International Journal of Advance Research, IJOAR .org
Volume 3, Issue 5, May 2015, Online: ISSN 2320-9135

EFFECTS OF CARBURIZATION ON MECHANICAL PROPERTIES OF RECYCLED STEEL WITH PERM KERNEL SHELL (PKS) AS CARBON ADDITIVES.

S.A.Afolalu*1, S.B.Adejuyigbe2, O.R.Adetunji3 and O.I.Olusola4

- **S.A Afolalu is currently pursuing a PhD degree program in Mechanical Engineering Department, Federal University of Agriculture Abeokuta Ogun-State, Nigeria. afoniran@yahoo.com.*
- *S.B. Adejuyigbe is currently a Professor in Mechanical Engineering Department, Federal University of Technology, Oye --Ekiti, Ekiti-State. Nigeria. samueladejuyigbe@yahoo.com.*
- *O.R. Adetunji is a lecturer with PhD degree holder in Mechanical Engineering Department, Federal University of Agriculture Abeokuta, Ogun-State, Nigeria. adetunjolayide@gmail.com*
- *O.I Olusola is a lecturer with PhD degree holder in Physics Department, University of Lagos, Akoka. Lagos-State. Nigeria. iolusola@unilag.edu.ng*

Keywords: Cutting tool, carburization, machining, palm kernel shell, tool wear , wear rate,

ABSTRACT

The prediction and control of wear is one of the most essential problems emerging in the design of cutting operations which has to be checked through local production. This work therefore studies the effects of carburization on mechanical properties of recycled steel with Perm Kernel Shell (PKS) as carbon additives. 40 pieces of recycled Steel tools were used for the project. The tools were carburized with 40 kg of pulverized carbon of Perm Kernel Shell using 30 % Barium trioxocarbonate (V) as an energizer in a muffle treatment furnace of about 1500^{o}C. Each sample was held at temperature of 800^{o}C, 850^{o}C, 900^{o}C and 950^{o}C for 60, 90 and 120 minutes holding time. The performance evaluation of the tool was done by using the tools (carburized and un-carburized) to machining low and medium carbon work piece on the lathe machine and also measured its impact/toughness using impact tester. The results shown best cutting performances and toughness in carburized tool of higher impact/ toughness value of 24 J over control sample of 17 J. The result of the performance evaluation tests corroborated the higher qualities of the carburized cutting tool over un-carburized type.

1.0 INTRODUCTION

In rapid development at present, activities such as recycling is given attention and emphasis to be renewed for each country. Utilization of waste or scrap materials such as palm kernel shell, used crankshaft, rod that should be the waste of valuable resources. Chemical composition can be increase and changed in microstructure with through carburization using palm kernel shell. However palm kernel shell has the possibility to become a high potential raw material in carburization as a result of its better hardness than other carbonaceous materials. The uniform distribution of palm kernel shell particle as shown in the microstructure of the composite is the significant factor that responsible for the improvement in strength and it enhances the improvement of wear property of the recycled polyethylene matrix composite [2]. Steel is an alloy of iron and carbon with carbon limit ranging from 0.06% to 2.0%. Its composition can be group into carbon steel, alloy steel and stainless steel. Carbon steel contain alloying elements 1% of carbon, 1.65% manganese, 0.6% copper , 0.05% sulphur, 0.6% silicon and 0.4% phosphorus. Alloy steel has the content of steel that exceed carbon steel limit with other elements that cannot be found in carbon steel such as chromium, cobalt and nickel. Stainless steel contains minimum of 10% chromium and it has microstructure of three grades; martensite, ferrite and austenite [3]. The content of carbon steel usually has comparative property with iron phase, low carbon steel possess low tensile strength which resulted to low malleability, brittleness and ductility and apart from its low cost. It has a microstructure offerrite and pearlite that are relatively soft and weak which enable its easy machinability. The carburizing furnaces are usually gas fired or electrically heated process. The carburizing temperature varies and the gas atmosphere for carburizing is produced from liquid or gaseous hydrocarbons such as propane, butane or methane [4]. The study of process parameters in metals during heat treatment has been of considerable interest for some years and it involves diffusion of one material into the other also increases rapidly with increasing temperature, particularly in materials that have poor thermal stability [5]. Barium Carbonate is suitable as an energizer for carburization due to its diffusivity level at elevated temperature and it enhances the rate of carbon absorption which increases the hardness and strength of the steel. The tool wear process can be divided into five stages; initial stage of wear; regular stage of wear, micro breakage stage, fast wear stage and tool breakage [6]. Explained that wear of the cutting portion of a tool and its life are very much important in metal cutting since the overall performance of the tool and machining economy are determined by essence, the values and mechanisms of the wear [7]. At the lower cutting speed, the tool life improves for all feed rate and depth of cut; however increase in tool life is much more significant at low cutting speed while at high cutting speed reduce the tool life [8].

