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Mechanical Properties of Imitation Sprocket Due to Treatment of Candlenut Shell Charcoal

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***Abstract*—The sprocket as a component of motorcycle manufactured to transmit rotary motion between two shafts are supposed to possess wear resistant properties. This motorcycle part are however produced in different wear resistance levels especially low, medium and high. Meanwhile, low grade sprocket (imitation) are known to wear off easily, however this challenge are usually tackled by increasing the surface hardness. Furthermore, carburizing process is one of the different ways to increase surface hardness of sprockets in direct contact with chains. This study therefore aims to utilize nutmeg shell as an activated carbon for hardening sprocket. The experiments was conducted with carburizing process at temperatures of 850ºC to 900ºC and 1 hour holding time then quenched in water, brine or oil media. The outcome of this study showed mechanical properties of imitation sprocket increased from 103.2 HV to 452.65 HV at 850ºC with water quenching.**

Keywords—carburizing, temperature, candlenut shell, imitation sprocket

I. Introduction

Motorbikes are one of the vehicles widely used as an important means of transportation. This selection is based on several advantages compared to other travel options due to the numerous pros, including more economical use of fuel where one liter of fuel is used to travel 50 - 80 km, requires a small parking area about 1 mx 2.5 m, plies narrow roads, purchased at a relatively affordable price, suitable for congested road conditions and significantly cheap maintenance costs.

Being a popular means of transportation in the society, motorbikes require regular maintenance and repair. Subsequently, periodic care is possible if supported by available spare parts. These parts are selected based on several factors, including the materials' mechanical properties. The components usually produced are categorized into various groups, including high, middle, and low class. Furthermore, presence of spare parts products in clusters aims to provide opportunities for consumers to adjust current financial conditions during the maintenance and repair of motorbikes. Also, use of parts with lower quality easily damages the component.

The sprocket is a motorcycle spare part with the function to transfer power. These components require mechanical properties resistant to friction and characterized by high hardness properties. Furthermore, the quality types are influenced by various elements contained in the products of heat treatment processes. Also, the carbon is an important component needed during the procedure. The material with greater carbon content demonstrates better mechanical properties. This element exists as waste in candlenut or pecan shells.

The skin of hazelnut has been widely used as an ingredient for mosquito coils or charcoal. Moreover, the shell fuel waste is used again as briquettes for environmentally friendly, alternative energy source [1]. Also, from the point of technological developments, advances in material sector related to mechanical properties are relatively low. Moreover, natural waste materials, including coconut shells, Schleicher charcoal has resumed development as one of the carbon elements used to improve mechanical properties [1]

W.S. Jaman et al examined low carbon steel as an alternative material to make dodos [2]. The carburizing pack method is a surface hardening method possibly suitable for application to dodos. Furthermore, parameters of the solid carburization method varied with temperature, holding time, and composition of carburizing material. Subsequently, maximum hardness was obtained at a temperature of 950 ºC, holding time 30 minutes, and a charcoal composition of 50% + 50% barium carbonate to obtain a value of 55.49 ± 3.74 HRC. The minimum hardness conditions is at 900ºC, 15 minutes, and with composition of 70% shell charcoal + 50% barium carbonate to obtain a value of 42.63 ± 5.29 HRC [2].

M. I. Fahreza et al tested the hardness quality of AISI 1050 steel before and after the solid carburizing process using 80% coconut shell charcoal as carbon and 20% eggshell as hardener, in a holding time of 60 and 90 minutes with oil and saltwater quenching media. The results obtained showed the highest increase in hardness value was at 90 minutes using saltwater quenching [3].

According to a report by K. Priyono et al, heat treatment improves the microstructure and mechanical properties of JIS S45C steel. Furthermore, the highest hardness was obtained at 850 and 900ºC in combination with temperature variations of 800ºC to 900ºC for 15 minutes and quenching in SAE 40 oil media, was 52.3 and 54.5 HRC, respectively or about 567 - 576 HV [4].

A. Murtiono examined heat treatment at an austenite temperature of 830 ºC for 45 minutes cooled with ice, free air and tempered at temperatures of 550ºC, 600ºC and 650ºC with a long holding time between 1- 2 hours. The test shows the optimum hardness value was 825.6 BHN quenched at 830ºC and 333 BHN, tempered for 1 hour at 550ºC. The outcome of tensile test shows yield strength was 607.72 MPa and the ultimate strength was 939 MPa. In addition, the amount of grain increase from the raw material was between 5.6 μm to 5.9 μm after quenching and tempering increased to 6.12 μm, 6.93 μm, and 7.15 μm [5].

