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EVALUATION OF WALNUT SHELL ABRASIVE SANDPAPER

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ABSTRACT

This study is focused on development of an eco-friendly abrasive sandpaper using walnut shell (WS) with the binding effect of epoxy resin on WS, iron oxide and silica, calcium carbonate ($CaCO_3$) and pulverized graphite. The method of mixing and mould compression using a hydraulic press matrix composite with five varying composition was used. The compositions were made by varying the weight of WS, epoxy resin with that of iron oxide and silica, calcium carbonate and pulverized graphite were left constant expressed in percentage weight The abrasive properties investigated were density, compressive strength and wear resistance and water and oil absorption rate. The results reveals obtained that the density, wear resistance rate and compressive strength of the tested composition decreases with increasing WS content despite the fact the rate water absorption increases with increasing WS. The result of obtained reveals that WS can be utilized in the production of abrasive sandpaper.

Keywords: Wear rate, absorption, Abrasive sandpaper, Epoxy and Silica sand.

INTRODUCTION

Rapid growth in industrialization has necessitated the need for improvement of materials properties which includes and not limited to lower cost, density, stiffness, strength and must be sustainable. The deployment of artificial and natural fibers in the manufacture of materials and components has shown remarkable uses in a diversity of areas including automobile, marine, aerospace, biomedical, mechanical and construction (Clyne and Hull, 2019). A lot of efforts have been put by different researchers in recent years to exploit locally sourced materials in the development, formulation, construction, manufacture of goods for instance building materials, tools and equipment, design and manufacturing etc. Researches and scientist worldwide are now concentrating on means of exploiting waste from either agricultural or industries as sources of feedstock in industries. The application of wastes will be cost effective, and might as well bring about environmental control and improve foreign exchange (Aku et al., 2012).The necessity to utilize this unlimited capacity in transforming wastes into wood or metal work tool identified as abrasive sandpaper.

Agricultural wastes are organic waste compounds from plant seeds, leaves, shells, fruits and roots such as oil walnut shell, palm shell, corn chaff, rice husk, sea shell and coconut shell. The convenience of agricultural wastes in manufacturing sector is not only cost effective but helps in the control of environmental pollution (Oyelaran *et al.*, 2015). Amongst the usage of these wastes are in the production of helmets, sand paper grains, brake pads, composite materials and as a fuel in energy technology (Nuhu and Adeyemi, 2015; Oyelaran *et al.*, 2015). Ample industrial and agricultural wastes are produced in developing nations, hence they can be converted as possible material or substitute in the production of parts and components

Abrasive materials are utilized in the shaping, finishing, or polishing of materials. They are made from very hard mineral materials developed in furnace and pulverized and sifted into diverse grain sizes also called grits (Atia and Maksoud, 2004, Oyawale and Odior, 1998). The utmost significant physical characteristics of abrasive materials are; toughness, grain shape, brittleness, hardness and grain size, purity, uniformity of the grains and character of fracture (Oyawale and Odior, 2010). Basically two familiar kind of abrasive materials exist namely synthetic and natural.

Abrasives are hard small particles utilized in grinding, polishing, abrade, scouring, cleaning and removal of solid material (Eckart and Aku, 2013) Grits are distinguished by their hardness, sharp cutting points, wear resistance and chemical stability (Aku et al., 2012). Researchers in Nigeria and indeed world over are focusing on the utilization agricultural or industrial wastes as feedstock for the manufacture of abrasive sandpaper. The exploitation of these wastes to useful products will not only be economical, but could also reduce our over dependence on importation and it will also aid in the area of environmental degradation (Ibrahim et al., 2019). Sandpaper is utilized in scraping and smoothening, It is made from an abrasive particles fixed to a backing material that is flexible by a glue (Ibrahim et al., 2019). Abrasives are hard small shapes particles with sharp edges that are irregular also known as grain size or grit (Obot et al, 2016). The method of abrasive machining are also utilized in many industries for instance woodwork, refractory, construction and manufacturing industries owing to its extraordinary adaptability (Scott, 2010).

