Advances In Multidisciplinary & Scientific Research
A Multidisciplinary & Interdisciplinary Journal
Vol. 3 No. 4, Dec 2017

Characterisation of the Performance of Carbon Brush Produced from Coconut Shell, Coal and Coconut Firber.

Oyetunji O .R[1]., Olaoye O.S[1] & Babatunde K. A[2]
[1]Mechanical Engineering Department. Ladoke Akintola University of Technology, Ogbomoso.
[2]Chemical Engineering Department, Ladoke Akintola University of Technology, Ogbomoso.
Lead Author's E-mail: oroyetunji @lautech.edu.ng
Corresponding Author's E-mail: osolaoye@lautech.edu.ng[1]
Corresponding Author's E-mail: kababatunde@lautech.edu.ng[2]

ABSTRACT

Graphite a major component used in the production carbon brush, is also an allotropy of carbon, is scarce in many nations. Some countries replace this with synthetic carbon from carbon black. This project is aimed at characterisation the performance of carbon brush produced from various source of carbon from coconut shell coal, coconut fibre and in the production of carbon brush. Coconut Shell, Coal and coconut fiber were gotten from Odo Oba market in Ogbomoso, Oyo state in Nigeria. They were dried and pyrolysed in airtight furnace at 500 ºC to obtain amorphous carbon. It was calcined at 1000 ºC and graphitised for 24 hours at a pressure of 1.5 KN in order to turn the amorphous structure to graphitic structure. The graphitised substances were mixed with copper, zinc, and other material to produce the carbon brush. The Taguchi experimental design L16 was used to formulate the process. The experimental work reveal that coconut shell has the highest carbon content of 84.84%, then coal, 79.09% and coconut fibre 77.60%. The resistivity value of carbon is expected to be low and coconut shell gives the lowest value out of the three. High conductivity value will make the brush to perform better and carbon brush made from coconut fibre has the highest value when compared to that of coconut shell and coal. Carbon brush made from coconut shell has the lowest bulk density, and a low bulk density is needed for good performance of carbon brush. Carbon brush made from coconut shell has the lowest coefficient of friction and likewise that from coal has the highest hardness. It is evidence that various source of carbon can give different performance to the carbon brush depending on which performance traits should be dominant.

Keyword: Characterisation, Performance, Carbon, Brush, Coconut Shell, Coal and Coconut Firber.

Aims Research Journal Reference Format:
Oyetunji O .R., Olaoye O.S. & Babatunde K. A. (2017): Characterisation of the Performance of Carbon Brush Produced from Coconut Shell, Coal and Coconut Firber. Advances in Multidisciplinary Research Journal. Vol. 3. No. 4, Pp 105-116

1. INTRODUCTION

Carbon brush is important for successful operation of all generators and majority of electric motors; and it is the seat of the greatest amount of trouble experienced in the operation of these machines (Solberg, 2009). Professor George Forbes in 1883 was the first to advocate the use of carbon for brushes and obtained a British patent but the idea was not practiced (Solberg, 2009). Carbon brush applications vary from automotive to consumer equipment such as industrial and in traction. Applications in the automotive are found in starters, alternators, fuel pumps, air conditioning, powered windows and wipers in cars and trucks. Carbon brushes are also used in consumer goods like: power tools, vacuum cleaners, electric cleaners, electric shavers, mixers and other domestic appliances. Applications in the industry include assembly lines and elevators. Carbon brushes are used in traction like railway and other public transport, specifically in locomotion and auxiliary electric motors. Brushes are used in direct current devices as electrical contact.

Direct current devices are made to prevent the material transfer and severe arc damage that may take place in Direct Current applications. Carbon brush is produced from carbon with an amorphous structure or graphite, an allotropic form of carbon. They worked together with slip-rings, commutator or other contact applications. Electrical brushes and brush materials require very good frictional characteristics combined with moderate conductivity. Solberg (2009) mentioned that the materials used in the manufacture of carbon brushes are coke, natural graphite, lampblack, powdered or finely divided copper, and various binder materials, which generally contain tar or pitch. Metals like tin, lead, zinc, silver, etc are included to promote certain properties in the carbon brush. Also some salt (compound) are added such as suessite (Fe_3Si), iron silicon ($FeSi$), iron oxide (FeO), copper iron ($FeCuO_2$), iron silicate (Fe_2SiO_4), lead silicate (Pb_{36} [(Si_2O_7)]), copper silica (Cu_3Si) etc. All these will promote properties like thermal conductivity, friction, resistivity, etc.