2.0 MATERIALS AND METHODS

2.1 Material

The materials involved for the research work were 40 kg of pulverized palm kernel shell, 40 pieces of recycled carbon steel tool, Barium trioxocarbonate (v) (BaCO3), Engine Oil, 12 units of steel boxes, and Engine Oil The equipment used for the carburization and test at EMDI, Akure, SON Enugu and Federal University of Technology Akure were; Muffle Electric furnace of 15000C capacity, lathe machines, grinding machine, digital weigh scale, hacksaw, polishing machine and impact tester.

2.2 Methods

Carburization was carried out at Engineering Materials and Development Institute, Akure (EMDI). The prepared 40 samples were inserted in the pulverized palm kernel shell with 30% proportion of Barium trioxocarbonate (v) salt ($BaCO_3$) as an energizer. The carburizer was weighed and packed into steel boxes with pulverized palm kernel shell cover to prevent the CO from escaping and prevent unwanted furnace gas from entering the steel box during heating. The furnace was loaded with sample set up and carburizing temperature of the furnace was adjusted to the required temperature (800, 850, 900 and 950

°C) for each stages respectively. As the carburizing temperature reached the required degree, it was then held at a particular temperature for the required time (60, 90 and 120 minutes). After the sample held at the specified holding time, the sample was discharged from the furnace and the material was quenched in engine oil.

Impact/toughness test of the carburized and un-carburized (control) samples were carried out at SON, Enugu with the maximum energy of the machine of 300 J for Charpy impact, length of the sample was 55 mm, V-Knut at point 22.5 mm. Also the performance evaluation (turning operation) of the sample was carried out at University of Lagos. Work piece of Low and medium carbon steel were turned on centre lathe machine with diameter 25 mm, length 100 mm, rake angle of the tool 7^{o}. The experiment was performed at different cutting speed, feed rate, spindle speed, cutting time, depth of cut and length of cut.

3.0 RESULTS

3.1 Impact / Toughness test

This test was carried out at Standard Organization of Nigeria (SON), Enugu.

The test was carried out at the room temperature which the samples assumed. The maximum energy of the machine used was 300J of Charpy impact, length of the sample = 55mm, V-Knut was used at point 22.5mm. The result of the test is shown in the Table 1.0

3.2 Result for the performance evaluation on Centre Lathe Machine

Turning operation was done on centre lathe machine, the treated recycled steel cutting tool was used to cut low and medium carbon steel to measure the time of cut as the results shown in Table 2.0, length of cut at different cutting speed and feed rate given result in Table 3.0 and Table 4.0 respectively

Table 1.0: Impact/Toughness test

	Sample (S)	Energy Absorbed (J)
1	950^{o}C, 120mins	24.0
2	950^{o}C,90mins	16.0
3	950^{o}C, 60mins	16.0
4	900^{o}C, 120mins	20.0
5	900^{o}C, 90mins	36.0
6	900^{o}C,60mins	65.0
7	850^{o}C, 120mins	40.0
8	850^{o}C, 90mins	20.0
9	850^{o}C, 60mins	61.0
10	800^{o}C, 120mins	22.0
11	800^{o}C, 90mins	12.0
12	800^{o}C, 60mins	13.0
13	Control	17.0

Table 2.0: Turning of low carbon steel to measure time of cut on center lathe machine.

