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PACK CARBURIZING OF SS400 STEEL USING COW BONE CROSSBREED POWDER AS ENERGIZER

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ABSTRACT

SS 400 steel is structural steel structural with low carbon content. This material can only be hardened through surface hardening such as pack carburizing. In this study pack carburizing process were used for structural steel SS 400. The research has been done by using various carburizing agent composition of Dendrocalamus asper bamboo charcoal ((BC) and cow bone crossbreed simental powder (CBP) 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 CBP is used: 15, 20 and 25 (% weight). The experiment was carried out using a muffle furnace at temperature 900 ^{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 cowbone limosine can beused as energizer in pack carburizating of structural steel SS 400. The hardness profile plot of the 75 wt% BC and 25% CBP in the carburizing agent was also higher than the other compositions. It can be concluded that, CBP can replace the function of $BaCO_3$ and $NaCO_3$ as energizer on pack carburizing surface treatment.

Keywords: Dendrocalamus asper bamboo charcoal, energizer, cow bone crossbreed simental powde, pack carburizing, carburizing agent, SS 400 steel, hardness number.

INTRODUCTION

The material SS 400 / JIS G3101 / ASTM A36 is equivalent to DIN: St37-2, EN S235JR, ASTM: A283C and UNI : FE360B steel. is a general steel (mild steel) in 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 low carbon content (max 0.17% C) / Low C Steel, this material cannot be hardened / 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 etal. 2015). Pack carburizng or solid carburizing uses solid carburizing agent material as the carbonaceous source. Indusatrial pack carburizing utilizes energizers in the surface hardening of structural stee SS 400. Different types of energizers are used together with carbonaceous materials to increase the carbon potential of carburizing agent. The commonly used energizers are $BaCO_3$, Na_2CO_3, and CaCO3. The recent years, the efficiency of different Energizers alternative has been studied. In the research carried out by Fatai, 2010. He 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 reasonable case depths were obtained with the naturally occurring mineral carbonates, when compared with the commercial carbonates. In the work, he concluded that it was possible to substitute the commercial carbonates with the naturally occurring mineral carbonates (Okongwu, 1989). Ihom et al. in 2013 carried out a research on the use of waste egg shells as energizers in the case hardening of mild steel the result was impressive as he observed a case depth of 0.71 mm after pack carburizing for 3 h (Ihom et al., 2013). Aramide et al. in 2010 used bones for the pack carburization of mild steel. The operation was carried out at temperatures of 850, 900, 950°C and soaking time of 15 and 30 min. Despite the short interval of soaking time, he had impressive result with improvement in the case depth and other mechanical properties of the mild steel (Aramide et al., 2010). This can be linked to the fact that bones contain both calcium carbonate and carbonaceous material. A typical bone mineral composition is as presented in Table 2. The composition shown in Table 2 explains why cross breed bone simental was used as calsium source for pack carburizing energizer material by Febriarno, F.W, (2014). The organic component serves as the Carbonaceous has been studied by Anjuli Agarwal et al., (2016 **),** while the carbonate in the inorganic component serve as energizer. As observed by Okongwu, the use of the naturally occurring carbonates reduces cost of buying commercial chemical carbonates, and also pollution problems. Cowbones constitute solid waste problem therefore exploring ways of utilizing them is very crucial and good Fatai, (2010). The objective of this work to pack carburizng low carbon steel SS 400 using CBP 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 (Ihom et al., 2013).

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 cow bone crossbreed simental powder (CBP) 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 CBP, with composition 85:15, 80:20 and 75:25. The carburizng temperatures were of 900 ˚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 cow bone

No	Name of Element	Crossbreed Simental 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

Febriarno, F.W, 2014

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 CBP on pack carburizing at temperature 900 ^{0}C and variation soaking time 2, 4, and 6 hours. The percentage of CBP 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 CBP 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 900 ^{0}C and variation soaking time 2 hours are shawn at Figure 1. Addition of 25% CBP obtained the highest hardness number of 390 Kg/mm^2, followed by the addition of 20% PCL CBP obtained fewer a surface hardness number of 322 Kg/mm^2, the addition of 15% CBP obtained the least a surface hardness number of 273 Kg/mm^2 and raw material with a surface hardness number 129 Kg/mm^2.