Walnuts are single rounded seed fruit, usually an eatable fruit after it is ripen. After it is ripen, on removing the husk walnut shell is revealed. Walnut shells, are mostly found commercially in two divisions (three- division's shells are also found). During the ripening process. The husk becomes brittle while the shell becomes hard in the course of ripening. The kernels normally obtainable as walnuts shells are cordoned off in a seed coat which is brown and encompasses anti-oxidants. The universal walnut production is growing briskly with the highest upsurge emanating from Asia. 2.55 million tonnes of walnut is cultivated universally in the year 2010. Averagely per hectare 3 metric tonnes yield of walnut worldwide in 2010 (Nnochiri and Emeka, 2017). Walnut shells have distinctive chemical and physical properties of adaptable abrasive soft material. These characteristics is responsible perfect for different applications, like walnut shell blasting, filtration, non-skid flooring, polishing, soaps and cosmetics (www. Azom. Com). A very limited research papers were found on composite made from walnut reinforcement Therefore in the present work walnut shell particle based composite is been produced with the aim of investigating its potential as possible substitute for asbestos in making of abrasive sandpaper

MATERIALS AND METHODS

Materials

Walnut shell (WS) was collected from Dust bins in Ogbomoso, Nigeria, silica sand, epoxy resin as matrix and binder, calcium carbonate, Silica and anhydrous iron oxide are added for the regulation of build-up friction film and to increase friction, powdered graphite as friction modifier and calcium carbonate ($CaCO_3$) as Reinforcement. Apart from WS, all other chemical material used were purchased from chemical shop in Lagos, Nigeria.

MATERIALS PREPARATION

The WS was put in a solution of detergent and water and soaked for 10 minutes for ease of dirt and other contaminants removal. It was rinsed properly with clean water and dried to constant weight using sunlight it was then after pulverized by milling. To improve the bonding capability of the pulverized WS it was treated with 10% sodium hydroxide (NaOH) solution (Pujari*et al*., 2014). After which it was sun dried again and 30 μm aperture sieve was used in sieving it to obtain a fine powder.

Production of Abrasives Specimen

The production of abrasive sandpaper involves a number of operations which includes weighing components, mixing of components, hot pressing, cooling, post curing and finishing (Koya and Fono, 2010). Epoxy resin of 250g was poured into moulds as control test to estimate the quantity of mixture that will fill the crater completely. On knowing the amount that will completely fill the mould, the material formulation for the WS based brake pads was determined. The weight of epoxy resin, WS were varied with those of the iron oxide, silica, calcium carbonate ($CaCO_3$) and pulverized graphite left unaltered expressed in percentage weight as presented in Table 1. The powder metallurgy technique used by Obot *et al*. (2016) and Obot *et al*. (2015) was used in this research in producing abrasive sandpaper specimens by fixing onto the surface of the backing paper pre-cast mixture.

Table 1 Composition of specimen formulation by weight percent

Sample	A	B	C	D	E
WS	10	15	20	25	30
Resin	40	35	30	25	20
$CaCO_3$	30	30	30	30	30
SiO_2	7	7	7	7	7
Fe	3	3	3	3	3
Graphite	10	10	10	10	10

WS, silica, iron oxide, graphite powder and calcium oxide were placed in mixing vessel after measuring and mixed properly for 15 minutes to achieve a homogeneous specimen indicated in Table 1. The require quantity of epoxy resin as indicated for each was poured separately in dishes and the prerequisite amount of hardener was added forming the matrix and carefully stirred for proper mixing for 10 minutes to attain homogeneous mixture. Subsequently, the produced matrix was placed on the mixed powdered material and then stirred to achieve a homogenous paste-like mixture. The produced paste was then poured to fill the mould cavities. The mould is powdered with talc achieved a better simplicity of component removal after casting. The process was repeated for the production of each brake pad samples and experimental test specimens. It was then allowed for between 80 and 120 minutes to cure. The produced samples were then cured at 150^0C for two hours in an electric oven as performed by Yawas *et al*., (2016). The specimens were then kept for 7 days in well aerated environment to attain complete strength prior to performing the analytical tests. The specimens were also kept for 7 days for strengthening prior to carrying out mechanical tests as performed by Cease et al (2006) and Simpson (2014). The following tests were performed after the strengthening day's density, hardness, tensile strength, coefficient of friction, compressive strength, water/oil absorption, wear (abrasion) resistance and thermal with the aim of ascertain their appropriateness for sandpaper production.