Y. Handoyo investigated JIS S45C steel, and developed a distinctive concept known as quenching and Tempering. The conventional quenching technique conducted at 880ºC with holding time of 50 minutes, and cooling media quench of oil and water. Similarly, the process of Tempering conducted at 560ºC with a holding time of 40 minutes. Testing conducted : The chemical composition were evaluated through macro structure, hardness and metallography testing. The techniques shows the carbon steel S45C in a medium with 0.45% carbon content. Furthermore, a non heat specimen treatment possesses an average hardness result at the upper and lower section of 19.2 and 18.8 HRc, respectively, while the microstructure was from pearlite and ferrite. The heat treatment at 880ºC with quenching media of oil had an average hardness result of 35,3 and 31,6 HRc for the upper and lower, while the microstructure comprises of bainite and martensite. Also, the treatments at 880ºC had water as the quenching media, with an average result 43,5 and 37,5 HRc respectively, with bainite and martensite as the dominant microstructure. The specimen treated at 880ºC with oil as the quenching media, and continued with a tempering temperature of 560ºC, and water as the cooling media resulted in hardness of 26,8 and 23,3HRc, respectively, while the microstructure were bainite and martensite. In addition, those exposed to 880ºC and a quenching media of water, with continues tempering at 560ºC, and water as the cooling media had an average hardness 27,8 and 26,6HRc for the upper and lower section correspondingly. The microstructure include bainite and martensite smooth [6].

Betan et al investigated the shear strength properties of low carbon steel hardened using schleichera oleosa charcoal. The hardening process involved temperatures of 800ºC, 850ºC, 900ºC and a holding time of 1 hour, 1.5 hours and 2 hours. These were then cooled in water and oil media. The results shows the highest hardness character of 11396 N / mm² at a temperature of 800ºC, with a holding time of 1 hour and oil applied during cooling [7].

II. RESEARCH METHODOLOGY

A. Material Preparation

The sprocket used for the hardness test specimen was the Grand 33T model manufactured in China (Figure 1). The sprocket was subjected to the initial Vickers hardness test using the Mitutoyo HM-200 engine.

Fig. 1. The Grand-33T sprocket made in China.

This was followed by the process of preparing the hardness test specimen. In addition, imitation sprockets were utilized using a milling machine accompanied by cooling water to avoid phase changes before heating. The carbon used for the carburizing process of imitation sprockets is candlenut shell or hazelnut skin originally burnt to produce charcoal. Furthermore, the charcoal is mashed using a hammer made of wood.

B. Imitation Sprocket Carburizing

The sprocket used for the surface hardening process is the grand-33T model Manufactured in China (figure 1). The steps of the imitation sprocket carburizing process are characterized by; 1. Binding hardness test specimens using fire-resistant wire in order to facilitate the lifting process out of the box. 2. Place candlenut shell charcoal into the box followed by the hardness test specimen. 3. Put the box into the heating chamber and close the door. 4. Adjust the carburizing temperature and holding time. 5. Remove the specimen from the box using the tweezers to place it into the cooling medium.

Fig. 2. Stages of the Carburizing Process.

C. Hardness Testing Process and Microstructure

Subsequently, the sprockets was lifted out of the heating chamber, cooled off in a cooling medium and hardness-testing process was performed. In addition, the carburized sprocket specimen were flattened on the surface of the polishing machine, further placed on the base of the Mitutoyo HM-200 engine for compression. Figure 3. as reported by A. Wisnujati shows the procedures involved in pressing an imitation sprocket specimen using a pyramid-shaped indenter at several points to produce data accuracy [8].

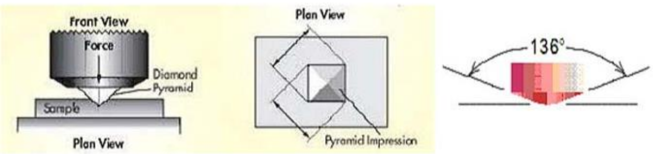

Fig. 3. Hardness testing with a pyramid indenter.

Fig. 4. Specimen polishing process and microstructure test.

For photos of microstructural specimens, the surface are etched to facilitate visibility with a magnifying lens (figure 4).

D. From the Test Results of Mitutoyo Test Machine

Vickres hardness value are obtained as in table 1.

TABLE I. VICKERS HARDNESS TEST RESULT

Quenching	Holding Time (hour)	Temperatur (°C)	Vickers Hardness (HV)
Sprocket Imitation	0	0	103,2
Water	1	850	452,65
Brine	1	850	267,97
Oil	1	850	333,5
Water	1	900	278,6
Brine	1	900	291,6
Oil	1	900	394,65

III. RESULTS DISCUSSION

A. Hardness Value Analysis

Furthermore, data from Vickers Hardness Test results outlined the hardness values for several carburizing processes with two temperatures and different quenching variations produce contradictory hardness values.

