DEVELOPMENT OF BRAKE PAD USING THE LOCALLY AVAILABLE MATERIALS

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Abstract: The major component of brake pad lining material is an asbestos fiber which is dangerous to health. The aim of this research work is to develop a brake pad which is free from asbestos materials and can perform similar function. Coconut shell, Periwinkle shell, egg shell, cashew nut shell, Graphite, mild steel brass, and epoxy resin were used as composition mixtures. The composition was grinded, mixed and compressed in a hydraulic press (Model Pi00ch-Type at 50KN/cm^3) and heated in a furnace at 1500^{0}C.The brake pads were removed and cured at 1200^{0}C for 8 hours. The brake pads were evaluated for different properties of samples A, B, C, and D and were found to give compressive strength (87MPa, 98MPa, 100MPa, and 113Mpa), Wear rate of (0.16mm/min, 0.15mm/min, 0.13mm/min, 0.11mm/min), Water absorption (0.5%, 0.9%, 0.6%, 0.8%), Hardness test (120HRC, 140HRC, 169HRC, 172HRC) and co-efficient of friction (0.30, 0.33, 0.38, and 0.42) respectively. The results obtained were found to compare reasonable with the results produced when a brake pad of a Toyota high lander was used.

Key words: Asbestos, Brake pad, Periwinkle shell, Fibers, Graphite

INTRODUCTION

Brake pad are components of disc brakes used in automobiles. They are steel backing plates with friction materials bound to the surface facing brake disc. Brake pads are used in braking system to control the speed of automobile [1] by converting the kinetic energy of the automobile to thermal energy by friction and dissipating the heat produced from the surrounding. Brake pads used in automobile brakes are of two types: drum brakes and disk brake. The drum brake is located inside a drum so that on application of brakes, the brake lining is forced out wards and pressed against the drum, while disc brake operate in similar way except that they are exposed to the environment [2]. Friction materials includes binders, structural materials, fillers and frictional additives. Those containing metal powders are called metallic friction materials while those of asbestos are called asbestos friction materials. Those without asbestos are referred as asbestos-free, non-asbestos friction materials [3]. It was realized that asbestos which were earlier used for the development of brake pad and brake linings in motor vehicles produce asbestos dust which when inhaled causes cancer of the lungs and brains in human [4]. He further investigated that the cost of asbestos for the manufacture of brake pads and brake shoes increase the cost of production and subsequently increase the selling price of brake pads and brake lining. Properties of materials are determined for materials suitability for brake pads and brake linings. These properties includes hardness, wear resistance, etc. [5]. [6] Reported that friction arises from surface interaction between two contacting materials and is affected by volume and surface dependent properties. Volume dependent properties are elastic and it modifies the hardness and thermal characteristics [7]. Brakes discover application in slowing down in different fields of use, for example, Engine vehicles and cranes, and the serious issues of the business brake cushions, with heavier burden, the issue of coating in Constituents (smooth reflexive surface) is regular. Coating lessens the coefficient of grinding between the brake drum and the liners prompting slip and in-effective slowing down [8] Abundance heat is created and dark stores on the wheel are delivered when the brake cushion is utilized unnecessarily and overabundance sound is created when in contact with water. The examination introduced in this original copy centers around the advancement of brake linings utilizing byproduct from farming and lodgings. The destroyed Periwinkle shells, Egg shell, Coconut shell, cashew nutshell, were portrayed regarding its essential arrangement. While the created brake lining was assessed as far as hardness, compressive strength, coefficient of grinding, water assimilation, and wear rate [9] developed an asbestos free friction lining materials from palm kernel shell, in the study the mechanical and physical properties as well as the static and dynamic performance compared well with commercial asbestos based lining materials. They obtained Hardness to be 3000kgf, Impact strength to be 0.07Jj/Mm2, Porosity 22.45%, Coefficient of friction 0.43 and thickness swell in water 5.03% [10] worked on the development of fly-ash based automotive brake linings. They developed friction composite using fly ash obtaining from a specific power plant in Illinois, Additives such as phenolic resin, aramid pulp, glass fibre, potassium titanate, graphite aluminum fibre and copper power were used in the composite development phase in addition to fly ash. The developed brake lining composite exhibited consistent coefficient of friction in the range of 0.35 – 0.4 wear rate lower than 12wt%. [5] developed a vehicle brake pad using Araldite, Epoxy resin, Carbon, Aluminium, Copper, Zinc, Zirconium, Cashew nut shell, Rubber, Palm Kernel shell, Coconut shell. They got their wear rate to be 0.03 – 0.08, Coefficient of friction 0.4 – 0.65, Hardness 80 – 85, Wear rate of 0.025mm/min to 0.06mm/min. [11] Developed a brake pad using Epoxy Resin, Cocoa bean shell, Silica, Iron oxide, Calcium carbonate and powdered graphite. The test conducted on the brake pad gave, average hardness value 109.15Mpa, Average Tensile Stress at break is 13.076, Breaking load 870 – 663N, Compressive Strength 15.133Mpa. [12] Developed an asbestos free brake pad using Bagasse. Tribology in industry Vol. 32, No.1 The results of his analysis gave Specific Gravity 1.65, Wear rate 4.40mg/m, Water absorption 5.03% after 24h, Compressive Strength 103.50Mpa, and Hardness test 92.