These brushes can either be of copper-graphite, amorphous carbon, graphite-flake, electrographite, metal graphite, resin bonded graphite, silver and silver alloys- graphite and specialized or proprietary materials depending on the characteristic of the equipment on which they are to be used. Some brushes were made from carbon fibres; this gives improve thermal conductivity of phase change materials packed around heat transfer tubes

2. METHODOLOGY

2.1 Pyrolysis of the materials

The materials were dried in the Sun for five days to reduce the moisture and were later pyrolysed at a temperature of 500 ˚C in a locally made furnace that has a maximum temperature range of 1500 ˚C. During the pyrolysis the gas and the tar were emitted through a pipe, in case the tar and the gas is to be collected a separate chamber to cool the tar will be constructed while the gas can be collected over water and stored in a gas can.

2.2 Analysis of Pyrolysed Raw Materials

The pyrolysed materials (chars) were taken to the laboratory at Center for Energy and Research Development (CERD) in Obafemi Awolowo University Ile Ife for analysis of the percentage of carbon and other elements using 1.7 MV tandem particle accelerator, Model 5SDH.

2.3 Calcination of the Pyrolysed Carbonaceous Materials

In order to remove the remaining combustible material in the pyrolysed coconut shell, coal and coconut fibre, it was heated in a furnace under air tight crucible to a temperature of 1200 ˚C. When the heating was carried out fumes were coming out through the opening at the top of the furnace. In order to control the effect of the heating the temperature was set at a rate of 5 ˚C per minute and heating continues until no more fumes were coming out again. When the fumes stopped it was further heated for five hours. The resulting product after the calcination is amorphous carbon.

2.4 Graphitisation of the Pyrolysed Carbonaceous Materials

After the calcination of the amorphous materials: coconut shell, coal and coconut fibre, were placed in an airtight crucible for graphitisation. It was heated to temperatures of 1000 ˚C and 1500 ˚C, kept constant for 5hours; 10hours, 15hours and 24hours with the application of constant pressure of 1.74 kN being the maximum pressure allowed with the mould before it starts buckling. Pressure higher than this will make the mould to buckle and collapse. The application of pressure will also enhance the graphitisation of the materials.

2.5 Taguchi Experimental Design

The design parameters that were varied using Taguchi Experimental Design were: raw material composition, temperature, moulding pressure, particle size, and duration of baking. After the production of carbon brush, the responses: Bulk Density, Electrical conductivity, Hardness test, Resistivity and Friction coefficient (static) were measured.

Advances In Multidisciplinary & Scientific Research
A Multidisciplinary & Interdisciplinary Journal
Vol. 3 No. 4, Dec 2017

3. RESULTS AND DISSCUSSIONS

The results of the component analysis for the pyrolysed carbonaceous materials of Coconut Shell, Coal and Coconut Husk carried out at Obafemi Awolowo University Center for Energy and Research using 1.7 MV tandem particle accelerator model 5SDH were stated below:

3.1 Component Analysis of Pyrolysed Coconut Shell

The analysis revealed that pyrolysed Coconut Shell has 84.84% of carbon, 7.70% of Nitrogen, 6.56% of Oxygen, and 0.59% of Silicon 0.31% of Sulphur.

3.2 Component analysis of pyrolysed Coal

The analysis revealed that pyrolysed coal has 79.09% of carbon 6.46% of Nitrogen, 12.60% of Oxygen, 0.64% of Sulphur and 1.21% of Silicon.

3.3 Component analysis of pyrolysed Coconut fibre(Husk)

The analysis revealed that pyrolysed Coconut fibre has 77.60% of carbon, 4.61% of Nitrogen, 14.04% of Oxygen, 0.56% of Phosphorous, 2.30% of Silicon and 0.89% of Potassium.

3.4 Comparison of the performance characteristics of carbon brush

The resistivity, hardness, conductivity, bulk density and coefficient of friction for each samples is being compared as follows:

3.4.1 Comparison of the resistivity characteristics of carbon brush.

The resistivity of coconut shell is within 2,859.79 Ωcm to 5560.25 Ωcm, that of coal is 1.88 x 10^6 Ωcm to 9.12 x 10^6 Ωcm and fibre has within 0.295 x 10^6 Ωcm to 1.135 x 10^6 Ωcm. The carbon with lower resistivity will give a high performance value for the brush. The coconut shell is best out of the three source of carbon. Also for the three samples resistivity decreases with increase in carbon particles. COCONUT SHELL (Graph of Resistivity versus Carbon particle).

