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Selection and Characterization of Some Ceramic Raw Materials in Kogi State Nigeria for Brake Pad Production.

Kolade Jones Olatunji[1], Akinbogun Tolulope Lawrence[2], Kashim Isa Bolaji[3], Dahunsi Olurotimi Akintunde[4].

[1]*Industrial Design Department, School Of Art Design, and Printing. Kogi State Polytechnic, Lokoja, Kogi State, Nigeria*
[2]*Department of Industrial Design Federal University of Technology, Akure, Nigeria.*
[3]*Department of Industrial Design Federal University of Technology, Akure, Nigeria.*
[4]*Department of Mechanical Engineering Federal University of Technology, Akure, Nigeria*

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ABSTRACT
There is a growing need to develop automobile brake pad materials from sustainable sources. The study of substitute brake pad materials from sustainable sources is an area that requires immediate attention. This is because previous materials used (such as asbestos) are known to have carcinogenic effects. Several studies have investigated alternative materials to asbestos for brake pads. There are five compositions of different categories of brake pads in the formulation of materials. In composition one the binder is 10% of the composition, filler is 38% of the composition, abrasives take 19% = 190 grams of the composition, fibre takes 8% and lubricant takes the remaining 25% altogether as one hundred per cent. Composition Two Line blend 2: (Two) is a composition of five different categories of brake pad materials of classification. The binder is 11% =110 grams of the composition, filler is 40% of the composition, abrasives take 17% of the composition while fibre is 9% and lubricant takes the remaining 23% altogether as one hundred per cent. Composition Three Line blend 3: (Three) is a composition of five different categories of brake pad materials of classification. The binder is 12% of the composition, filler is 41% of the composition, abrasives take 16% of the composition, fibre takes 12% and lubricant takes the remaining 25% together as one hundred per cent. Composition Four Line blend 4: (Four) is also a composition of five different categories of brake pad materials of classification. The binder is 14% of the composition, filler is 42% of the composition, abrasives take 15% of the composition, fibre takes 14% and lubricant takes the remaining 15% altogether as one hundred per cent. Composition Five Line blend 5 (Five) is a composition of five different categories of brake pad materials of classification. The binder is 15% = 150g of the composition, filler is 45% of the composition, abrasives take 12% of the composition, fibre takes 15% and lubricant takes the remaining 13% altogether as one hundred per cent.

Keywords: Brake pads, asbestos, blends, composition, heterogeneous, X-ray diffraction (XRD).

I. INTRODUCTION

Brake pad materials are heterogeneous substances composed of different elements. Each constituent element has its functions which include the improvement of frictional properties at low and high temperatures, reduction of noise, prolonging life, increasing strength and rigidity as well as reduction of porosity (Jang et al, 2004; Cho et al., 2005 Mutlu et al., 2005; Zaharudin et al., 2012). Brake linings were invented by Bertha Benz the wife of Karl Benz who invented the first patented automobile during her historic first long-distance car trip in the world in August 1888. (Llewellyn, 2008). There are so many natural resources in Nigeria and some of these mineral resources are well represented in Kogi State some of these minerals are highly deposited in million tonnes as earlier stated by Akinbogun, Kashim and others that made research on mineral deposits in Nigeria. In Kogi State over 23 out of 32 mineral resources present in Nigeria are highly represented all over the three senatorial Districts and some of these minerals are good for ceramic production.

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Objectives

The objectives of this study are to:

i. Source for raw materials that will meet up with expected standard qualities when used for brake pad production within Kogi State;
ii. Characterize the raw materials that are free from asbestos sourced in Kogi State such as Quart or Silica, Feldspar, Talc, and Kaolin to ascertain their chemical composition;
iii. Formulate different samples from the raw materials to get the best mix;

Scope of the Study

The materials to be used for the production of brake pads from Kogi states such as quartz, feldspar, talc, mica, kaolin, and other components that are non-indigenous materials such as ceramic fibre, fibreglass, and phenolic resin can be sourced from the local markets within the country. Kogi State where the minerals for the brake pad were sourced is one of the most naturally endowed states in Nigeria. Some of the natural resources in Kogi State are in commercial quantities (Fatoye, 2018).

II. MATERIALS AND METHOD

The production of brake pads was developed from carefully selected materials following the criteria given by Blau (2001) following standard production procedure as given by Edokpia et al (2014) and Bashar et al (2012) and then evaluated the result of the brake pad produced with the standard test methods. The research method that was used for this study is product development or research and development (R&D) This approach is commonly used in some professional disciplines such as environmental studies, medicine, pharmacy, engineering, veterinary medicine, and also in general science and development approach was used for the production of the brake pad using indigenous raw materials such as kaolin, quartz, feldspar, and talc, sourced from Kogi state in Nigeria. Research and development to determine the effect of a variable number of materials in any kind of application to gather information.

