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STUDY PACK CARBURIZING OF THE LOW CARBON STEEL USING BAMBOO CHARCOAL AND BROILER CHICKEN BONE POWDER AS ENERGIZER

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ABSTRACT

This study is determining of the change in the surface hardness of low carbon steel that has undergone pack carburizing treatment. The specimen is SS400 low carbon steel. The research has been done by using various carburizing agent composition of Dendrocalamus asper bamboo charcoal ((BC) and broiler chicken bone powder (BBCBP) as the source of carbon and Calsium element as an energizer or a catalyst. Alternative carburized media applications are still rarely performed on research. The composition of the BBCBP is used: 15, 20 and 25 (% weight). The experiment was carried out using a muffle furnace at temperature 925 ^{0}C with soaking time for 2, 4 and 6 hours. Hardness tests were taken using vickers micro hardness tester, observation with SEM (scanning electron microscopes), to determine the number of hardness and microstructure specimen. The work showed that BBCBP can beused as energizer in pack carburizating of low carbon steel SS 400. The hardness profile plot of the 75 wt% BC and 25% BBCBP in the carburizing agent was also higher than the other compositions. It can be concluded that, BBCBP can replace the function of Barium Carbonate and Natrium Carbonate as energizer on pack carburizing processing

Keywords: Dendrocalamus asper bamboo charcoal, energizer, broiler chicken bone powder, pack carburizing, carburizing agent, SS 400 steel, hardness number.

INTRODUCTION

The low carbon steel SS 400 material / is equivalent to : JIS G3101, ASTM A36, DIN: St37-2, EN S235JR, ASTM: A283C and UNI : FE360B steel (Rai, 2016). It's a generally mild steel, which the chemical composition is only carbon (C), Manganese (Mn), Silicon (Si), Sulfur (S) and Posfor (P). Its use is for general purpose structural steel applications such as bridges, marine plates, oil tanks, etc. The SS 400 / JIS G3101 steels with carbon content (max 0.17% C) (Abdulraoof, 2016). This material cannot be hardened or heat treated through a quench and temper process.This material can only be hardened through surface hardening such as carburizing, nitriding or carbonitriding, where surface hardness can reach 500 Brinell (approximately 50 HRC) at a surface depth of 10 to 20 microns depending on the process parameters (Ahmad, 2015). Pack carburizing is a carburizing process to harden the surface using a solid carburizing medium. The carbon source is usually teak charcoal, and uses an energizer. in the form of $BaCO_3$, Na_2CO_3, and $CaCO_3$. To replace the role of the energizer, alternative energizer materials have been studied. In a study conducted by (Aramide, Ibitoye, & Oladele, 2010), They assessed the Optimizing Process Parameters pack carburization of mild steel, using pulverized bone as carburizer. The objective of the research work was to reduce cost and pollution problem associated with the use of chemically pure or commercial carbonates of calcium, sodium, and barium. The researcher observed that effect of using mixtures of palm kernel shell and coconut shell as carburizers for low carbon steel. In the work, he concluded that it was possible to substitute the commercial carbonates with the naturally occurring mineral carbonates. The tensile strength and hardness properties show that better properties were obtained with mixtures of the carburizers compared to the use of single carburizing agen (Reginald

Umunakwe, et al, 2017). The work (Ihom, 2013) showed that cowbone can be used as energizer in pack carburization of mild steel. The hardness profile plot of the 60 wt% charcoal / 40% cowbone carburized mild steel was also higher than the other compositions. In this study, various carburizing compounds were used to pack carburised mild steel. Various weight percentages of cow bone were used as energizer in the carburizing compounds. The experiment was carried out using a muffle furnace at 925°C for 8 hours. Hardness tests were taken using Vickers micro-hardness tester. The result showed that 60 wt% charcoal / 40 wt% cowbone had the best result with an effective case depth of 2.32 mm produced on the case of the carburized steel. Low carbon steel containing 0. 15% to 0. 3% of carbon does not respond to hardening heat treatment processes like quenching and tempering and hardly any martensitic transformation takes place on quenching. Thus, to improve the surface hardness carburizing treatment is done in which the surface composition of the low carbon steel changes by diffusion of carbon and results in to hard outer case with good wear resistance (Priyadarshini, Sharma, & Arora, 2014). The effects of varied carburizing temperatures and holding time on the mechanical properties of AISI/SAE1020 steel have been investigated (Oluwafemi, Oke, Otunniyi, & Aramide, 2015). Standard test samples prepared from the steel sample were subjected to pack hardening process using carbonized palm kernel shell as a carburizer at 800°, 850°, 925° and 950°C and held for 60, 90 and 120 minutes, quenched in oil and temper at 500°C for 60 minutes.
The objective of this work to pack carburizng low carbon steel SS 400 using BBCBP as energizer. Structural steel SS 400 finds application in engineering components such as gears, shafts, car bodies, and several other areas and case hardening is normally applied to increase the wear resistance of these components. It gives the component a hard case and a tough core.