2. MATERIALS AND METHODS

2.1 Materials

1. Binder

Epoxy tar was chosen as the folio in this brake cushion definition. Epoxy tar serves an elective cover contrasted and the phenolic tar utilized in business brake cushions everywhere on the world. This is on the grounds that epoxy pitch is promptly accessible and is less expensive than phenol tar, and is a sort of thermo set polymer framed by a buildup response among phenol and formaldehyde and can go about as a framework for restricting together various substances [13].

2. Fillers

Three (3) different fillers were selected in this study as alternative filler and for comparison purposes, i.e. coconut, cashew nut and egg shell.

i Coconut Shell.

Coconut shell is non-food part which is one of the hard agro squanders. Coconut shell is a high possible material because of its high strength and modulus properties. Coconut shell powder shows praiseworthy properties contrasted with different materials like ease, sustainable, high explicit solidarity to weight proportion, low thickness less scraped spot to machine and ecological cordial. Blending coconut shell powder with epoxy gum upgrades its properties and makes a wide scope of uses [13].

ii. Egg shell

Typically egg shells are viewed as side-effects at cafés, food ventures, and houses and so on this will establish contamination to the climate yet it has high compressive strength. Egg shell powder can be considered as an option in contrast to the standard plant-based materials. By utilizing the eggshells contamination can be diminished. Egg shell is the least expensive material and this is a side-effect for the customary use. The egg shells have high compressive strength, polyamide, has great effect strength and nylon dark has great elasticity. By and large, this composite has great application in car. Different pieces of auto require compressive, sway, rigidities dependent on the necessity of the part these materials are blended in various extents. [14]

iii. Cashew Nut Shell

The cashew nut comprises of part, shell and testa. It contains on a normal 20 to 22% part (palatable bit), 2-5 % testa and 65-75% shell (external covering). The cashew nutshell contains 25-30% dull ruddy earthy colored thick phenol fluid known as Cashew Nutshell Fluid and shortened as CNSL [14]. The actual properties of CNSL considered are dampness content, explicit gravity and Consistency.

iv. Periwinkle Shell

The periwinkle shell is broadly ovate, thick, and sharply pointed except when eroded. The shell contains six to seven whorls with some five threads and wrinkles. The color is variable from grayish to gray-brown, often with dark spiral bands [15].

3. Mild steel

Mild steel is utilized as support since it is comprised of carbon and iron, with substantially more iron than carbon. Indeed, and no more, steel can have about 2.1 percent carbon. Gentle steel is perhaps the most usually utilized development materials. It is extremely solid and can be produced using promptly accessible characteristic materials. It is known as gentle steel in light of its generally low carbon content. [16]

4. Abrasive

Mild steel is utilized as support since it is comprised of carbon and iron, with substantially more iron than carbon. Indeed, and no more, steel can have about 2.1 percent carbon. Gentle steel is perhaps the most usually utilized development materials. It is extremely solid and can be produced using promptly accessible characteristic materials. It is known as gentle steel in light of its generally low carbon content. [16]