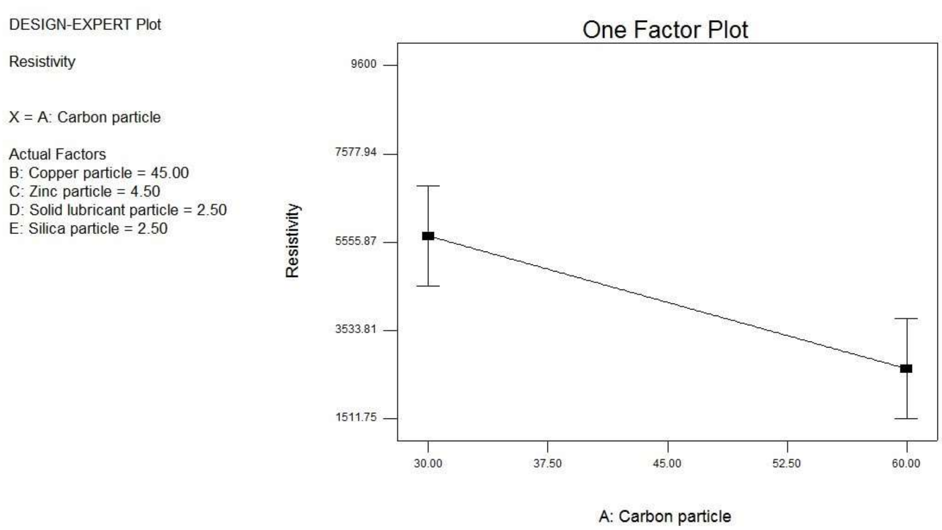

Figure 3.1: Graph of Resistivity versus carbon particle content in carbon brush produced from coconut shell.

COAL (Graph of Resistivity versus carbon particle)

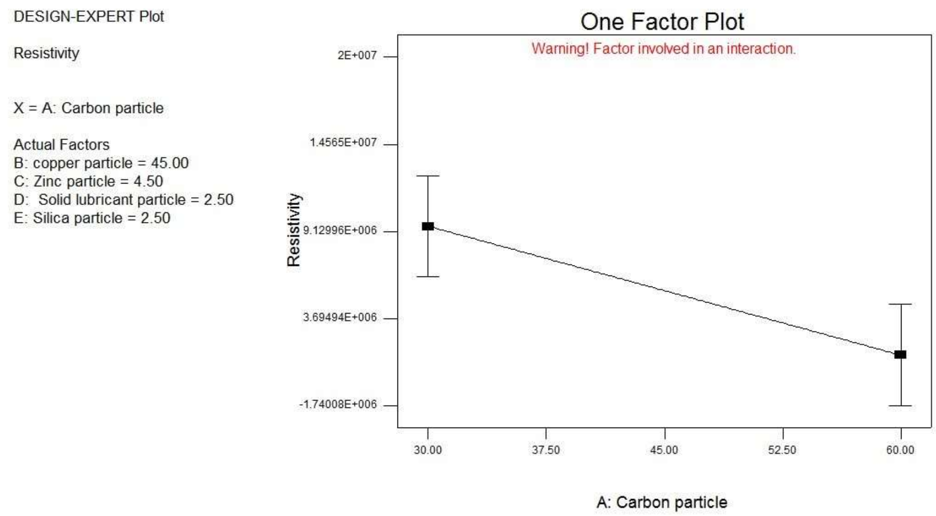

Figure 3.2: Graph of Resistivity versus carbon particle content in carbon brush produced from coal.

COCONUT FIBRE (Graph of Resistivity versus carbon content)

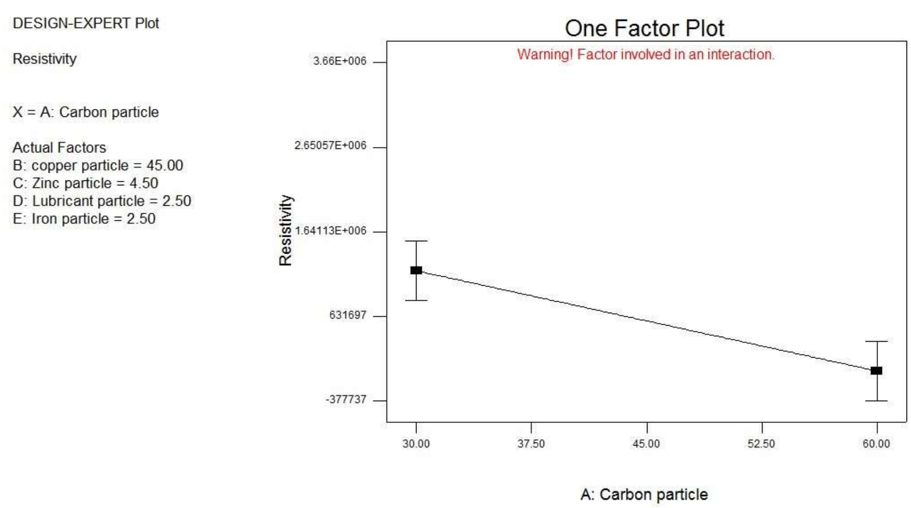

Figure 3.3: Graph of Resistivity versus carbon particle content in carbon brush produced from coconut fibre.