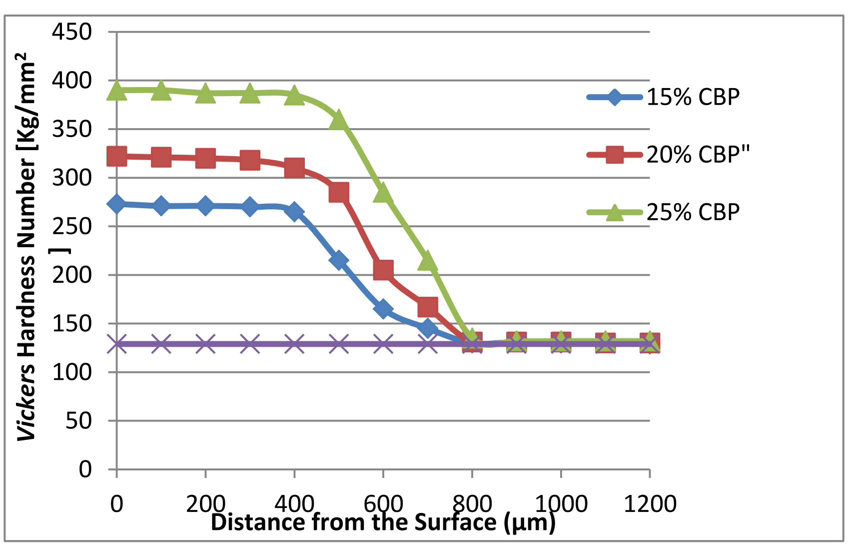


Figure 1. Influence CBP on pack carburizing at time 900^{0}C and soaking 2 hours

Based on the Figure 2. the CBP addition have an effect to increase of a surface hardness number of specimens. The greater the percentage of CBP, the surface hardness number also increases. The highest surface hardness number of 595 Kg/mm^2 , in the pack carburizing treatment at temperature 900 ^{0}C, soaking time 4 hour and 25 % CBP in the carburizing agent. Furthermore, for 20% CBP in carburizing agents, the resulting a surface hardness number is 524 Kg/mm^2 and 340 Kg/mm^2 for addition 15% CBP. The resulting a surface hardness number of specimens is higher than the pack carburizing treatment at at temperature 900 ^{0}C and soaking time 2 hours.

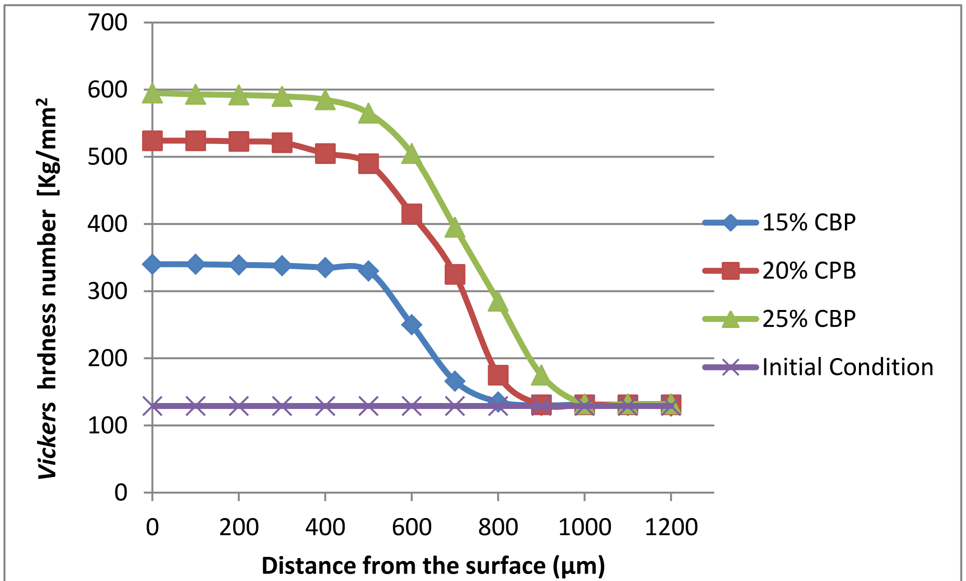


Figure 2. Influence CPB on pack carburizing at time 900^{0}C and soaking 4 hours

Specimens with pack carburizing treatment at temperature 900 ^{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 CBP as an energizer so that carbon diffuses faster into the mterial. The composition 25% CBP in carburizing agent resulted a surface hardness number is 652 Kg/mm^2. It's the most surface hardness number after the pack carburizing treatmen at temperature 900 ^{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% CBP at carburizing agent most effective compared to other processes. It's shown in Figure 3.