MATERIALS AND METHODS FOR EXPERIMENT

For the present study, structural steel (SS 400) was used. The chemical properties of the material are presented in Table 3. Carburizing agent were a mixture of Dendrocalamus asper bamboo charcoal ((BC) and broiler chicken bone powder (BBCBP) as the source of carbon and Calsium element as an energizer or a catalyst. The percent carbon content in various parts of micropropagated Dendrocalamus asper plants are shawn in Table 1, the Chemical composition of cow bone are are presented in Table 2. The geometry of the parts, based on ASTM G99 was cylindrical, with (10 mm) diameter and (50 mm length For the pack carburizing technique used in this research, the samples were packed in a tight carburizing steel container, in a carburizing agent with enclosed granules of BC powder of cook and BCBP, with composition 85:15, 80:20 and 75:25. The carburizng temperatures were of 925 ˚C, and variations of soaking time 2, 4, and 6 hours.

Table 1. Percent carbon content in various parts of micropropagated Dendrocalamus asper plants

Height Range (cm)	Fresh Weight (gr)	Twigs		Leaf		Root	
		Dry wt (gr)	% Carbon	Dry wt (gr)	% Carbon	Dry wt (gr)	% Carbon
0-20	0.83-11.00	0.09-0.71	51.7-53.9	0.19-0.77	49.2-51.0	0.26-1.67	42.9-50.3
21-50	1.57-18.98	0.68-2.06	53.4-54.4	0.50-1.51	49.3-50.5	0.25-4.16	44.7-48.1
51-100	15.63-62.29	2.27-6.74	52.8-53.9	1.11-2.74	49.9-51.0	2.69-8.85	44.7-48.1

Anjuli Agarwal et al., 2016

Table 2. Chemical composition of broiler chicken bone

No	Name of Element	Broiler Chicken Bone mg/dl	Crossbreed Ongole mg/dl
1	Ca	10,14 ± 0,91	9,09 ± 0,86
2	C	1,71 ± 1,11	2,00 ± 1,12
3	P	5,61 ± 0,58	7,30 ± 1,39
5	S	1,71 ± 1,11	2,00 ± 1,12

Ghanaim Fasya, et al, 2015

RESULT AND DISCUSION

Hardness Test Result

The surface hardness test used is the Vickers method with load (P) of 60 Kg. Figure 1-Figure 3 indicated Influence BCBP on pack carburizing at temperature 925 ^{0}C and variation soaking time 2, 4, and 6 hours. The percentage of BCBP in the carburizing agent causes a change in the level of surface hardness number of the specimen. The specimen initial material having a very low hardness number, because no additional carbon in materials.. If the percentage of BCBP in carburizing agent increase, the faster the carbon diffuses into the Fe gaps. The increasing number of C atoms causes the surface hardness number of steel to increase. In the pack carburizing treatmen at time 925 ^{0}C and variation soaking time 2 hours are shawn at Figure 1. Addition of 25% BCBP obtained the highest hardness number of 400 Kg/mm^2, followed by the addition of 20% BCBP obtained fewer a surface hardness number of 325 Kg/mm^2, the addition of 15% BCBP obtained the least a surface hardness number of 275 Kg/mm^2 and raw material with a surface hardness number 130 Kg/mm^2.