2.2 Samples' Characterization

The samples of the sandpapers produced properties were determined. Some of the mechanical and physical properties of the produced samples. Such as water absorption, wear rate, hardness and strength were determined.

Density test

Density of WS abrasive composite was measured via Archimedes' principle. Weight of the fluid displaced is equal to the buoyant force on a submerged object. This principle was used to establish the volume and consequently the density of the irregular shaped produced composite was obtained by measuring its mass in air and its effective mass when submerged in water. The difference between the real and effective mass gives the mass of water displaced. The density of the sample was obtained using Equation 1.

$$\text{Density } (\rho) = \frac{Mass\ (M)}{Volume\ (V)} \qquad (1)$$

Compressive strength determination

Enerpac Universal Hydraulic Digital Material Testing Machine 100KN was used in carrying out the compressive test in accordance with ASTM D3410/D3410M specifications. The specimen used were cut to 20 × 20 × 10 mm in order to meet the specification of the instrument. The work pieces were loaded continuously until occurrence of failure. The amount of load that causes failure was digitally displayed and recorded (Aigbodion and Akadike, 2010). Equation 2 was then used calculate the compressive strength.

$$\sigma_c = \frac{P}{A} \qquad (2)$$

Where, P is load applied in N, σc is compressive strength in MPa, and A is cross sectional area in mm^2.

Water and Oil Soaking Test

A 48-hour oil and water soaking test were carried out on the abrasive paper produced with the intention of assessing the water absorption behaviour of the abrasive material produced. The original weight of each specimen was taken as the initial weight and recorded as W_i prior to soaking in distilled water and SAE60 engine oil respectively for 48 hours. The samples were then removed from the oil and water and cleaned properly to remove some water and oil that might have remain on to surfaces of the samples. After cleaning they were reweigh and recorded as W_w and W_o for water sample and oil samples respectively. The absorption was calculated using the formula used by Ademoh and Olabisi, (2015) and Edokpia *et al*., (2014) as shown in Equation 3 and 4 for oil and water absorption respectively.

$$\text{Oil absorption\%} = \frac{W_i - W_o}{W_i} \times 100 \qquad (3)$$

$$\text{Water absorption\%} = \frac{W_i - W_w}{W_i} \times 100 \qquad (4)$$

Wear Resistance Test

"Tribometer" apparatus, Anton Paar, Switzerland was utilized in studing the dry sliding wear resistance of the sample following ASTM: G99 – 05 standard (Idris *et al*., 2015). Figure 1, shows Pin-on-Disc tribometer motion diagram. The samples used have a thickness of 5 mm and of 25 mm diameter. The variance in weights prior and after test of the samples gives the wear of the samples. To obtain the wear rate, loss in weight was converted using the Equation 5 as used by Aigbodion and Akadike, (2010).

Wear rate = $\frac{\Delta W}{S}$ (mg/m) (5)

Where ΔW = difference in weight before and after test in mg and S = sliding distance in m.

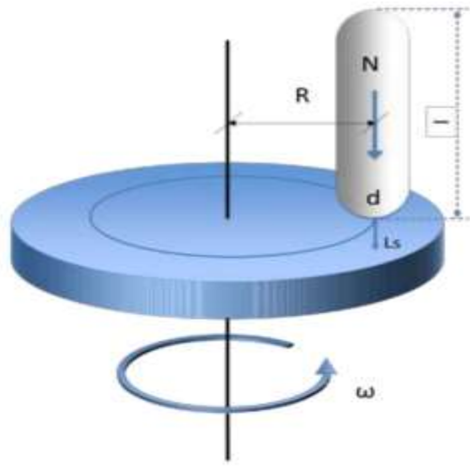

Figure 1 Pin-on-Disc tribometer motion diagram

RESULTS AND DISCUSSIONS

Density

The effects of variation in density with WS content in the samples are shown in Figure 2. From the observed results there is decreased in density of the samples with increase WS content. This could be ascribed to the decreased of the interfacial bonding of the WS and the resin (Idris *et al.*, 2015). Their lightness in weight makes them conform to standard (Olabisi et al., 2016). The result obtained concurs with previous studies. The values of between 0.771 – 1.491 g/cm^{3}obtained in this work meets the recommended values for use as abrasive materials (Kim *et al*., 2003). This study advice that in considering environmental factor, it might be utilized as replacement of asbestos in the production of abrasive materials as a result of the carcinogenic health it poses.