Table 2.1 Sample A Composition Mixture of the Brake Pad

Function	Material	Amount	% composition
Binder	Epoxy resin	25g	25%
Abrasives	Brass	10g	10%
Fiber reinforcement	Mild steel	10g	10%
Filler	Coconut shell	15g	15%
	Periwinkle shell	10g	
	Egg shell	10g	10%
	Cashew nut shell	10g	10%
Lubricant	Graphite	10g	10%
	Total	100g	100%

Table 2.2 Sample B Composition Mixture of the Brake Pad

Function	Material	Amount	% composition
Binder	Epoxy resin	30g	30%
Abrasives	Brass	10g	10%
Fiber reinforcement	Mild still and cast iron	10g	10%
Filler	Coconut shell	10g	10%
	Egg shell	10g	10%
	Periwinkle shell	10g	10%
	Cashew nut shell	10g	10%
Lubricant	Graphite	10g	10%
	Total	100g	100%

Table 2.3 Showing Sample C Composition Mixes of the Brake Pad

Function	Material	Amount	% composition
Binder	Epoxy resin	35g	35%
Abrasives	Brass	10g	10%
Fiber reinforcement	Mild still and cast iron	10g	10%
Filler	Coconut shell	10g	10%
	Periwinkle shell	10g	10%
	Egg shell	5g	5%
	Cashew nut shell	10g	10%
Lubricant	Graphite	10g	10%
	Total	100g	100%

Table 2.4 Showing Sample D Composition mixes of the Brake Pad

Function	Material	Amount	% composition
Binder	Epoxy resin	40g	40%
Abrasives	Brass	10g	10%
Fiber reinforcement	Mild still and cast iron	10g	10%
Filler	Coconut shell	15g	15%

	Egg shell	5g	5%
	Periwinkle shell	5g	5%
	Cashew nut shell	5g	5%
Lubricant	Graphite	10g	10%
	Total	100g	100%

2.2 Methodology

Tables 2.1-2.4 above show the percentage composition mixtures of the samples for the developed brake pad. The fillers: coconut shell, periwinkle shell, cashew nut shell, in the composition mixes were dried and grinded into smaller sizes and sieved through 100, 200, 350μm mesh. Brass chips, mild steel chips, epoxy resin and phenol resin were added to the composition as additives. The composition is mixed properly with a mixer for 20minutes to obtain a homogenous component and transferred to a mould for cold pressing by a hydraulic press (Model Pi00ch-Type at 50KN/cm^2) at Federal Polytechnic Mubi Production Workshop. The samples were then transferred to an electric oven and heated at a temperature of 1500^0 and pressure of 100KN/cm^2 for 2 minutes. The brake pad was removed from the mould and cured in the oven at a temperature of $1200c^0$ for 8 hours.

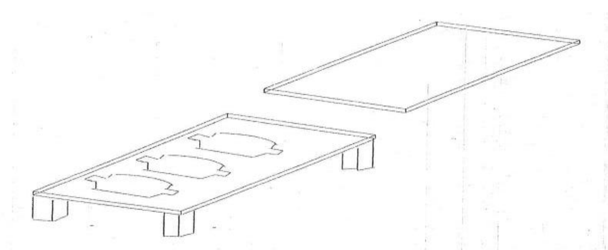

Fig.2.3 Mould design

Fig.2.4 Pressing assembly and its parts

2.3 THEORETICAL CONSIDERATIONS

1. Coefficient of static friction test

The brake pad was placed on the polished steel plate and the angle of inclination increased until the pad just began to slide down the surface, the height x, corresponding to the slope was measured. The length of the steel L, was constant [17].

2. Compressive strength

The compressive test was done using the Honsfied Tensometer. The samples of diameter 22.7 mm was subjected to compressive force, loaded continuously until failure occurred. The load at which failure occurred was then recorded [18][19][20].

3. Wear rate

The wear rate of the sample was measured using pan on disc machine sliding it over a cast iron surface at a load of 20N, sliding speed of 5.02m/s and sliding distance of 5000m. All test were conducted at room temperature. The inial weight of the sample was measured using a sample pair electric weighing machine with an accuracy of 0.01g. During the test, the pin was pressed against the counterpart rotating against the cast iron disc (Hardness 65HRC) of counter surface roughness of 0.3µm by applying the load. A friction detecting arm connected to a strain gauge held and loaded the pin samples vertically into the rotating hardened cast iron disc. After running through a sliding distance, the samples were removed, cleaned with acetone, dried and weighed to determine the weight loss to wear. The difference in weight measured before and after test give the wear of the samples. The formula used to convert the weight loss into wear rate is [19][20].