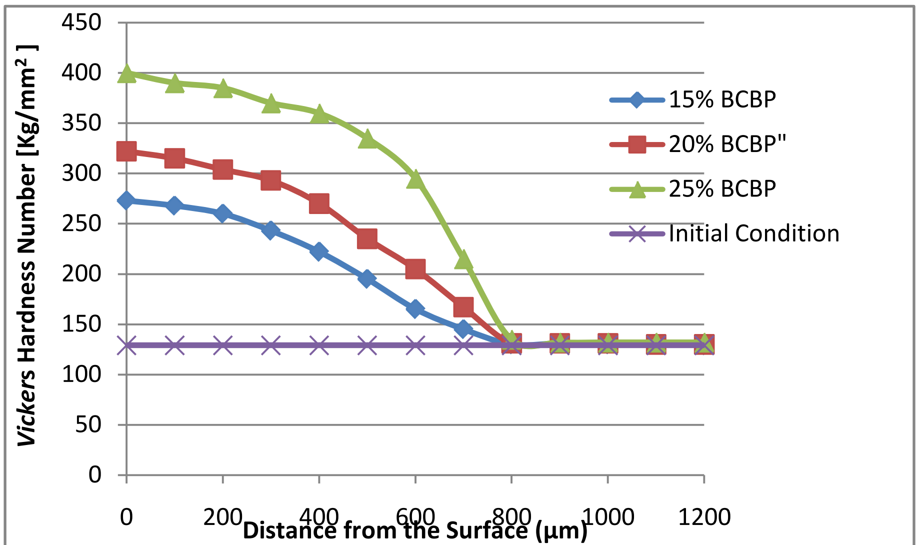


Figure 1. Influence BCBP on pack carburizing at time 925 ^{0}C and soaking time 2 hours

Based on the Figure 2. the BCBP addition have an effect to increase of a surface hardness number of specimens. The greater the percentage of BCBP, the surface hardness number also increases. The highest surface hardness number of 595 Kg/mm^2 , in the pack carburizing treatment at temperature 925 ^{0}C, soaking time 4 hour and 25 % BCBP in the carburizing agent. Furthermore, for 20% BCBP in carburizing agents, the resulting a surface hardness number is 525 Kg/mm^2 and 345 Kg/mm^2 for addition 15% BCBP. The resulting a surface hardness number of specimens is higher than the pack carburizing treatment at at temperature 925 ^{0}C and soaking time 2 hours.

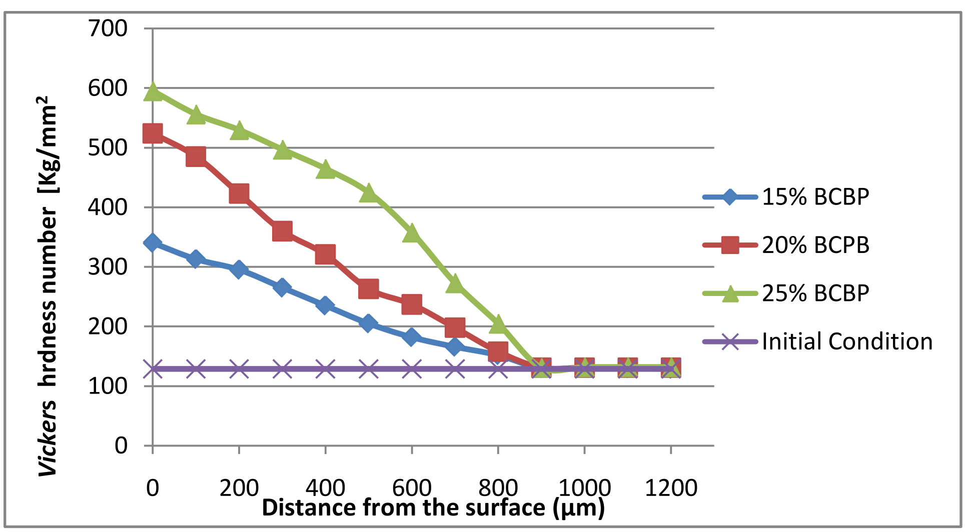


Figure 2. Influence BCBP on pack carburizing at time 925^{0}C and soaking 4 hours

Specimens with pack carburizing treatment at temperature 925 ^{0}C and soaking time 6 hours have the most surface hardness number compared with this initial material are shawn in Figure 3. Due additional of bamboo carbon and supported by BCBP as an energizer so that carbon diffuses faster into the mterial. The composition 25% BCBP in carburizing agent resulted a surface hardness number is 650 Kg/mm^2. It's the most surface hardness number after the pack carburizing treatmen at temperature 925 ^{0}C and soaking time 6 hours. This indicates that the pack carburizing process is influenced by energizer which speeds up a process. Calcium content with the addition of 25% BCBP at carburizing agent most effective compared to other processes. It's shown in Figure 3.