Sample (s)	Lenght of cut (mm)	Time of cut (minutes)
800^0C, 60mins	50	1.50
800^0C,90mins	50	1.47
800^0C, 120mins	50	1.49
850^0C, 60mins	50	1.58
850^0C 90mins	50	1.44
850^0C,120mins	50	1.50
900^0C, 60mins	50	1.49
900^0C, 90mins	50	1.38
900^0C, 120mins	50	1.20
950^0C, 60mins	50	1.22
950^0C, 90mins	50	1.24
950^0C,120mins	50	1.19
Control	50	1.23

Note- Time of cut at cutting speed of 29.85m/min, Spindle speed of 380 Rev/min, feed rate of 19.00m/min, depth of cut 2mm on low carbon steel work piece of 25mm diameter.

Table 3.0: Turning of Medium carbon steel to measure time of cut on center lathe machine.

Sample (S)	Length of Cut (mm)	Time of Cut (minutes)
800^0C, 60mins.	50	2.17
800^0C, 90mins.	50	2.20
800^0C, 120mins.	50	2. 14
850^0C, 6mins.	50	2.12
850^0C 90mins.	50	2.10
850^0C, 120mins.	50	2.04
900^0C, 60mins.	50	2.08
900^0C, 90mins.	50	2.09
900^0C, 120mins.	50	2.08
950^0C,60mins.	50	2.05
950^0C, 90mins.	50	2.03
950^0C, 120mins.	50	2.02
Control	50	2.04

Note- Time of cut at cutting speed of 21.20 m/min, Spindle speed of 270 rev/min, feed rate of 13.50 m/min, depth of cut 2 mm and work piece of 25 mm diameter.

Table 4.0: Cutting operation to measure length of cut of different speed and feed rate.

Sample	Speed (mm/min)	Feed (mm/min)	Length of cut (mm)
800°C, 120min	270	0.15	25.70
850°C, 120min	270	0.15	26.50
900°C, 120min	270	0.15	28.30
950°C, 120min	270	0.15	29.50
Control	270	0.15	26.30
800°C, 120min	380	0.20	35.60
850°C, 120min	380	0.20	35.50
900°C, 120min	380	0.20	38.05
950°C, 120min	380	0.20	38.55
Control	380	0.20	37.50
800^0C, 120min	560	0.25	40.05
850^0C, 120min	560	0.25	49.00
900^0C, 120min	560	0.25	55.05
950^0C, 120min	560	0.25	57.00
Control	560	0.25	56.0

Note-Work piece diameter is 25mm, depth of cut - 2mm and rake angle 7°

3.3 Discussion of Result

The carburization contributed to the strength liberated from the carbon in solid solution and carbides precipitated during quenching. The treatment gave clear traits of diffusion of carbon into the center of the sample which led to increased volume fraction of carbides that formed in the material and the phase transformation influenced the mechanical properties of its higher impact/ toughness value of 24 J over control sample of 17 J as shown in Table 1.0 and fig 1.0 which agreed with the findings by [9].

From the experiment on the mechanical properties of the carburized and un-carburized samples the length and time of cut increases with cutting speed but at constant cutting speed the sample soaked longer at high temperature has more length of cutting with less cutting time for carburized tools compare to the un-carburized sample. It can be seen in fig 2 to 4 and table 2-4 shown best cutting performances of the carburized tool at highest carburizing temperature over the un-carburized control sample. Impact strength decreases with increase in hardness. Ability of the developed cutting tools to cut both medium carbon and low carbon steel without recording any failure or significant wear during operation.