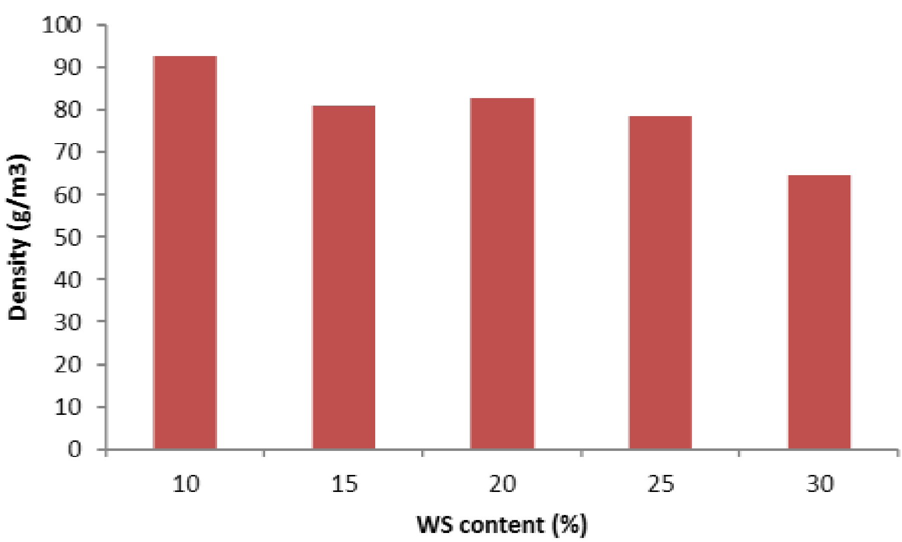

Figure 2 Density variations with WS Content

Compressive strength

The effect of WS content on the compressive strength of the abrasive sandpaper are shown in Figure 3. The results show that the compressive strength which ranges between 64.73 and 92.78 MPa increases with the decrease in WS content. This could be ascribed to the strong interaction between the filler and the resin resulting from good distribution and dispersion of the WS in the matrix. The obtained result concur with the investigations of Idris *et al*., 2015 and Bala *et al*., 2016.

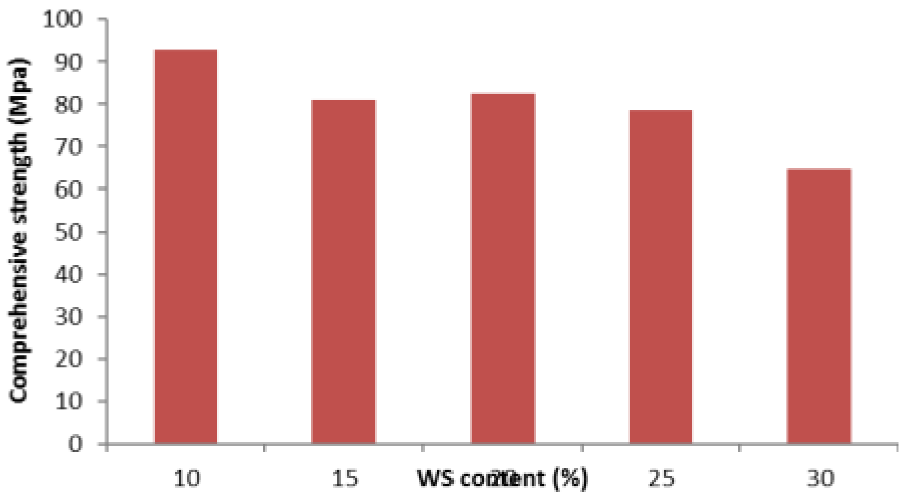

Figure 3 Variations of compressive strength with WS Content

Wear rate

The wear rate variation with WS content of the abrasive sandpaper is displaced in Figure 4. From the table it will be seen that the wear rate from this work ranges between 3.09 and 6.20 mg/m. With the wear rate reducing with increasing WS content. This could be attributed to an enhanced interfacial bonding existing between the matrix and reinforcement resulting in better surface characteristic. The obtained result concur with the study carried out by Idris *et al*., 2015.