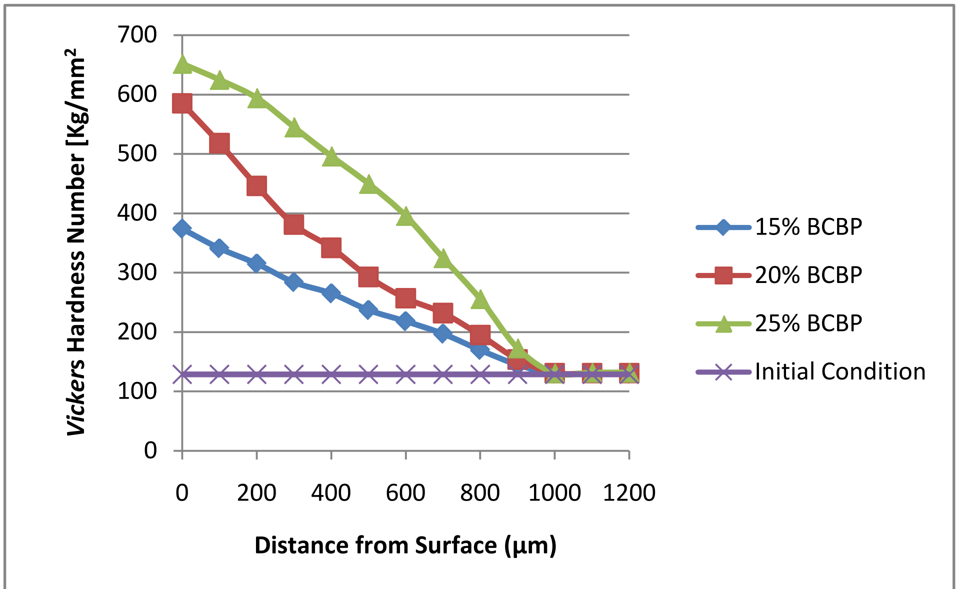


Figure 3. Influence BCBP on pack carburizing at time 925^{0}C and soaking 6 hours

Micro Structure Specimens on Pack Carburizing

The result of micro structure observation of the initial material before pack carburizing treatment can be seen in Figure 4.

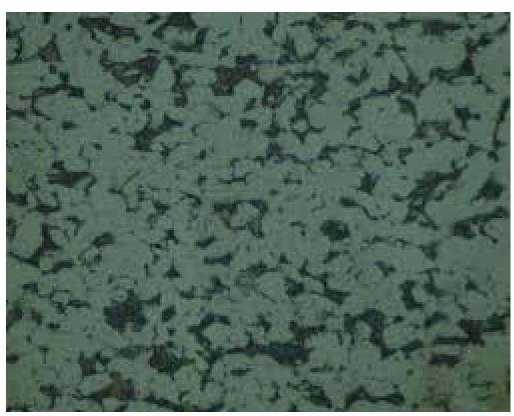
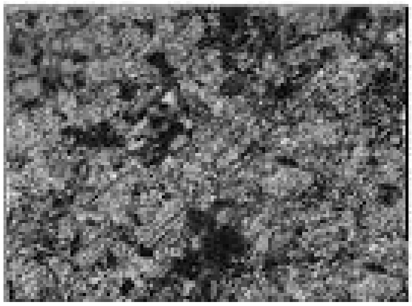
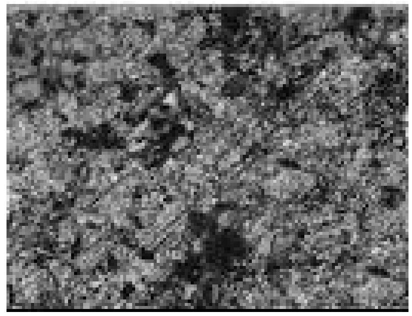


Figure 4. Initial material micro structure of SS 400 steel

Based on Figure 4 show that ferrite (light-colored and white) and pearlite (dark and black) are larger in size than carbides. The carbide will enlarge in case of heat treatment of the workpiece (low carbon steel). Then the ferrite structure is more dominant than the pearlite structure are fewer in number, so that the surface hardness number of the initial material are lower. This occurs because there is no addition of carbon element given to the initial material and relating to to the carbon content contained in the structural steel SS 400 of 0.168% C. The observation of the microstructure of specimen with pack carburizing treatmen at temperature 925^0 C,soaking time 6 hours, with vriations of addition 15%, 20%, 25% BCBP in carburizing agen were showed in Figure 5 .



a



b

c

Figure 5. Micro structure of the specimens with pack carburizing treatmen at temperature 925^0 soaking time 6 hours
a. 15%BCBP b. 20%BCBP c. 25%BCBP