Materials for Brake Pads

All the materials that were collected for this study were sourced from Kogi State due to the availability and proximity of the materials to the researcher. Kaolin was sourced from Agbaja Oworo, Feldspar Itakpe, Quartz Ajaokuta, and Talc from Mopa-Amuro all in Kogi State, other materials like ceramic fibre, glass fibre, phenolic resin, and other elements in the form of minor oxides were bought in the market. The summary of the composition is given in the Table below as per the material's constituent as follows: the binder was given first from composition 1-5 of the materials, on the column the next is filler as the next, while fibre comes next to the column as number 3 followed by 4 which is a lubricant, number 5 is an abrasive.

Brake pad Materials and their Uses Table 1.

SN	Brake Pad Materials	Material	Reasons for Materials Choice
1.	Binder	Phenolic resin	Holds all the materials in place in brake pad production
2.	Fillers	Kaolin/Silica	Maintains overall compositions, cheapens and productions, etc.
3.	Fibre	Ceramic and glass fibres	Friction materials reinforcement
4.	Lubricant	Talc	Lubricants influencing the wear characteristics of the lining
5.	Abrasives	Quartz	To increase friction and maintain cleanliness

Source: Author Field Work, 2021

Raw Materials Characterizations.

Physical, Chemical and Chemical characterizations always denote the potential of the raw material. The material samples obtained from various stations were analysed to determine their mineralogical and chemical composition using the X-ray diffraction (XRD) and X-ray fluorescence (XRF) machines. The XRF analysis was done at Spectral Laboratory, Kaduna, Kaduna State, Nigeria. The major raw materials used in this study

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were kaolin, feldspar, talc, silica and iron ore. The particle size of materials for the production of brake pads was analysed with a sieve of 100, 200, and 300 µm was picked for the research. Measurement of particle size distributions is usually carried out across a wide range of studios and understanding how they affect products and processes are critical to the success of brake pad production (Malvern, 2019).

Table 2 REPORT OF THE XRF ANALYSIS

ELEMENT	KAOLIN	FELDSPAR	QUARTZ	TALC	IRON-ORE
SiO_2	59.641	65.803	92.925	68.425	61.110
V2O5	0.030	0.030	0.015	0.071	0.053
Cr2O3	0.022	0.022	0.129	0.070	0.080
MnO	0.084	0.040	0.019	0.151	0.035
Fe_2O_3	3.404	0.921	0.452	8.030	30.209
Co3O4	0.010	0.005	0.014	0.041	0.138
NiO	0.002	0.005	0.003	0.003	0.000
CuO	0.046	0.057	0.037	0.050	0.029
Nb2O3	0.011	0.013	0.008	0.011	0.137
MoO3	0.003	0.006	0.006	0.000	0.000
WO3	0.000	0.000	0.013	0.292	0.017
P2O5	0.086	0.000	0.000	0.479	0.000
SO3	0.203	0.717	0.132	2.493	0.078
CaO	0.299	0.809	0.241	0.000	0.409
MgO	0.721	0.000	0.000	1.139	0.000
K2O	2.214	15.804	0.171	0.055	2.308
BaO	0.068	0.031	0.064	16.302	0.083
Al2O3	31.808	13.808	4.860	0.018	4.585
Ta2O5	0.026	0.034	0.048	1.616	0.005
TiO2	0.284	0.137	0.132	0.014	0.067
ZnO	0.025	0.010	0.000	0.018	0.001
Ag2O	0.020	0.021	0.011	0.604	0.000
Cl	0.839	0.593	0.595	0.096	0.531
ZrO2	0.028	0.020	0.017	0.000	0.048
SnO2	0.000	0.956	0.000	0.023	0.078
PbO	0.018	0.045	0.004	0.023	0.023
BaO	0.068	0.031	0.064	0.097	0.027
HBO	0.007	0.003	0.000	0.012	0.002
As2O5	0.000	0.000	0.002	0.001	0.001
SeO2	0.001	0.000	0.001	0.005	0.005
CdO	0.032	0.080	0.037	0.168	00.163

Source: Author Field Work, 2021

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Material Processing.

In processing materials the below stages in Table 2 were taken for the brake pad production, in the material processing only feldspar and quart were calcinated before milling.