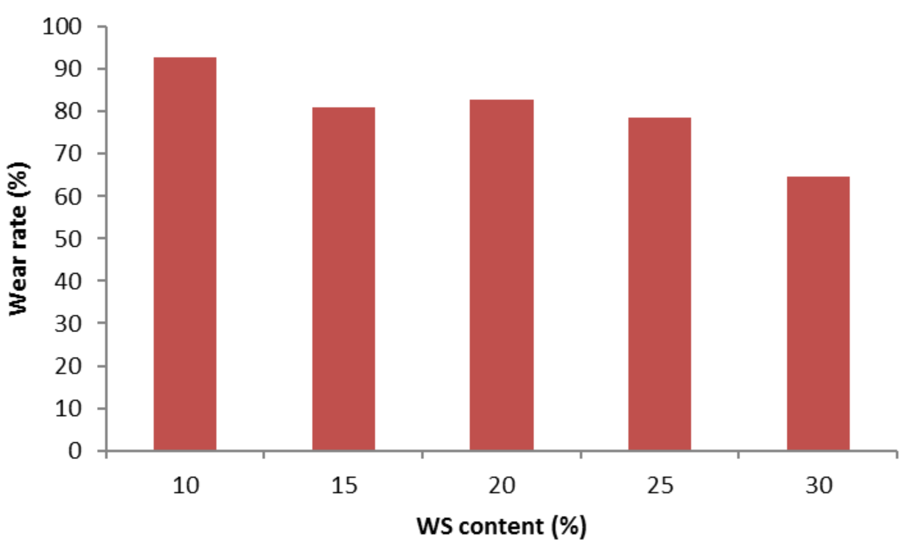

Figure 4 Wear rate variations with WS Content

Water absorption

From the results obtained and displaced in Figure 5, it shows that water absorbent property of produced abrasive paper which ranges between 0.895 and 2.719% increases as weight of fillers increases. The same trend was observed for the oil absorption property of produced abrasive material. The decrease in water and oil absorption rate might be as a result of the increased interfacial bonding between filler and binder resulting in decrease in porosity (Edokpia *et al.*, 2014). The result is in agreement with that of conventional abrasive material with oil and water absorption rates of 0.3% and 0.9% respectively. All the samples presented lower absorption rate, hence superior to the conventional abrasive sandpaper. This implied that the abrasive paper studied possesses superior absorption rate than the conventional, hence will present superior resistance when exposure to environmental water vapour.