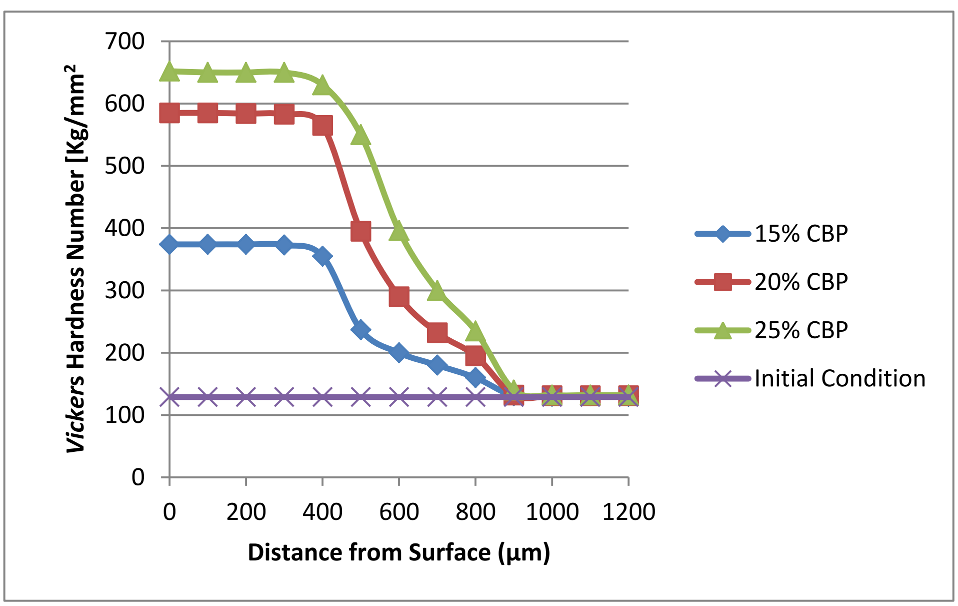


Figure 3. Influence CPB on pack carburizing at time 900^{0}C and soaking 6 hours

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.

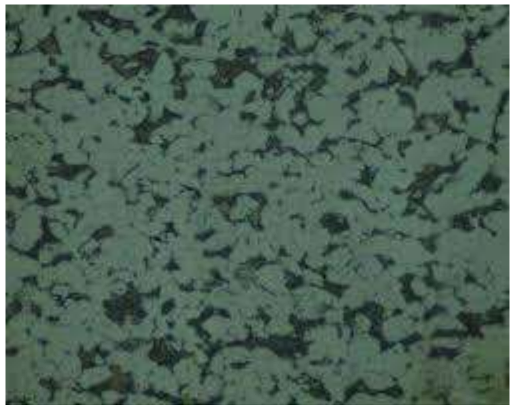
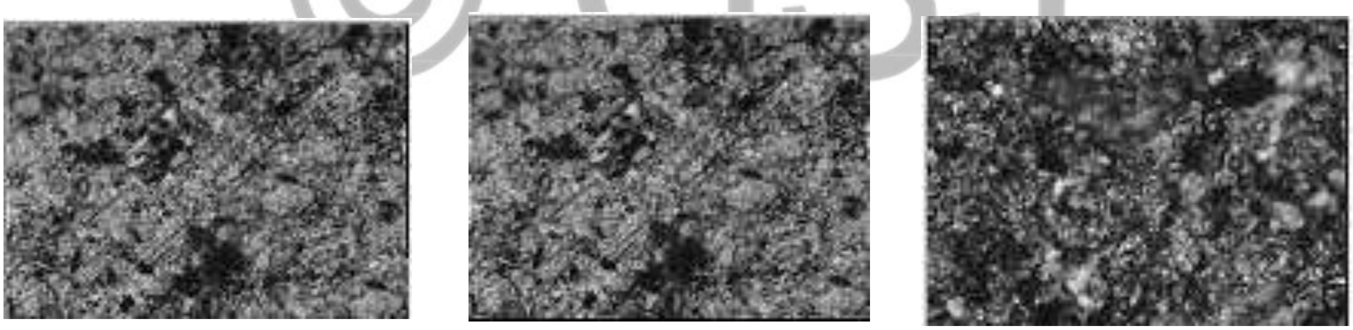