III. RESULTS AND FINDINGS

The chemical Composition and the concentration of elements obtained from the XRF of the selected materials free of asbestos that were sourced from Kogi State for the ceramic brake pad production as analysed are presented below

Ajaokuta Quartz Chemical Composition

The chemical Composition and the concentration of elements in quartz obtained from the XRF analyses are presented. Itakpe quartz or silica contains one major component which is SiO2- 99.37 wt. %, it dominated the whole table with few other minor constituent elements such as MnO - 0.013, TiO_2 - 0.019, $A1_2O_3$ is zero per cent, CaO - 0.243, BaO - 0.091, CuO - 0.013. Quartz is one of the most abundant minerals in the Earth's crust and the most important silica mineral, occurring in large amounts in igneous, metamorphic, and sedimentary rocks. The mineral is widely used as a raw material in several industrial applications. Because of its chemical composition (SiO_2) and its specific properties, quartz can be used both as a bulk product and a high-tech material. There are three types of silica: Rock, Granular, and Powder type and it's often used as filler in ceramic brake pads and acts as a glass former in ceramics.

Itakpe Feldspar Chemical Composition

The chemical Composition and the concentration of elements in Feldspar obtained from the XRF analyses are presented. Feldspar is a group of minerals with a framework of silicates and it is one of the most common rock-forming minerals of planetary crusts. Feldspar XRF from laboratory results, it is evident that Itakpe Feldspar contains three major elements which are SiO2-63.60 wt %, AI_2O_3-18.40 wt. %, and contains thirteen minor elements and all the present elements are nontoxic. It reveals that Itakpe feldspar is a potash feldspar because it has 16.92 wt. % of potash (K_2O). It serves as an abrasive in brake pads and plays a role in reducing excess friction on the brake disk and regulating fillers. It has good adhesion with binders and can improve the strength of brake pads

Mopa/Amuro Talc Chemical Composition

The chemical Composition and the concentration of elements in Talc obtained from the XRF analyses are presented: Talc is a mineral that is common with unique attributes and commercially important. A complete chemical analysis of the talc sample shows that the constituent sample contains two major elements that are friendly for brake pad production SiO2 47.71 wt. % and MgO 25.40 wt. %, and chlorite, serpentine, sphene, and iron oxides 19%. Talc mineral with a layered structure. It plays a role in reducing friction and regulating fillers. It has good adhesion with binders and can improve the strength of brake pads. The study of talc samples reveals that the talc sample includes four main lithological groups: steatite group, talc carbonate group, talc chlorite group, and ferruginated talc.

Agbaja Kaolin Chemical Composition

The chemical composition of raw kaolin from Agbaja was determined by using XRF kaolin contains two major oxides, SiO_2-54.80 wt. %, AI_2O_3-3I.6O wt. % and nine other minor, constituent elements. Results of the Chemical Analysis and the Raw Materials above show the individual elements that are present in materials that can be used in producing the brake pad. Kaolin mineral is a commercially solid powder. It is regularly used for a variety of applications, it can serve as filler in brake pads. The thermal property of kaolin samples was investigated between 1000 to 1400^oC temperatures to ascertain their suitability for producing automobile brake pads. In the research work, kaolin clay was explored, exploited, and employed specifically for ceramic disk brake pads (Aderiye, 2014).

Beneficiation Scheme of the Materials

The summarised processes or stages in Figure 3.1 below were taken to process the major materials such as silica, feldspars, talc, and kaolin for the production of the ceramic brake pad.

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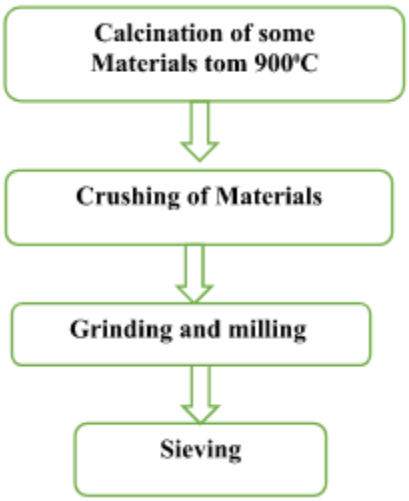


Figure 1 Beneficiation Scheme of the

Materials

Samples of the processed materials as presented in Figure 1 below are talc, kaolin, feldspar, silica, and iron oxide that were used for the brake pad lining.

Processed Materials

Plate 1: Samples of the processed Materials
Source: Author Field Work, 2021

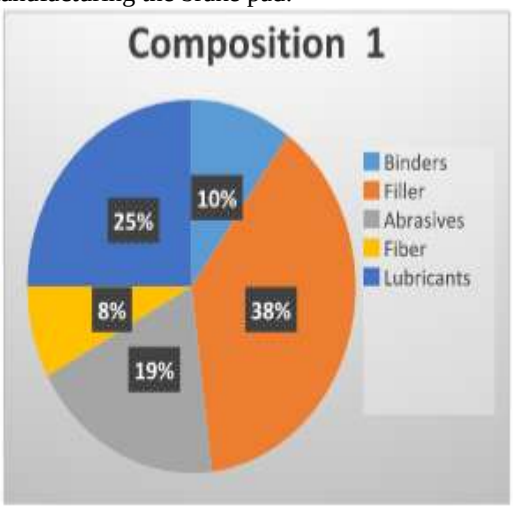
The Design and Fabrication of the Brake pad aided in making machines

Production of pattern and POP Mould for the production of Aluminium Mould for the brake pad production as in Plate 2. below.