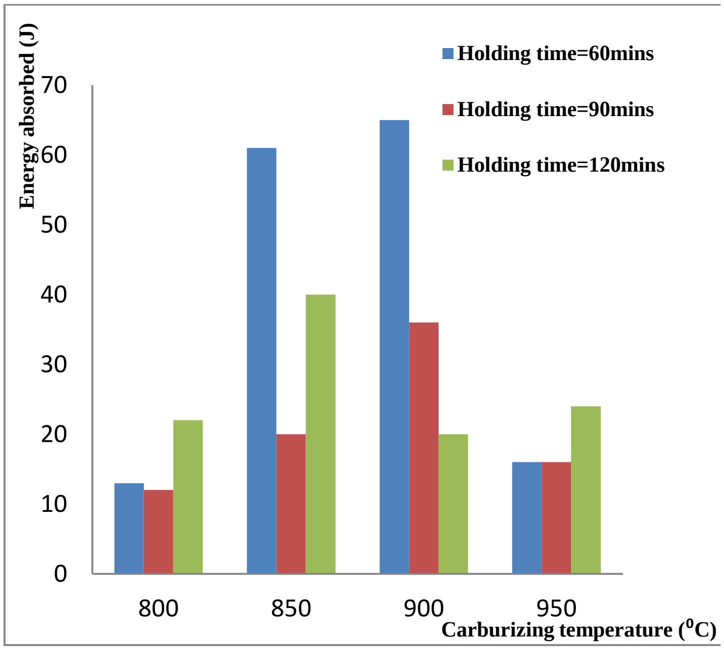

Figure1: Energy absorbed against Carburizing Temperature.

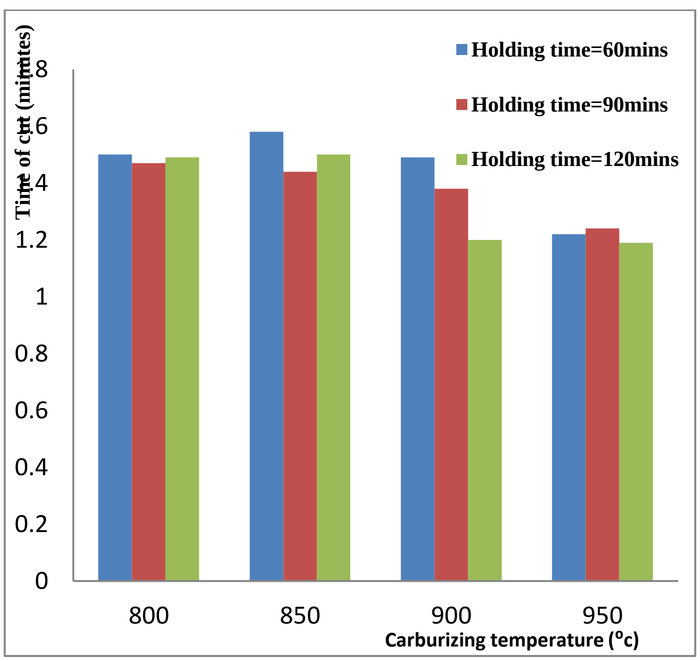

Fig 2: Time of cut against carburizing Temperature for Cutting speed of 29.85m/min and Spindle speed of 380rev/min. (Feed rate= 19.00m/min, depth of cut= 2mm and work piece diameter=25mm).