Wear rate $= \frac{\Delta W}{S}$ where $\Delta W =$ weight difference of the sample before and after the test in mg. S is total sliding distance in m

4. Water absorption

The water/oil (SAE 20/50) absorption of the samples was determined by soaking the samples in water and oil for 24 hours. Before the test, the samples were oven dried and the weight measured. The samples were cleaned after 24 hours in water and oil, and weighed. The percentage absorption was calculated using equation [12].

Absorption = $\frac{W_{1-} W_0}{W_0} \times 100\%$ Where $W_0 =$ Weight of sample before immersion (g) and W_1 Weight of sample after immersion (g)

5. Brinell Hardness Test

The Brinell hardness was obtained using a digital hardness tester. The material of diameter 22.7 was used to carry out the test samples. The hardness values were determined according to the provisions in American Society of testing and materials (ASTME-18-79) using the Brinell hardness tester B scales (Frank welltest Brinell hardness tester model 38506) with 1.56mm steel ball indicter, minor load of 10kg, major load of 100kg and hardness value of 101.2HRB as the standard[12].

3. RESULTS AND DISCUSSIONS

It can be seen from the graph in Figure 3.2 that the highest compressive strength was obtained at 40% epoxy resin additions of all the sample mixtures A, B, C, and D and gave the results (87MPa, 98Mpa, 100MPa, 113MPa) and lowest compressive strength were obtained at 25% epoxy resin addition and gave the results (25Mpa, 42MPa. 38MPaand 60MPa) respectively. It was observed that increase in epoxy resin addition increases the compressive strength of the brake pad and decrease in epoxy resin decreases the compressive strength of the break pad.

From figure 3.3 it can be seen that the Hardness test of samples A, B, C, and D were found to be highest at 40% epoxy resin additions, and gave the results (120HRC, 140HRC, 169HRC and 172HRC) and the lowest hardness was obtained at 25% epoxy resin addition and gave the results (40HRC, 60HRC, 40HRC, 100HRC) respectively. It was observed that increase in epoxy resin addition increases the hardness of the brake pad and decrease in epoxy resin addition decreases the hardness of the brake pad.

From the graph in figure 3.4, it can be seen that the wear rate of samples A, B, C, and D have the highest values of (0.16mm/min, 0.15mm/min, 0.13mm/min, and 0.11mm/min) at 25% epoxy resin addition and have their lowest values of (0.01mm/min, 0.02mm/min, 0.01mm/min, 0.02mm/min) at 40% epoxy resin addition respectively. It was observed that increase in epoxy resin addition decreases the wear rate and decrease in epoxy resin addition increases the wear rate of the brake pad.

From figure 3.5, the highest values of water absorption of sample A, B, C, and D were obtained at 25% epoxy resin addition with values (0.5%, 0.9%, 0.6%, 0.8%) and lowest values of (0.4%, 0.1%, 0.3%, 0.2%, 0.3%) at 40% epoxy resin addition. It was observed that increase in epoxy resin addition decreases water absorption and decrease in epoxy resin addition increases the water absorption of the brake pad.

From figure 3.6 the highest values of coefficient of friction of samples A, B, C, and D were obtained at 40% epoxy resin addition, with values (0.30, 0.33, 0.38, and 0.42) and lowest values of (0.11, 0.13, 0.20, 0.34) at 25% epoxy resin addition. It was observed that increase in epoxy resin addition increases the coefficient of friction of the brake pad.