At the Figure 5 it is shown that the number pearlite structures are increasing and the grain size is evenly distributed along the penetration, although there is still a lot of ferrite. The greater the percentage of BCBP in carburizing agent, the more pearlite micro structures are formed, the finer and smaller the grain size. Refered in Figure 5a, 5b, and 5c. The increased amount of pearlite more than the microstructure of the initial conditions may occur due to the effect of adding a carbon element to the specimen during the diffusion process of carbon interaction with of pack carburizng the material at temperature 925 ^{0}C and soaking time 6 hours. The addition of BCBP with a concentration of 25% as an energizer accelerates the process of carbon diffusion into the steel so as to form more pearlit structures. So the surface specimen becomes harder than before and also influenced by temperture and soaking time so that it can change the physical properties of structural steel SS 400. The result of observation of microstructure from material that has been pack caburizing with ratio of 75% BC and 25% BCBP at temperature 925 ^{0}C and soaking 6 hours can be seen in Figure 5c.

Chemical Composition Test Result

Table 3. results of chemical composition test before treatment (Raw Materials SS400 steel) and after pack carburizing treatment (on optimum parameter) at a temperature of 925 ^{0}C, soaking time 6 hours and addition 25% BCBP in carburizing agent. From the data in Table 1 above, the composition test results on specimens before and after treatment, there was an increase in carbon content in which the raw materials contained 0.168% C while the carburizing on the surface according to the composition test contained 0.78% C. This proves that carbon has entered the surface of low carbon steel

Table 3. Results of chemical composition

No	Name of Element	Raw Material % average	After Pack Carburizing % average
1	Fe	98.342	97.480
2	C	0.168	0.74
3	Mn	1.400	1.400
4	P	0.045	0.065
5	S	0.045	0.065
6	Si	0	0,025

CONCLUSION

The surface hardness number of low carbon steel SS400 with pack carburizing treatment were influenced by the temperature of carburizing, soaking time and the ratio percentage between BC and BCBP in the carburizing agent. powder and media quenching. The sample pack carburizing with the addition of 25% BCBP at 925 °C temperature and soaking time 6 hours are considered the most effective pack carburizing treatmen of structural steel SS400. Because it resulted the largest asurface hardness number, that is 650 Kg/mm^2. Based on observation of micro structure, there is a more of pearlite after treatment than the initial condition. Conclusion BCBP can replace the function of $BaCO_3$ and Na_2CO_3 as energizer on pack carburizing surface treament

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References.

Abdulraoof, A. M. (2016). Investigation the Mechanical Properties of Carburized Low Carbon Steel. *Int. Journal of Engineering Research and Application Www.Ijera.Com ISSN*, *6*(92), 2248–962259. Retrieved from http://www.ijera.com/papers/Vol6_issue9/Part-2/J060902059065.pdf

Ahmad, J. K. (2015). Carburizing of Steel. *International Journal of Materials Science and Applications*, *4*(2), 11. https://doi.org/10.11648/j.ijmsa.s.2015040201.13

Aramide, F. O., Ibitoye, S. A., & Oladele, I. O. (2010). *Pack Carburization of Mild Steel , using Pulverized Bone as Carburizer : Optimizing Process Parameters*. (16), 1–12.

Ihom, P. A. (2013). Case hardening of mild steel using cowbone as Energiser. *African Journal of Engineering Research*, *1*(October), 97–101.

Oluwafemi, O. M., Oke, S. R., Otunniyi, I. O., & Aramide, F. O. (2015). Effect of carburizing temperature and time on mechanical properties of AISI/SAE 1020 steel using carbonized palm kernel shell. *Leonardo Electronic Journal of Practices and Technologies*, *14*(27), 41–56.

Priyadarshini, S., Sharma, T., & Arora, G. (2014). Effect of Post Carburizing Treatment on Hardness of Low Carbon Steel. *International Journal of Advanced Mechanical Engineering*, *4*(7), 763–766. Retrieved from http://www.ripublication.com

Rai, P. K. (2016). Study on Mechanical Properties of Carburized Mild Steel Subjected to Heat Treatment. *International Journal of Engineering Technology and Computer Research (IJETCR)*, *4*(1), 83–87.

Reginald Umunakwe, Obinna C. Okoye, C. I. M. and D. O. K. (2017). Effects of Carburization with Palm Kernel Shell/Coconut Shell Mixture on the Tensile Properties and Case Hardness of Low Carbon Steel. *FUOYE Journal of Engineering and Technology*, *2*(1), 1–6.