of ferrite, however cementite structure already exists but is relatively small and dominated by martensite in addition to pearlite structures. Therefore, the hardness in this condition increases when compared to previous treatments as shown in Figure 6.

The following identifies microstructure for carburizing process at a temperature of 800°C with a 90 minutes holding time. The outcome of this observation for sample showed a different microstructure change compared to previous one where samples was dominated by martensite structure in addition to a small portion of ferrite and pearlite as shown in Figure 7.

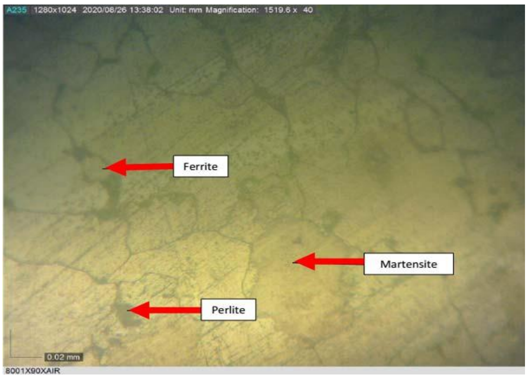

Fig. 7. Microstructure photo at 800°C with holding for 90 minutes.

The microstructure for carburizing process at 850°C with a 90 minutes holding time shows pearlite structure formed in grain boundaries is increasingly dominant. However, from results obtained, the hardness value increases as shown in Fig. 8.

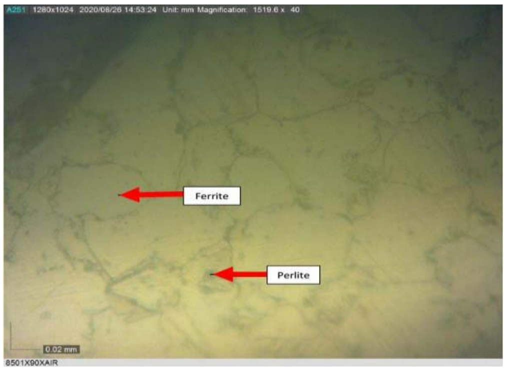

Fig. 8. Microstructure photo at 850°C with holding for 90 minutes.

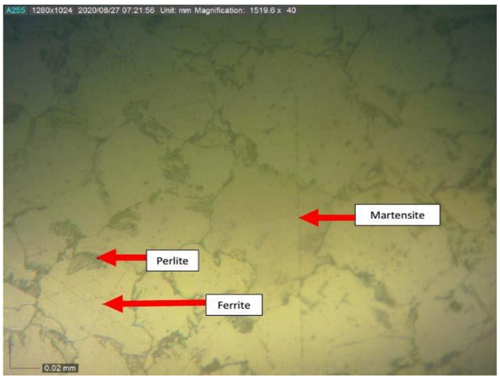

Fig. 9. Microstructure photo at 900°C with holding for 90 minutes.

Furthermore, for samples treated with a temperature of 900°C with a 90 minutes holding time, the martensite and pearlite structure are noticed therefore produces a fairly good hardness value. However, when compared to hardness value of samples in Figure 8, the mechanical properties becomes lower as shown in Figure 9.

IV. Conclusion

In conclusion, from the research conducted sizes of charcoal greatly influence hardness of steel, however with higher temperature of carburizing process surface hardness of this metals gradually decreases.

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