Fig.3.1 Developed brake pad

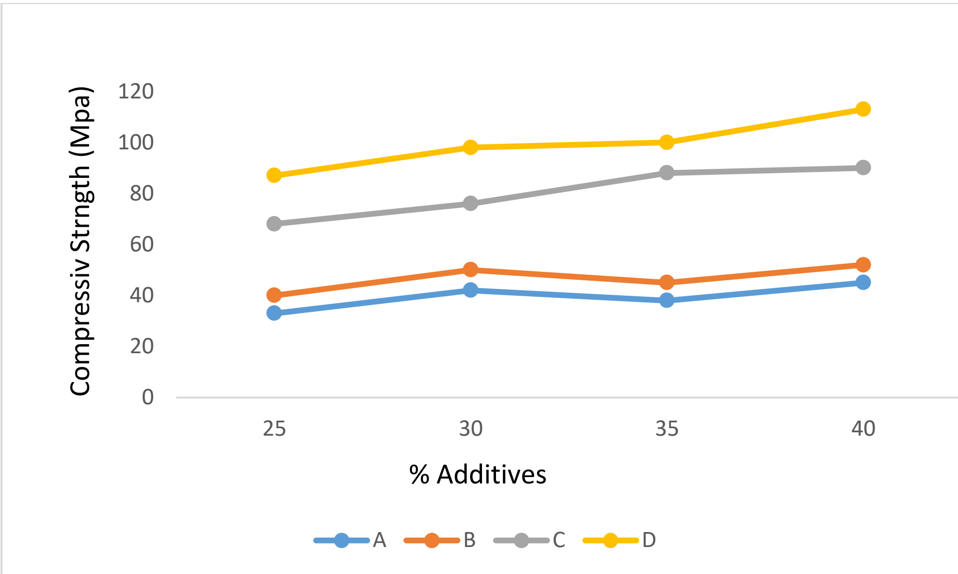

Fig. 3.2 Graph of Compressive Strength against Epoxy resin additions

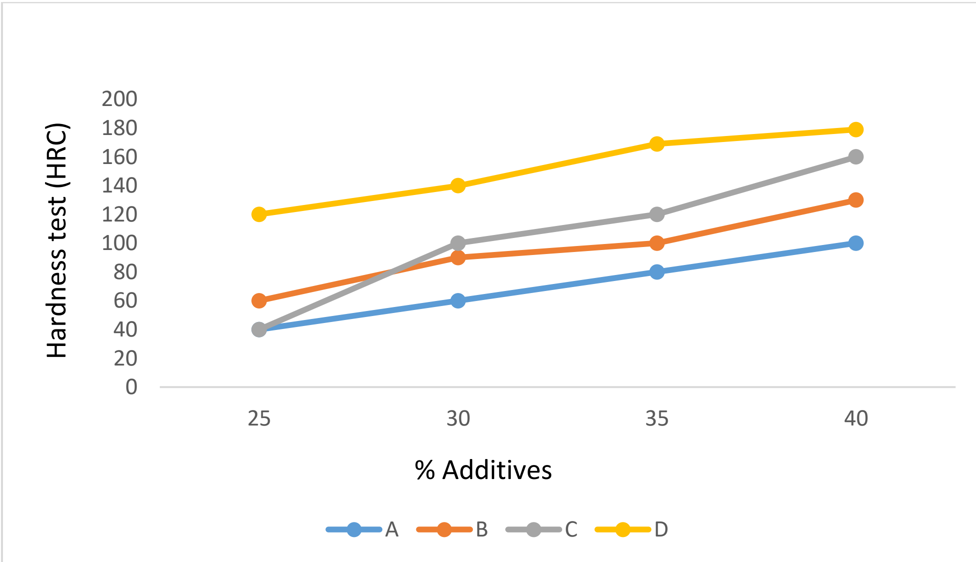

Fig. 3.3 Graph of Hardness against Percentage Epoxy resin addition

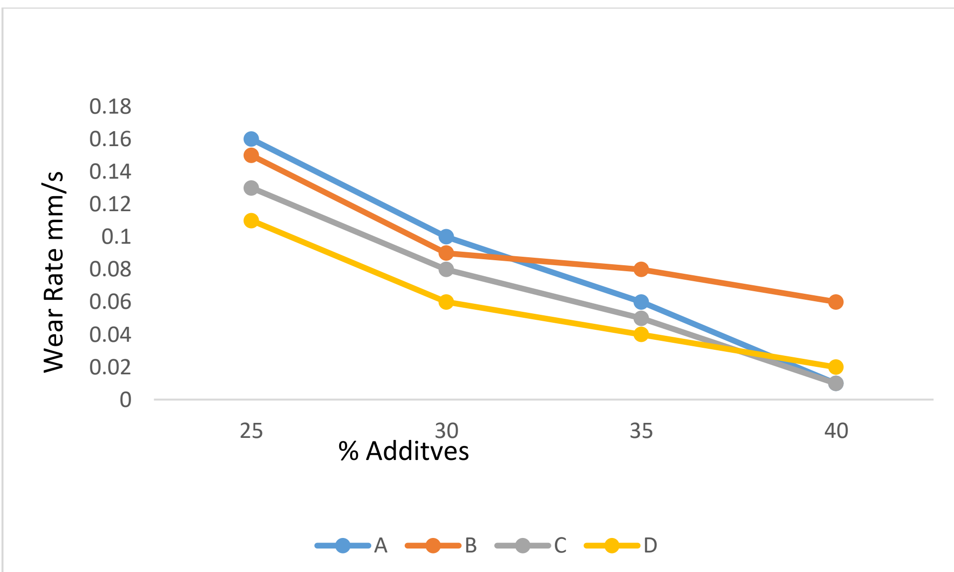

Fig. 3.4 Graph of Wear rate against Percentage Epoxy resin addition

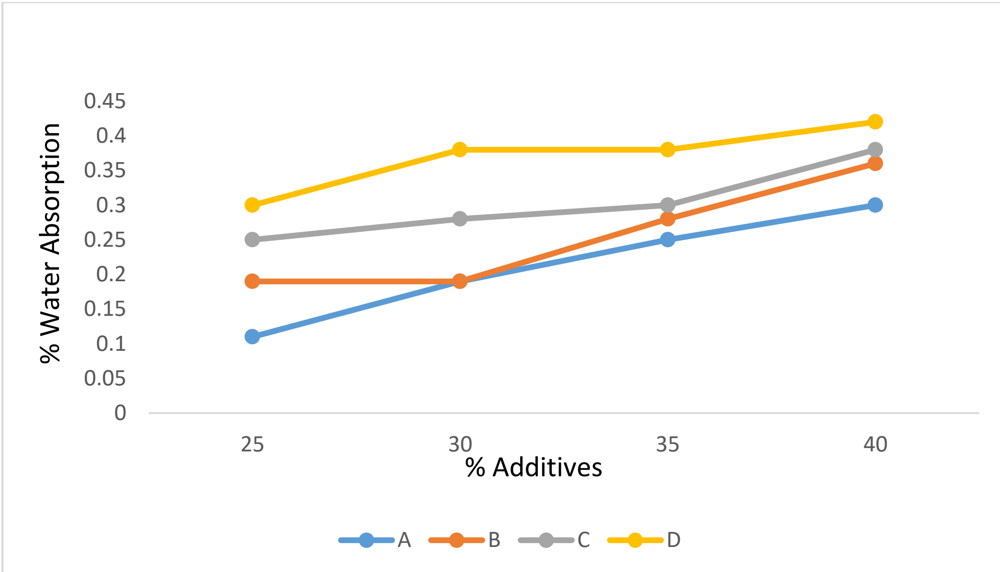

Fig. 3.5 Graph of Water absorption against Percentage Epoxy resin addition

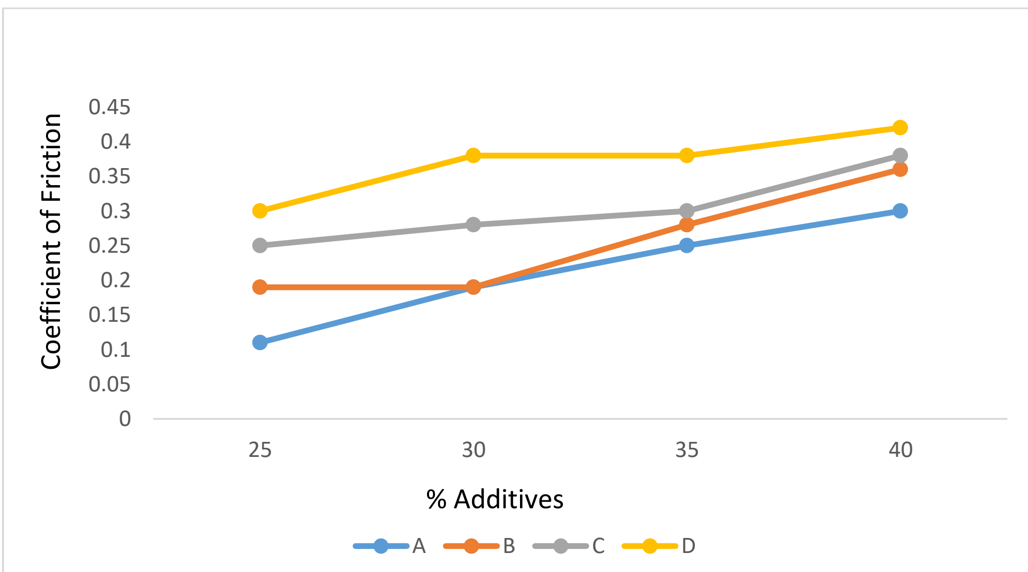

Fig. 3.6 Graph of Co-efficient of friction against Percentage Epoxy resin addition

Table 3.1 Optimum Composition Mixture for the Brake pad lining

Sample	Composition Mixture	Constant % additives	Compressive strength(MPa)	Wear rate (mm/min)	Water absorption (%)	Hardness test (HRC)	Co-efficient of Friction
A	Epoxy resin 25% Coconut shell 20% Periwinkle shell	Brass 10% Mild steel 10% Graphite 10%	87	0.16	0.5	120	0.30

	15% Cashew nut shell 10%						
B	Epoxy resin 30% Coconut shell 15% Periwinkle shell 15% Cashew nut shell 10%	Brass 10% mild steel 10% Graphite 10%	98	0.15	0.9	140	0.33
C	Epoxy resin 35% Coconut shell 15% Periwinkle shell 10% Cashew nut shell 10%	Brass 10% Mild steel 10% Graphite 10%	100	0.13	0.6	169	0.38
D	Epoxy resin 40% Coconut shell 20% Periwinkle shell 5% Cashew nut shell 5%	Brass 10% Mild steel 10% Graphite 10%	113	0.11	0.8	172	0.42