Plate 3: The fabricated Aluminium mould
Source: Author Field Work, 2023

Materials and Formulation of Brake Pad

The materials were sourced and processed and the raw materials were sized, batched, and mixed into varying desired amounts. The choice of material selection was based on the following physical and mechanical properties, the crushed and sieve materials were mixed with the other materials in different proportions to determine the optimum friction lining formulation for manufacturing the brake pad.



Percentage Compositions of Materials(%)

Line blend 1 Figure 3 is a composition of five different categories of brake pad materials of classification. The binder is 10% = 100grams of the composition, filler is 38% = 380grams of the composition, abrasives take 19% =190gram of the composition, fibre takes 8% =80grams and lubricant takes the remaining 25% = 250 grams altogether as one hundred per cent.

Line blend 2: Figure 4 is a composition of five different categories of brake pad materials of classification. The binder is 11% =110 grams of the composition, filler is 40% = 400 grams of the

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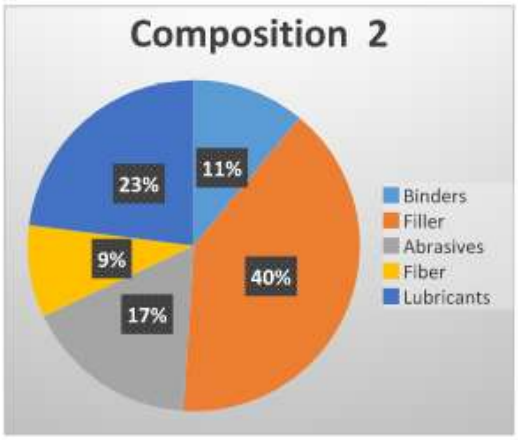
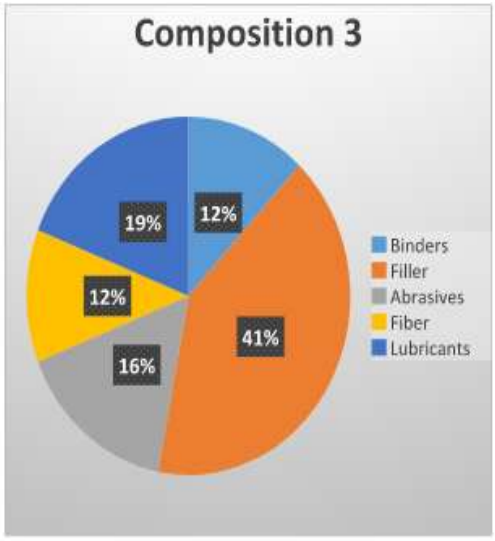
composition, abrasives take 17% = 170gram of the composition while fibre 9% = 90grams and lubricant take the remaining 23% = 230gram altogether as one hundred per cent.



Line blend 3: Figure 5 is a composition of five different categories of brake pad materials of classification. The binder is 12% = 120 grams of the composition, filler is 41% = 410 grams of the composition, abrasives take 16% = 160grams of the composition, fibre takes 12% = 120gram and lubricant takes the remaining 25% = 250 together as one hundred per cent.



Line blend 4: Figure 6 is a composition of five different categories of brake pad materials of classification. The binder is 14% = 140gram of the composition, and the filler is 42% 420gram of the composition, abrasives take 15% =150gram of the composition, fiber takes 14%140gram and lubricant takes the remaining 15% = 150gram all together as one hundred per cent.

IV. SUMMARY.

The basic steps for the production of ceramic brake pads included raw material sourcing, procurement, beneficiation, mixing, forming, curing, green machining, pre-sinter thermal processing, firing, final processing, and packaging were followed. The outcomes of this study can provide additional knowledge to road users in selecting suitable brake pads for their automobiles. The goal of the study in general is to reveal the properties of materials for brake pads by reviewing the materials and constituents currently used as automotive brake friction material. Brake pads are composed of materials that give the right combination of friction, wear, heat distribution, vibrations, and noise. In the commercial brake pads market, complete compositional disclosure of brake friction material is rare because the information is treated secretly and the manufacturers are not always ready to disclose it to anybody. There was no specific composition that could represent the majority of brake pads in existence. Each subcomponent of different brake friction materials will have its varying ingredients and components.

V. CONCLUSION.

The conclusion of this research was based on the project's specific objectives. The outcome of the study was able to meet the objectives of the research which is to source the materials to be used for the production of the ceramic Brake Pad. The materials that were sourced locally within Kogi State were characterized to determine whether the materials were good enough for the production of functional ceramic brake pads. The materials were found to meet up with the criteria for the production of brake lining.

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