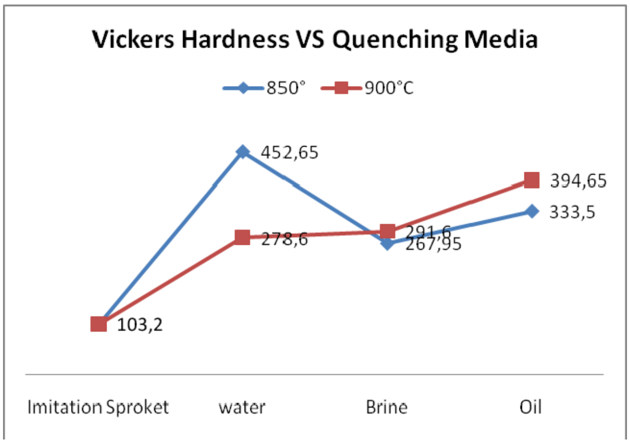

Fig. 5. The effect of quenching variation on the vickershardness value.

Figure 5 above shows the effect of quenching media temperature due to candlenut shell carbon treatment during carburizing process. Furthermore, changes in level of hardness were noticed to vary where for temperature, the quenching process in water media was relatively higher at about 850°C when compared with other media. However, when specifically examined in various quenching media at a temperature of 850°C, the hardness value decreased in brine but increased in oil medium. Meanwhile, at temperature of 900°C, the hardness value increases every time a different quenching process was used. In general, the hardness value of this imitation sprocket increased when carburized with candlenut shell charcoal.

B. Vickers Hardness Value Analysis Based on Microstructure

This involves analysis of microstructural specimens from carburizing process with the aim of outlining the occurring phases. Furthermore, in Figure 6, the phase structure due to sprocket treatment at 850°C with water quenching media becomes visible. Meanwhile, shape of perlite phase is noticed around the considerable ferrite surroundings. The value of vicker hardness in this condition is relatively high, specifically at 452.65 HV.

Fig. 6. The microstructure of the carburizing process at a temperature of 850 C with water quenching media for candlenut shell carbon charcoal.

Figure 6 shows the phase structure due to treatment at 850°C with brine quenching media, however this is totally different from water quenching media. Furthermore, in this treatment variable, the new pearlite structure appears in small quantities,therefore resulting in a hardness value of 267.97 HV. Meanwhile from Figure 5 and Table 1, hardness value of the sprocket specimen in this condition is lower than all other samples.

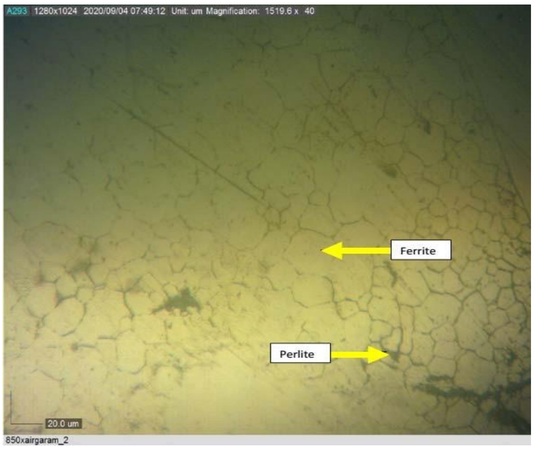

Fig. 7. The microstructure of the carburizing process at a temperature of 850 °C with brine quenching media for candlenut shell carbon charcoal.

In addition, resulting microstructure here is almost the same as in figure 7. However, in this variable condition with oil quenching media, pearlite structures present at the grain boundaries are relatively small and visible in almost all ferrite areas as shown in figure 8.

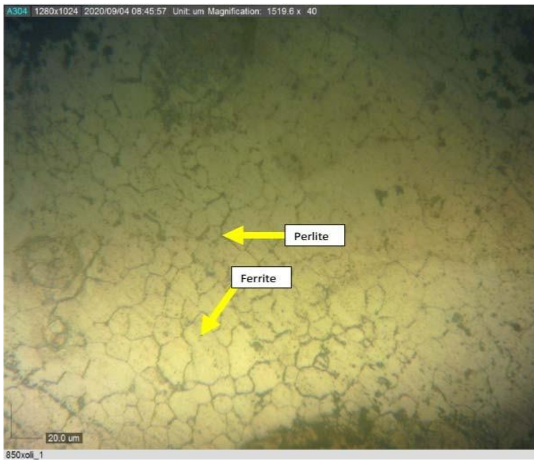

Fig. 8. The microstructure of the carburizing process at a temperature of 850 °C with oil quenching media for candlenut shell carbon charcoal.