3.4.2 Comparison of their conductivity

The graph of conductivity for coconut shell is linear but the rate of increase is very small. The graph of coal and coconut fibre is parabolic with that of fibre of higher rate than coal. Result shows that conductivity property is best developed with carbon brush made from coconut fiber. COCONUT SHELL (Graph of Conductivity versus carbon content)

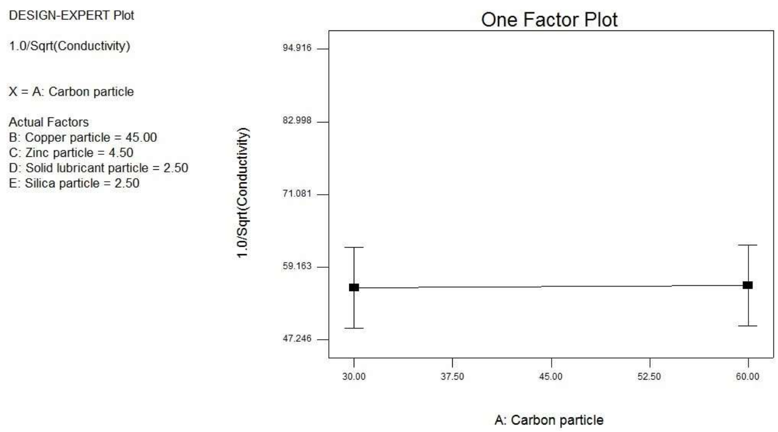

Figure 3.4: Graph of conductivity versus carbon particle in carbon brush produced from coconut shell

COAL (Graph of Conductivity versus carbon content)

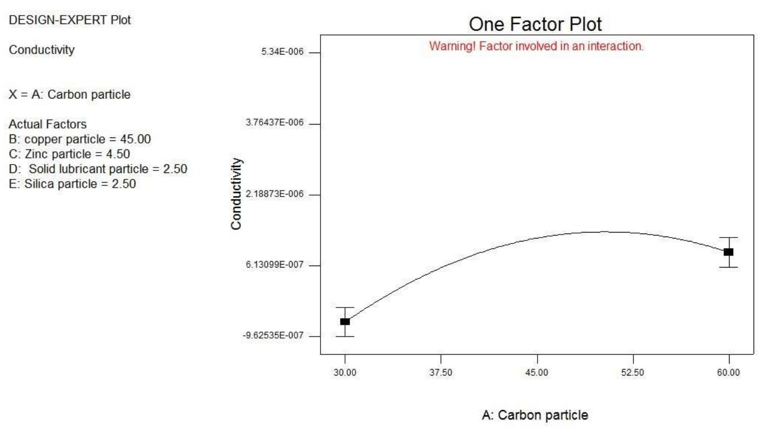

Figure 3.5: Graph of conductivity versus carbon particle in carbon brush produced from coal

COCONUT FIBER (Graph of Conductivity versus carbon content)

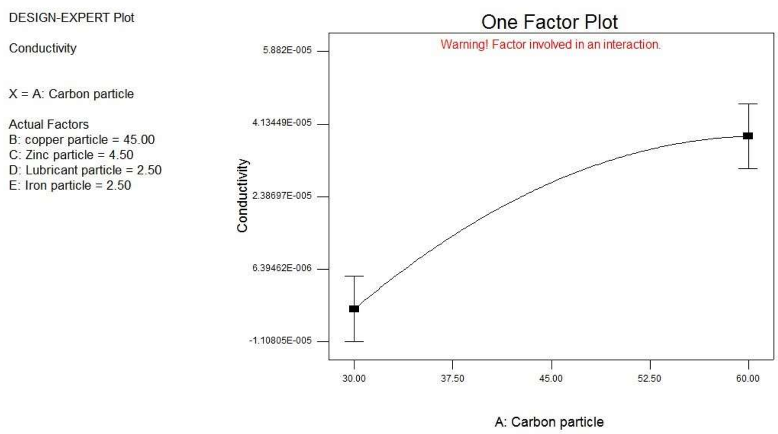

Figure 3.6: Graph of conductivity versus carbon particle in carbon brush produced from coconut fiber

3.4.3 Comparison of their bulk density

The bulk density of the brush produced from coconut shell is within the range of 1.845 to 1.95 g Cm-^{3}, that of coal is from 2.754 to 4.259 g Cm-^{3} and fibre takes the value of 3.25 to 3.633 g Cm-^{3}. Carbon brush perform better at low bulk density and that of coconut shell gives a better result. The three samples are linear in relationship and their bulk density increases as carbon content increase. The graph of coal has the highest rate and follow by coconut shell.