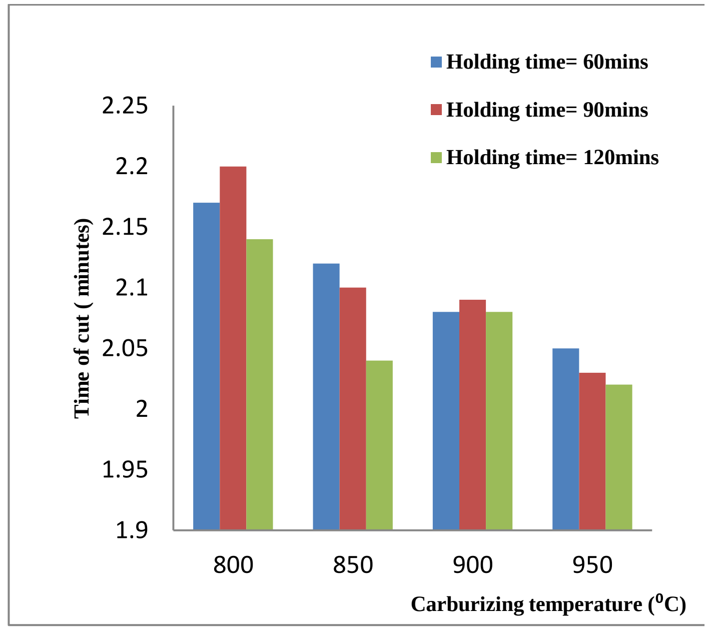

Fig 3: Time of cut against Carburizing Temperature for Cutting speed of 21.20m/min and Spindle speed of 270 rev/min, (Feed rate= 13.50m/min, depth of cut= 2mm and work piece diameter=25mm).

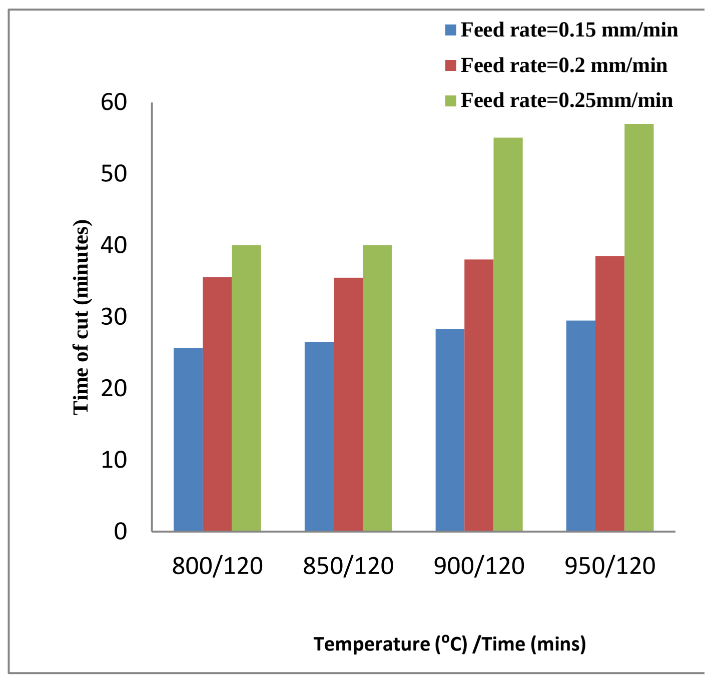

Figure 4: Time of cut against Temperature under different feed rate.

4.0 Conclusion

From the result of the investigations and discussion, the following can conclusion has been made;

1. This research work has shown successfully that the carburization of recycled steel with palm kernel shell as additive is feasible.
2. The uniformly penetration of the pulverized palm kernel shell at high carburizing temperature into the core and surface of the tool contributed to the improvement in machinability.
3. There was significant different in the mean impact or absorbed energy of the tool at various carburizing temperature and holding time.
4. The carburizing temperature and holding time made significant different in performance of the tool during experimental investigation.
5. Impact strength was progressively increased with increase in carburizing temperature and holding time which enhance improvement in impact strength of the carburized tool over un-carburized sample.

Acknowledgement

I appreciate the support offered by the Management of Standard Organization of Nigeria, Enugu, Federal University of Technology Akure, Ondo-State, Engineering Materials and Development Institute, Akure during the research work.

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