Figure 4. Initial material micro structure of SS 400 steel

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 900^0 C,soaking time 6 hours, with vriations of addition 15%, 20%, 25% CBP in carburizing agen were showed in Figure 5 .



a b c

Figure 5. Micro structure of the specimens with pack carburizing treatmen at temperature 900^0 soaking time 6 hours
a. 15%CBP b. 20%CBP c. 25%CBP

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 CBP 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 900 ^{0}C and soaking time 6 hours. The addition of CBP 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% CBP at temperature 900 ^{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 900 ^{0}C, soaking time 6 hours and addition 25% CBP 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	0.78
3	Mn	1.400	1.400
4	P	0.045	0.045
5	S	0.045	0.045
6	Si	0	0,025

CONCLUSION

The surface hardness number of structural steel SS400 with pack carburizing treatment were influenced by the temperature of carburizing, soaking time and the ratio percentage between BC and CBP in the carburizing agent. powder and media quenching. The sample pack carburizing with the addition of 25% CBP at 900 °C temperature and time soaking 6 hours are considered the most effective pack carburizing treatmen of structural steel SS400. Because it resulted the largest asurface hardness number, that is 652 Kg/mm^2. Based on observation of micro structure, there is a more of pearlite after treatment than the initial condition. Conclusion CBP can replace the function of $BaCO_3$ and $NaCO_3$ as energizer on pack carburizing surface treament

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References.

[1] Fatai O. A., Simeon A. I., Isiaka., Oluwole O., and Joseph O. B. Pack Carburization of Mild Steel, using Pulverized Bone as Carburizer: Optimizing Process Parameters. *Leonardo Electronic Journal of Practices and Technologies*, ISSN 1583-1078, issue 16, 2010, pp. 1-12.

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

[3] Aramide, F. O., Ibitoye, S. A. and Oladele, I. O. Pack Carburization of Mild Steel using Pulverized Bone as Carburizer. *Optimizing Process Parameters*, 16, 2010, pp. 1–12.

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

[5] Ngakan, D. and Putra, K. Carburizer Effectiveness from Different Carbon Sources on Pack Carburizing Process, *2*(1), 2016, pp. 5–10.

[6] Oluwafemi, O. M., Oke, S. R., Otunniyi, I. O. and Aramide, F. O. 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), 2015, pp.41–56.

[7] Aramide, F. O., Ibitoye, S. A., Oladele, I. O. and Borode, J. O. Effects of Carburization Time and Temperature on the Mechanical Properties of Carburized Mild Steel Using Activated Carbon as Carburizer. *Materials Research*, *12*(4), 2009, pp.483–487. https://doi.org/10.1590/S1516-14392009000400018

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

[9] Saini, B. S. and Gupta, V. K. Fatigue Crack Propagation Behaviour of Some Low Alloy Steels in Case Carburised Condition, *3*(September), 2012, pp. 330–339. https://doi.org/10.1504/IJMATEI.2012.049270.

[10] M. Cai, H., Ding, J., Zhang, L. And Li, Z. Tang, Deformation and fracture characteristics of ferrite/bainite dual-phase steels, *Chinese Journal of Materials Research*, 5(2), 2009, pp. 673–683.

[11] Setiyawan, A. Effect of Carburizing Process on Physical and Mechanical Properties of Blower Dinamo Ampere Blade on Diesel Car, Thesis, Surakarta: Universitas Muhammadiyah Surakarta, 2003.

[12] Liu, C. C., Xu, X. J. and Liu, Z. A. FEM Modeling Of Quenching and Tempering and Its Application in Industrial Engineering, International Journal of Finite Elements in Analysis *and Design*, 39, 2003, pp. 1053-1070.

[13] Xu, D.H. and Kuang, Z. B. A Study on The Distribution of Residual Stress Due To Surface Induction Hardening, International Journal of Engineering Materials and Technology, 118, 1996, pp. 571-575.

[14] Ennis, P. .J. and Lupton, D. F. The relationship between carburization and ductility loss, Behaviour of High Temperature Alloys in Aggressive Environments, In: *Proceedings ofthe International Conference*; 1979, Oct. 15-18, London: The Metals Society; 1980, pp. 979-991.

[15] Ward D.M., Influence of carburization on the properties of furnace tube alloys, In: Corrosion and Mechanical Strength at High Temperatures Guttmann, V. and Merz, M. (Eds.), Applied Science Publishers, Ltd., London, 1981, pp. 71-83