Commercial Brake pad			110	0.08	0.9	101	0.38

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

The development of an automobile brake pad for TOYOTA HIGHLANDA using locally available materials was successfully in this research work. Coconut shell, periwinkle shell, and egg shell were locally sourced for this work and were used as base materials, epoxy resin as binder materials, mild steel as fiber reinforcement, and brass chip as abrasives and egg shell as filler. From the analysis of the experiment conducted, it was revealed that, sample composition mixture D gave better compressive strength compared to the commercial break pad. The wear rate of sample D locally developed break pad is slightly above the commercial break pad. Sample composition A break pad gave a better percentage of water absorption compared to the commercial break pad and the value of hardness test of the developed break pad sample D gave a better value of hardness test compared to the commercial break pad. It was concluded that sample D composition mixture can produce an alternative for the commercial break pad. Sample D gave the higher coefficient of friction more than the value provided by Toyota highlander, and sample D gave exact value with the Toyota highlander. Samples A and B gave values of coefficient of friction less than the value provided by the Toyota highlander brake pad. It can be concluded that all that samples coefficient of friction compares reasonable with the values obtained from the Toyota highlander.

4.2 Recommendations

The development and validation of a friction material involve a significant amount of testing in the laboratory and on the road. On-road brake tests with real-world conditions normally are the final tests that are performed to evaluate and validate the formulation. Thus, vehicle testing on a test track is the ultimate measure for the overall assessment of the performance of the brake pad composites. Further investigation of the performance and wear of the developed brake pads should be conducted for actual real-world road conditions. Further investigation also is needed to establish the effects of load, braking distance, and braking time on wear properties.

5.0 REFERENCES

[1] Nagesh S. N., Siddarayu C., PrakashS., Ramesh M. R., (2014). Characterization of brake pads by variation in composition of friction materials, Procedia Material Science 5, pp295-302

[2] Bono S. G., Dekyrger W. J (1990). Auto Technology, Theory and Service. 2nd ed. DELMAR publishers, New York, 45-48

[3] Lawal S.S., Ademoh N. A., Bala K. C.., Abdulrahman A.S (2019). Reviews in automobile brake pads production and prospects of Agro Base composites of cashew Nut Shell and Nigerian Gum Arabic binder. Covenant Journal of Engineering Technology. Vol. 3. No. 2 pp. 2682-5317.