The hardness value for this specimen was 333.5 HV, an increase of about 2.4% from specimen used in Figure 8. This microstructure condition was dominated by ferrite phases as the matrix.

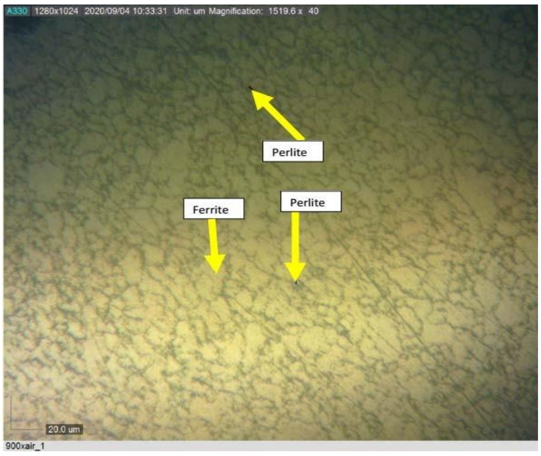

Fig. 9. The microstructure of the carburizing process at a temperature of 900°C with water quenching media for candlenut shell carbon charcoal.

In Figure 9 above, the treatment is at a temperature of 900°C with oil quenching media. Furthermore, results of microstructural photos shows structure of the perlite phase with same composition in most ferrite area, however hardness value is relatively the same as in Figure 8. The vickers hardness value is 278.6 HV. Meanwhile, when compared with specimens using water quenching in carburizing process at 850°C, the hardness value of the vickers decreases significantly.

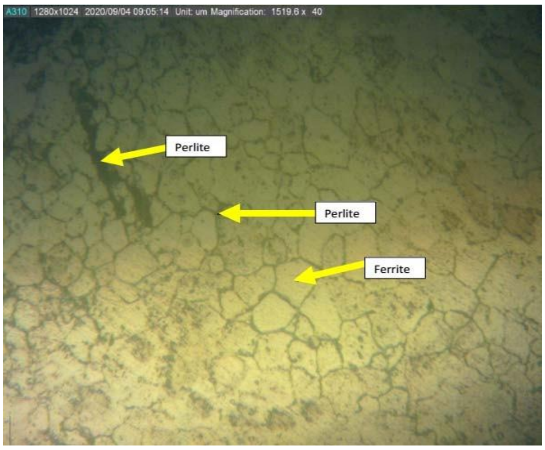

Fig. 10. Microstructure of the carburizing process at a temperature of 900 °C with brine quenching media forcandlenut shell carbon charcoal.

Meanwhile for the carburizing process at a temperature of 900°C with brine quenching media as shown in Figure 9. The outcome of this experiment produces more perlite microstructure than water quenching media at the same temperature. However, when compared with the same quenching medium at a temperature of 850°C, the vickers hardness value has increased.

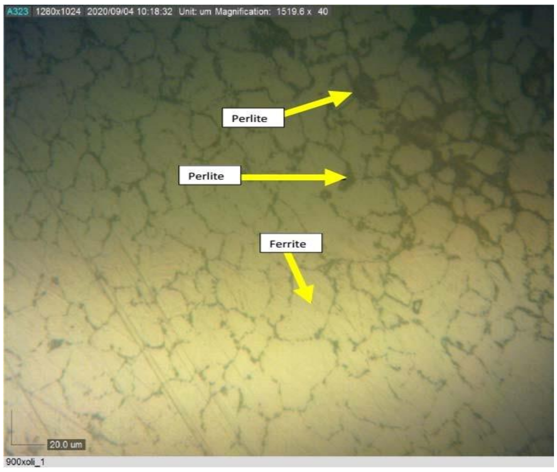

Fig. 11. The micro structure of the carburizing process at atemperature of 900 °C with oil quenching media for candlenut shell carbon charcoal.

Figure 11 shows treatment process at a temperature of 900°C with oil quenching media, revealing a larger microstructure of perlite in some parts. This condition gives a better hardness impact compared to the same quenching medium at a temperature of 850° C.

IV. Conclusion

From results of these experiments conducted, the conclusions are as follows:

- Candlenut shell charcoal used as an activated carbon improves the mechanical properties of imitation sprocket.
- Hardness value of the imitation sprocket is only 103.2 HV and was increased to 452.65 at a temperature of 850°C with water quenching media.

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