COCONUT SHELL (Graph of Bulk density versus carbon content)

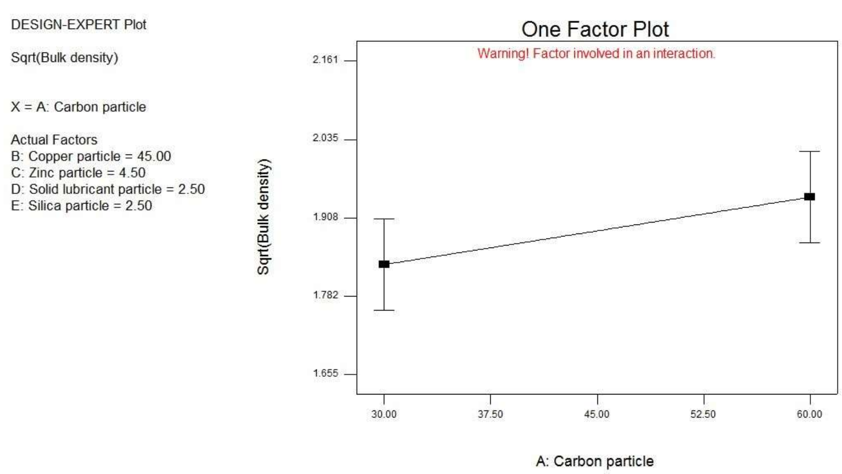

Figure 3.7: Graph of bulk density versus carbon particle of carbon brush produced from coconut shell.

COAL (Graph of Bulk density versus carbon content)

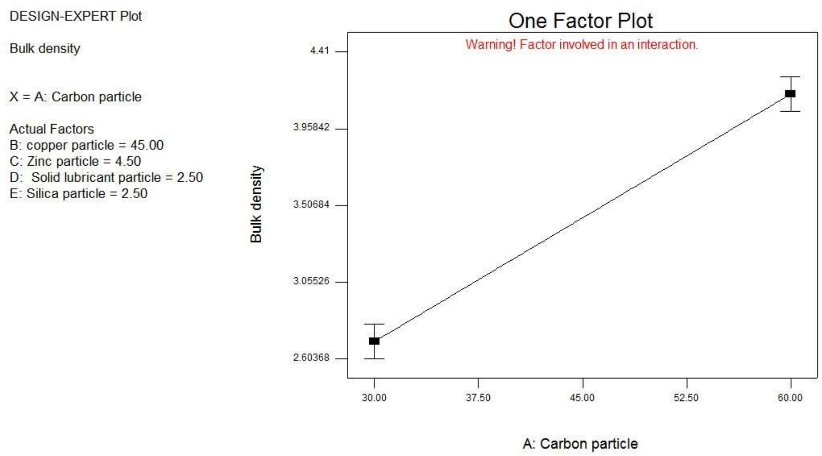

Figure 3.8: Graph of bulk density versus carbon particle of carbon brush produced from coal.

COCONUT FIBRE (Graph of Bulk density versus carbon content)

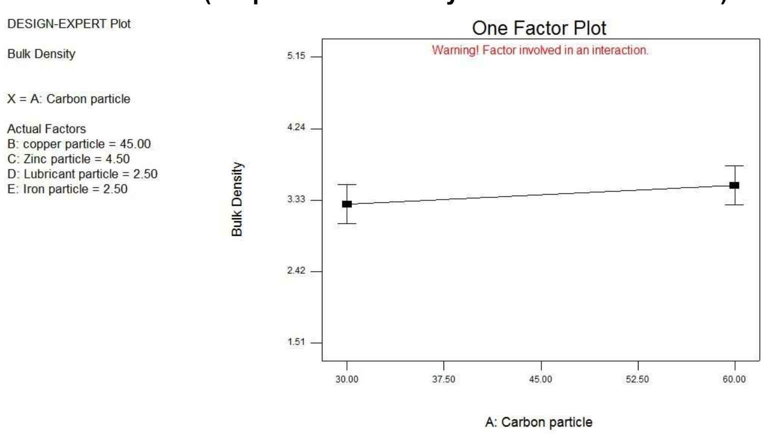

Figure 3.9: Graph of bulk density versus carbon particle of carbon brush produced from coconut fibre.

3.4.4 Comparison of their coefficient of friction

The coefficient of friction of carbon brush made from coconut shell ranges from 0,601 to 0.586, that of coal is from 0.8704 to 0.64034 and that of coconut fiber is 0.6375 to 0.594. Since that made from coconut shell has the minimum friction coefficient it is adjudged better where low friction coefficient is needed for good performance of carbon brush. The coefficient of friction of coconut shell and coal increase with increase in carbon content, but that of coconut fibre decreases with increase in carbon content. COCONUT SHELL (Graph of coefficient of friction versus carbon content)