[4] Onyeneke F. N., Anaele J. U and Ugwuegbu C.C (2014). Production of Motor Vehicle Brake Pad using Local Materials (prewinkle and Coconut Shell). International Journal of Engineering and Science Vol. 3 Issue 9 pp 17-24 ISSN 2319-1813.

[5] Ufuoma P. A., Solomon I., Francis M., Chika Edith Mgbemena (2019). The development of Vehicle Brake Pad using Local Materials (Palm Kernel, Coconut and Cashew Shells as Base Materials). Journal of Engineering. Vol. 7 Issue 6. Pp 61 – 67.

[6] Rabinowioze (1956). Friction and wear of materials (John Wilay and sons Inc. NY) rhee, S.K. (1970) wear equation for polymers Sliding against metal surface. Wear 6 page 431-445

[7] ILoeje, O.C., Enetanya A. N and Omen Kukwu R. C. (1989). Development of Locally Sourced friction Materials Sc Ass of Nigeria Conf., Nsukka.

[8] Yamashita, Y., Nkagawa, M., Ibuki, and M., Kishimoto, H. (1993): Friction Material for making Brake Pads. US Pat. 5266395 (United States Patent and Trademark Office)

[9] Dagwa I.M., and Ibhadode A. O. A (2005). Design and Manufacture of Experimental Brake Pad Test Rig. Nigerian Journal of Engineering Research and Development. Basade Publishing Press Ondo, Nigeria. Vol. 4, No. 3 Pp 15-24.

[10] Smart M. and Claugh Y.P (2007). Development of Fly ass-based automotive Brake Linings. Journal of Tribology Intrnational. Volume 40 Issue 7, 1217-1224.

[11] Adeyemi I. O., Ademoh N. A., and Okwu M. O (2016).Development and assessment of composite brake pad using Pulverized Cocoa Beans Shells Filler. International Journal of Material Science and Application. 5 (2): 66-78. ISS2327-2635.

[12] Aigbodion V.S., Akadike U., Hassan S. B., Asuke F., Agunsoye J.O (2010). Development of Asbestos free Brake Pad using Bagasse. Tribology in Industry Vol. 32 No. 2010.

[13] Rhee, S. K., (2000): 'Wear of Metal-Reinforced Phenolic Resins," Wear, 18, 471-477

[14] Ramousse, S., Hoj, J. W., Sorensen, O. T. (2001): Thermal Characterization of Brake Pads, Journal of Thermal Analysis and Calorimetry, Vol. 64, 933 – 943

[15] Elakhame Z. U., Olotu O.O., Abiodun Y. O., Akubueze E. U.., Akinsanya O.O.,Kaffo P. O., and Aladele O.E (2017). Production of Asbestos Free Brakes Pad using Periwinkle Shell as Filler Material. International Journal of Science and Engineering Research Vol. 8 Issue 6 ISSN 2229-5518.

[16] Elinn, R. A., Trojan, P. K., (1992): "Engineering Materials and Their Application,"Fourth Edition, Houghton Mifflin, Boston, USA

[17] Darlington E., Chukwumobi, O., Patrick O (2015). Production of Eco-friendly Brake Pad using raw Materials Sourced Locally in Nsukka. Journal of Engineering Technologies and Policy. ISSN 2224-3232 Vol. 5, No. 11

[18] Aigbodion V.S., Akadike, U.,Hassan S.B., Asuke F., Agunsoye J.O (2010). Development of Asbestos-free brake pad using Bagasse. Tribology in Industry 32(1): 12-18

[19] Orterle, W.,GriePentrog M., Gruss T., and Urban, I (2001).Chemical and Microstructural changes induced by Friction and Wear of Brakes, Wear, 251, 1469-1476

[20] Blau P (2001).Composition, functions, and testing of friction brake materials and their additives. Technical Report, Oak ridge National Laboratory, p. 29 Available through NTIS, Springfield, Verginia.