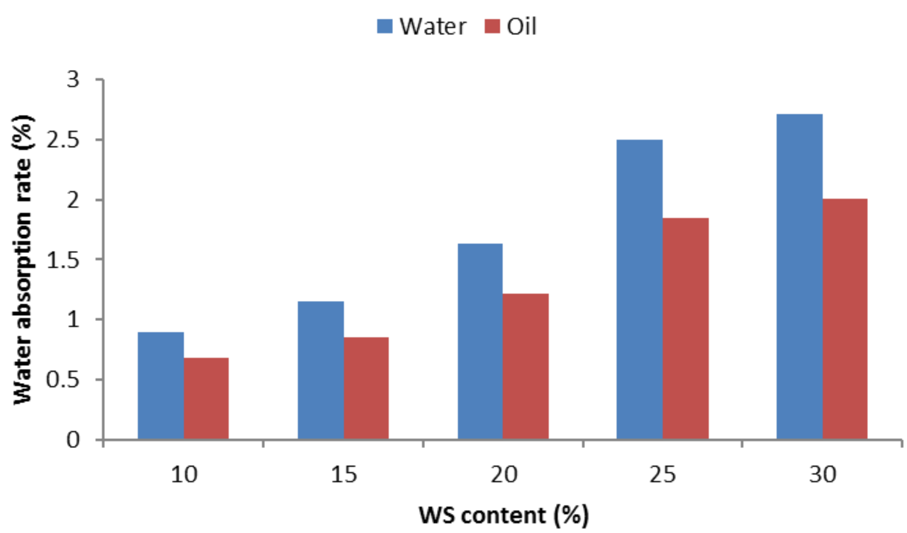

Figure 5 Oil and water absorption rate variations with WS content

CONCLUSION

The obtained results reveals that the density, wear resistance rate and compressive strength of the tested composition decreases with increasing WS content despite the fact the rate water absorption increases with increasing WS. The composite with 10% WS has better properties in terms of density, compressive strength, water and oil absorption while the 30% WS composite has the best wear resistance properties. The result obtained reveals that WS can be utilized in the production of abrasive sandpaper.

REFERENCES

Clyne, T.W.; Hull, D. An Introduction to Composite Materials, 3rd ed.; Cambridge University Press: Cambridge, UK, 2019.

S.Y. Aku, D.S. Yawas, P.B. Madakson and S.G. Amaren, ‘Characterization of Periwinkle Shell as Asbestos-Free Brake Pad Materials’, *Pacific Journal of Science and Technology*, vol. 13, no. 2, pp. 57-63, 2012.

Maleque, M.A., Atiqah, A., Talib, R.J. and Zahurin, H. (2012). New Natural Fibre Reinforced Aluminum Composite for Automotive Brake Pad. *International Journal of Mechanical and Materials Engineering (IJMME)*, 7(2): 166 – 170.

Nuhu A. Ademoh Development and Evaluation of Maize Husks (Asbestos-Free) Based Brake PadIndustrial Engineering Letters, Vol.5, No.2, (2015) 67 -81

Aku, S., Yawas, D., Madakson, P., &Amaren, S. (2012). Characterisation of Perinwinke shell as asbestors-free barke pad materials. Pacific journal of science and technology, 13(2): 57-63.

Nuhu, A., &Adeyemi, I. (2015). Development and Evaluation of Maize Husks (Asbestos-Free)Based Brake Pad, Industrial Engineering Letters, 5(2): 67-80.

McGranahan and C. Leslie, Genetic Resources of Temperate Fruit and Nut Crops, 1991, 907–974.

M. Kornsteiner, K.-H. Wagner and I. Elmadfa, Food Chem., 2006, 98, 381–387.

V. Akbari, R. Jamei, R. Heidari and A. JahanbanEsfahlan, Food Chem., 2012, 135, 2404–2410.

D. Vyas, S. K. Sharma and D. R. Sharma, Scientia Horticulturae, 2003, 97, 141–152.

M. L. Martinez, D. O. Labuckas, A. L. Lamarque and D. M. Maestri, J. Sci. Food Agric., 2010, 90, 1959–1967.

Ali Jahanban-Esfahlan and RyszardAmarowicz Walnut (Juglansregia L.) shell pyroligneous acid: chemical constituents and functional applications RSC Adv., 2018, 8, 22376

Pujari, S., Ramakrishna, A. and Kumar, M. S. (2014). Comparison of Jute and Banana Fibre Composites: A Review. *International Journal of Current Engineering and Technology*, (2): 121 – 126.

Nuhu A. Ademoh Development and Evaluation of Maize Husks (Asbestos-Free) Based Brake Pad

Industrial Engineering Letters, Vol.5, No.2, 2015, 67 - 81

Oluyamo, S. S., Bello, O. R., and Yomade, O. J. (2012). Thermal Conductivity of Three Different Wood Products of Combretaceae Family; *Terminalia superb, Terminaliaivorensis and Quisqualisindica*. *Journal of Natural Sciences Research. Vol. 2, No. 9*, pp. 18-29

Edokpia, R. O., Aigbodion, V. S., Obiorah, O. B., Atuanya, C. U. (2014). Evaluation of the Properties of Ecofriendly Brake Pad Using Egg Shell Particles–Gum Arabic. *ScienceDirect, Elsevier.* B. V. DOI: 10.1016/j.rinp.2014.06.003

Ademoh A. Nuhu, Adeyemi I. Olabisi. (2015). Development and Evaluation of Maize Husks (Asbestos-Free) Based Brake Pad. *International Institute for Science, Technology and Education (IISTE): Industrial Engineering Letters -IEL*. Vol. 5, No. 2, pp. 67–80.