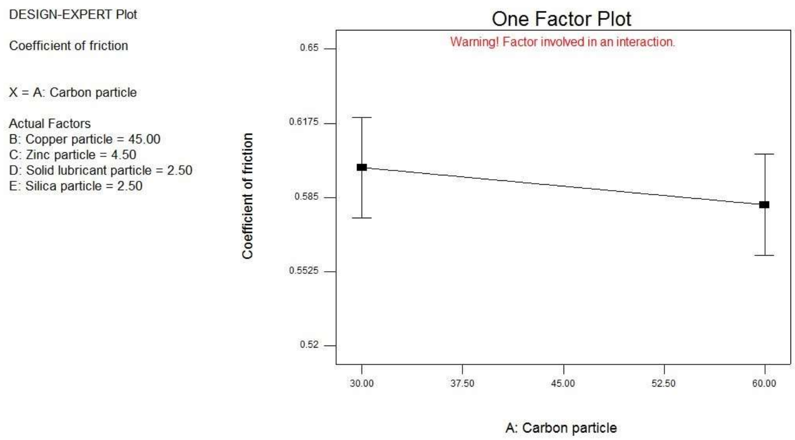

Figure 3.10: Graph of coefficient of friction versus carbon particle in carbon brush produced from coconut shell.

COAL (Graph of coefficient of friction versus carbon content)

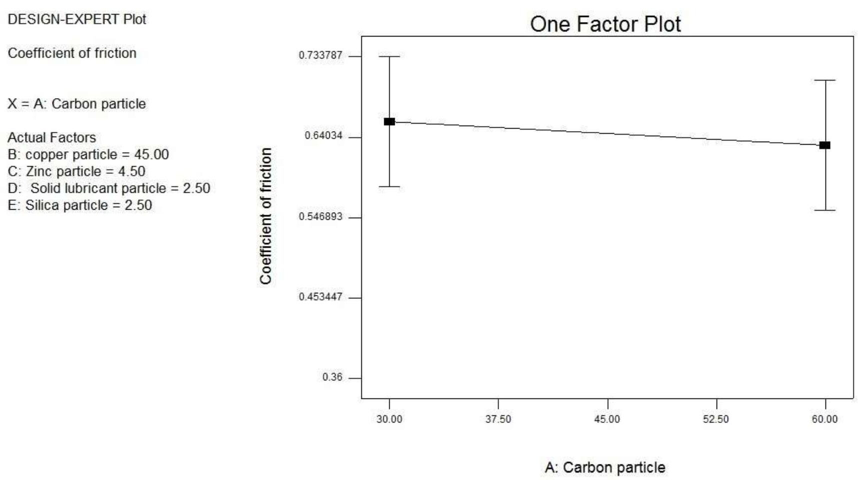

Figure 3.11 : Graph of coefficient of friction versus carbon particle in carbon brush produced from coal.

COCONUT FIBRE (Graph of coefficient of friction versus carbon content)

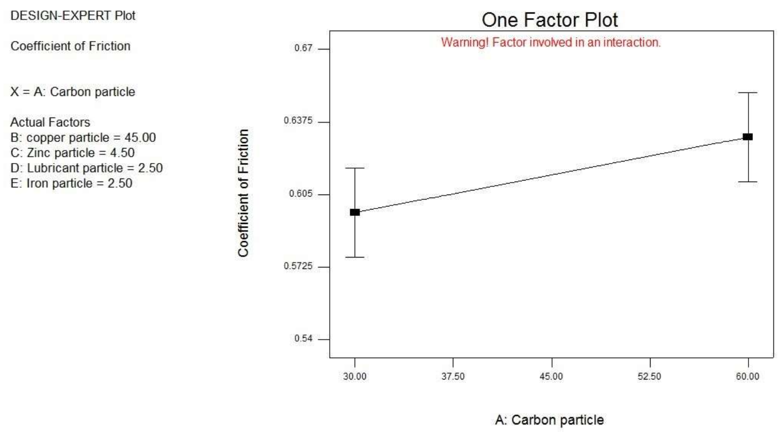

Figure 3.12: Graph of coefficient of friction versus carbon particle in carbon brush produced from coconut fibre.

3.4.5 Comparision of their hardness characteristics

The hardness value of the brush made from coconut shell has a highest value of 69.1KgF and it decreases as the carbon content increase while that made from coal has a highest value of 86.15 KgF and decreases as the carbon content increase. The brush made from coconut fibre has a highest value of 73.5 KgF and it also decreases as the carbon content increase. It is evident that coal will give the highest value of hardness.

COCONUT SHELL (Graph of Hardness versus carbon content)

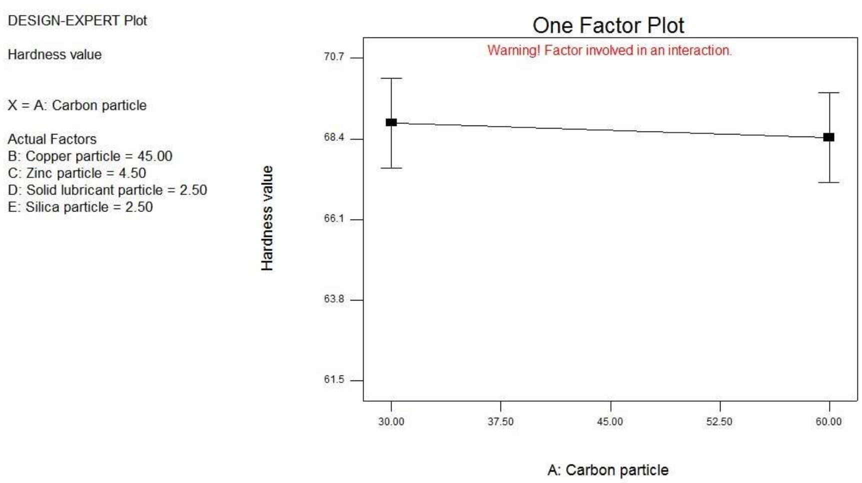

Figure 3.13 : Graph of coefficient of friction versus carbon particle in carbon brush produced from coconut fibre.

COAL (Graph of hardness versus carbon content)

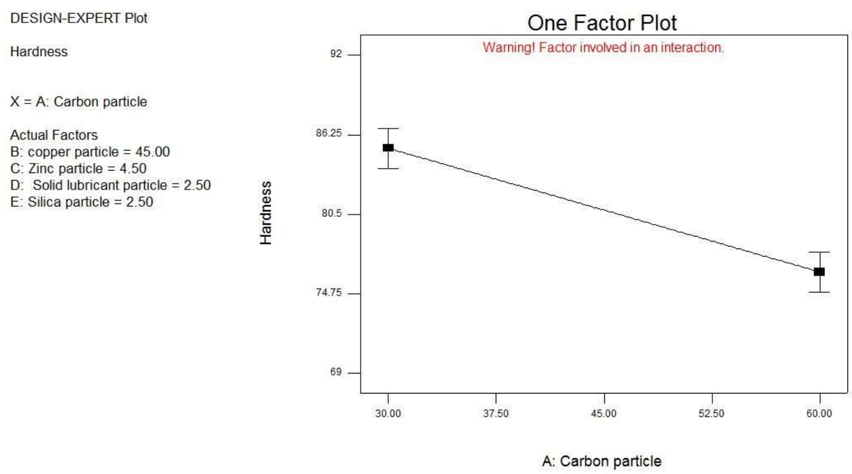

Figure 3.14 : Graph of hardness versus carbon particle in carbon brush produced from coal.

COCONUT FIBRE (Graph of hardness versus carbon content)

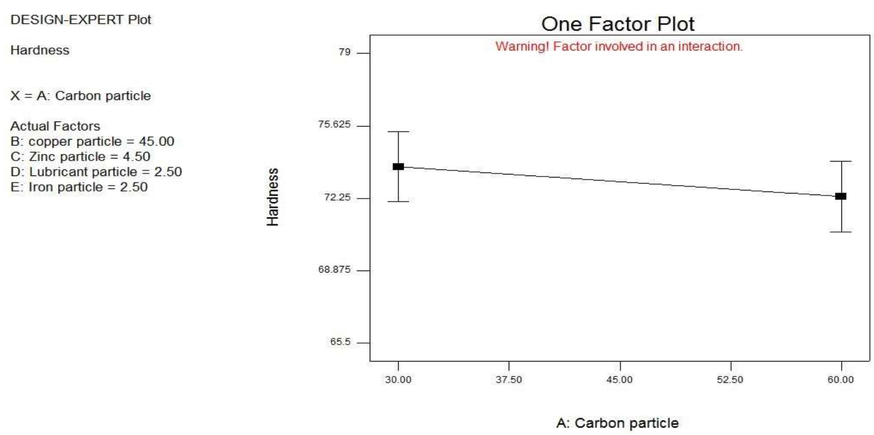

Figure 3.15: Graph of hardness versus carbon particle in carbon brush produced from coconut fibre.

4. CONCLUSION

The experimental work reveal that coconut shell has the highest carbon content of 84.84%, then coal, 79.09% and coconut fibre 77.60%. The resistivity value of carbon is expected to be low and coconut shell gives the lowest value out of the three. High conductivity value will make the brush to perform better and carbon brush made from coconut fibre has the highest value when compared to that of coconut shell and coal. Carbon brush made from coconut shell has the lowest bulk density, and a low bulk density is needed for good performance of carbon brush. Carbon brush made from coconut shell has the lowest coefficient of friction and likewise that from coal has the highest hardness. All these can be used to determine best choice of carbon to be used in the production of carbon brush.