S.S. Lawal*N.A .Ademoh, K.C. Bala, A.S.Abdulrahman*, 2019 A Review of the Compositions, Processing, Materials and Properties of Brake Pad Production *J. Phys.: Conf. Ser.* **1378** 032103

Kim, S. J., Kim, K. S. and Jang, H. (2003). Optimization of Manufacturing Parameters for Brake Lining using Taguchi Method. *J. Material Process Technology*, 136: 202 – 208.

Idris, U. D., Aigbodion, V. S., Abubakar, I. J., Nwoye, C. I.(2013). Eco-friendly asbestos free brake-pad: Using bananapeels. *Journal of King Saud University – Engineering Sciences*

Roubicek, V.,Raclavska, H.,Juchelkova D.,Filip, P.,(2008),Wear and environmental aspects of composite materials for automotive braking industry,*Wear,Vol.265*,pp167-175.

Fona, R.S., and Koya, O.A. (2013a).Characteristics of Pulverized Palm Kernel Shell for sustainable waste diversification.International Journal of Science & Engineering Research ,4.

Fono–Tamo, R. S., &Koya, O. A. (2013b). Evaluation of Mechanical properties of Friction Pad developed from Agricultural Waste. International Journal of Advancements in Research & Technology, 2(154), 2278–7763.

Ibhadode, A. O. A., & Dagwa, I. M. (2008). Development of asbestos–free friction pad material from palm kernel shell, Journal of the Brazilian Society of Mechanical Sciences and Engineering. 30(2), 166173.

www.en.m. Wikipedia.org/wiki/walnut, Walnut; Agriculture-Transport Information Service, Association for German Insurance, 2010. Accessed on 30th June, 2020.

Emeka Segun Nnochiri, Helen Oluyemisi Emeka (2017). Improvement of geotechnical properties of lateritic soil using walnut shell ash, Bulletin of Engineering Tome X Fascicule 4 105 - 109

www. Azom. Com/ article, 2016. Accessed on 30th june, 2020.

Atia, M. R. and Maksoud, T. M. A. (2004). Review of intelligent grinding and dressing operations. Journal of Machining Science and Technology, 8, 263-276.

Oyawale, F. A. and Odior, A.O. (1998). Manufacture of abrasive paper from locally sourced raw materials in Nigeria. Journal of Emerging Trends and Applied Sciences, 1(1), 40-47.

Odior, A. O. and Oyawale, F. A. (2010). Manufacture of abrasive grains from locally sourced raw materials in Nigeria, Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS), 1(1), 40-47

Obot, M. U., Yawas, D. S., Aku, S. Y., Obada, D. O. (2016). An assessment on the production of abrasive sandpaper from locally sourced materials, Tribology in Industry, 38(2),176-185

Aku, S., Yawas, D., Madakson, P., & Amaren, S. (2012). Characterisation of Perinwinkeshell as asbestors-free brake pad materials.Pacific Journalof Science and Technology, 13(2), 57-63.

Ibrahim H.K., Abdulhamid, A.S., Abdulkareem, S., Shuaib-Babata, Y.L., Popoola O.T., Kareem, A.G., Adeyi A. M., Busari, O.Y., Ambali, I.O. (2019). Development of abrasive sandpaper grains from agro waste material for polishing of wood surface.Adeleke University Journal of Engineering and Technology, 48-60.

Eckart, K., & Aku, S. (2013). Development of an abrasive material using periwinkle shells. Journal of King Saud University of Engineering Science, 5(3), 23-37.

Scott, I. (2010). Tribology of abrasive machining process. William Andrew Publishing, 268.

V. Akbari, R. Jamei, R. Heidari and A. JahanbanEsfahlan, Food Chem., 2012, 135, 2404–2410.

www. Azom. Com/ article, 2016. Accessed on 30th June, 2020.

www.en.m. Wikipedia.org/wiki/walnut, Walnut; Agriculture-Transport Information Service, Association for German Insurance, 2010. Accessed on 30th June, 2020.