REFERENCE

1. Dalsuke, N., Fumihiro, H., Shinichi S., and Takahiro, S .(2014). “Carbon brush produced by mixing a carbonaceous filler and a binder and kneading, shaping, and baking the mixtures” United States Patent, Patent No US7,859,166B2.
2. ECP, (2005). Types of carbon brushes. www.engineeringcarbonproducts.com.[Accessed 25 July 20011]
3. Else, H. (1957). “Contribution to the theory of the contact between a carbon brush and a copper collector ring” Stackpole carbon company, St Marys,Pennsylvanis Publication (6.March 1957).
4. Franklin, R.E.(1951b) Crystallite growth in graphitizing and non-graphitizing carbons, www. profiles.nlm.nih.gov/ps/access/krbbfy.pdf
5. Gorden, E. (2013). “ Hardness Test” A Publication of Gordon England Company, http://www.gordenengland.co.uk\ Accessed on 15 April , 2013.
6. Haihui, Z., Qiang. Y., Qiling, R. , Hua, W. , Jinhua, C., Yafei, K. (2008). “ Catalytic graphitization of carbon fibers with electrodeposited Ni-B alloy coating” Elsevier , material chemistry and physics 110 (2008): 434-439, www.elsevier.com/locate/matchemphys.
7. Harris, P.J(1997). “Structure of non-graphitizing Carbon” International Materials Review 1997, Vol42,No 5.
8. Harry, M. (2000) Science of carbon materials. Universal de Alicante, Spain.
9. Helwigcarbon (2008) “Specification Guide for carbon brushes” http://www.helwigcarbon.com. 2014
10. Honbo, R., Sawa, K., Wakabayashi, H., Murakami, Y., Inayoshi, N., Inukai, K., Shimoyama, T., Morita, N, (2005) “Development of the lead-free carbon brush material for starters,” IEICE Trans. Electron.,8:1675-1681.
11. Honbo, R., Sawa, K., Wakabayashi, H., Murakami, Y., Inayoshi, N., Inukai, K., Shimoyama, T., Morita, N, (2009) “Lead-free carbon brush material for starters,” www.denso.com. Vol.14,pp :97104
12. Hugh, O. P. (1993). “Handbook of Carbon, Graphite, Diamond and Fullerenes” Noyes publications,Park Ridge, New Jersey,U.S.A. 1993
13. Hu, Z. (2005). “ Peripherial speed factor on wear of carbon brushes from micrometers. http://www.sciencedirect.com/science
14. Hu, Z., Chen, Z., Xia, J. and Ding, G. (2008) “the wear property of high- resistivity carbon brushes made with and without MoS_2 in variable humidity. Transactions of non ferrous metals society of China, vol. 18, issue 2, April 2008, pages 340- 345.
15. Ichiki, T. (1978). “Theory and practice of carbon brushes, Toyo Tanso, Japan,
16. Jeff. D. K. P.E, (1993) “ Carbon brushes for elevators: composition functionsolutions” A paper presented at NAEC THEC SEMINAR, May 5,1993.by Jeff. D Koenitzer,P. E Vice president of engineering, HELWIG Carbon products Inc. Milwaukee, Wisconsin. www.helwigcarbon.com
17. Jeft, D. K. (2003). “ Brushholders and the performance of carbon brushes, “ Technical note No22 Reliable solutions today (Electrical apparatus service Association, Inc)
18. Joglekar, G. D and Danesewar, S. (2013)”Characteristics metal-graphite brushes made by powder metallurgy Technique” Symposium on Non Ferrous metal Industry in India. Global source for metal information”Transverse strength of a material| (ASTM,DIN,EN,JIS,BS,etc) info@metalinfo.com .
19. Nahar, S.,R., Singh, N., and Gupta, P. K. (2008). “Analysis of major,minor constituents and various phases in carbon brushes by classical gravimetry, titremetry and by instrumentation method” www.sciencedirect.com

20. Peter, J .F. H. (1999). "Charcoal, interdisciplinary science reviews, Vol. 24,No.4 pp.301-306.
21. Peter, J . F. H .(2001) " Rosalind Franklin's work on coal, carbon and graphite" Interdisciplinary science Review. 26(3):204-210.
22. Solbreg, T.A. (1927). Carbon brushes. Journal of the American Society of Naval Engineers, 39 (4),636-657.
23. Solbreg, T.A. (2009). Carbon brushes. Journal of the American Society of Naval Engineers, 39 (4),636-657.Verson of record online, onlinelibrary.wiley.com:18 March 2009.
24. Stiller, A.H, Zondi, O. J. and Stansberry, P. G. (1998). "Method of producing high quality, high purity, isentropic graphite from coal" United States Patent 57055139 June 1998.
25. Sun, T. K., Bongbeen Yim and Youngtack Park (2005) "Application of Taguchi experimental design for the optimization of effective parameters on the Rapeseed methyl ester production. Environmental engineering research. www. Eer.or.kr
26. Xia Jin-tong, Hu Zhong-Liang, CHEN Zhen-hua and DING Guo-yun (2007) "Preparation of carbon brushes with thermosetting resin binder" Trans Non-ferrous Material Society, China(2007) 13791384.