REVIEW ON NATURAL COMPOSITE BASED BRAKE PAD MATERIAL

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Abstract

Friction materials have their significant role for braking and transmission in various machines and equipment. Their composition keeps on changing to keep pace with technological development and environmental/legal requirements. Earlier brake pads are made from asbestos and having good physical and chemical properties. But they are having many health hazards associated with asbestos handling. Hence it has lost favor and several alternative materials are being replaced these days. In this work a non-asbestos bio-friction material is enlightened which is developed using a banana stem fibre and crump rubber powder along with other ingredients. The specimen is made by compression mold process. The developed friction material samples are tested on a wear testing machine and found that composite samples have performed satisfactorily in terms of amount of wear and coefficient of friction when compared with premium asbestos-based brake pads. The same composite materials can be used to produce automobile disk brake pads.

Keywords: Natural fiber, ecofriendly, wear rate, friction material

Mr. Masrat Bashir et al [5] investigated the characteristics by varying the composition of filler material which is used in brake pad material. The formulation of material is done by adopting powder metallurgy technique, the size of powders used, are in the range of 50µm - 100µm and the fibres have length ranging from 0.97mm – 1.75mm. The fabrication of composites is made of twelve different materials by keeping parent composition of 11 ingredients (65 wt.%) constant and varying two ingredients. phenolic resin and banana peel (modified binder - 35 wt. %). Total a handful of ten samples are made by varying the phenolic resin and banana peel powder, keeping the other, material filler, reinforcement and friction modifiers constant for the brake pad material. The brake pad material hardness increases by adding more banana peel powder and also was also observed that on increasing the temperature, the banana peel powder becomes more gelatinous and at higher temperatures. The increase in banana peel powder, has the better binding ability of resin at higher temperatures. Based on the different ten composition of the material the experiment is made with the help of reciprocating friction monitor digitally controlled machine for evaluation of friction and wear properties of the material under dry and lubricated conditions. The result obtained was highest in coefficient of friction 0.78. Sample which had a composition of 40wt% of phenolic resin and 60wt% of banana peel powder had better tribological frictional property. It showed highest fade coefficient 0.39 and moderate wear behaviour.

1. Mr. Masrat Bashir, Sheikh Shahid Saleem and, Owais Bashir friction and wear behaviour of brake pad material using banana peel powder. International Journal of Research in Engineering and Technology Volume: 04, Issue: 02 Feb-201

Mr. Giredaran & C. Thiagarajan conducted an experiment on characterization of epoxy based reinforced composite of the fibre of lemon peel or lemon waste. The composite material is made by incorporating matrix (epoxy resin: Araldite LY556), fibre (lemon peel) and hardener. The experiment is comprised of 5 specimens with varying composition of fibres and based the composite four experiment is conducted. Test based on measuring the density of the material, percentage of a void fraction of a compound rises, as the percentage of reinforcement rises but the material used in this experiment exhibited smaller void substance. The density of the material increased to 20%-30% (fibre content) and decreased to 20% corresponding density value 1.3g/cm^3 with its theoretical value 1.2g/cm^3. The second experiment is conducted based on the micro hardness test, tester of Leitz Microhardness is used; the result obtained was as the augmentation raises the hardness increases and the vale obtained is 21.12(VH value) with corresponding weight fraction particulate (%) fibre 20. Tensile test is conducted for different specimen in the UTM where the maximum value obtained is 36.65 MPa for the corresponding weight% of fibre 20, bending test is also conducted for the specimen by 3-point bending test using UTM 201 as per ASTM D2344-84 so that accurate test results can be obtained. The specimen with 20% weight fraction with corresponding stress value of 63.21 MPa is obtained. The observation of the experiment concluded that the fibers are divided without withdrawing from the matrix.

1. M. M. Giredaran & Dr. C. Thiagarajan eco-friendly automobile brake pad using lemon peel International Journal of Mechanical and Production Engineering Research and Development. Vol. 9, Issue 6, Dec 2019

Rudramurthy et al [4] investigated tribological properties of eco-friendly brake pad material using coconut shell powder as a filler material. The natural filler material is made into two different compounds with different matrix material, phenol formaldehyde & epoxy resin were used as matrix, the weight % of phenol formaldehyde and epoxy resin are kept constant for the value of 60% and 30%. Fiber glass is used as reinforcement for phenol formaldehyde the material is comprised into three different compositions of weight percentage of 6,9&12. The weight percentage of coconut shell powder is kept about 10-20%. The average size of the filler material is 304micro meter. Other filler materials including hardener of H-172 grade and zinc stearate were added to fabricate hardening and to have mould releasing characteristics such that it should not stick to the moulding surface. For epoxy resin the weight percentage of glass fiber are kept constant for the following values of 6,9&12 but the coconut shell powder is added of 40 weight% compared to other material. Phenol formaldehyde which was in the powder form, was converted into laminates using compression moulding hot press the temperature, range of 135ºC to 145ºC with the pressure value of 108 bars. Epoxy resin based composite mixture which was in the liquid form, the same equipment was used to fabricate the materials. Specimens required for the tests were fabricated from the commercially available two brake materials considered CAB1 and CAB2. The experiment is followed by 3 body abrasion tests under different conditions and compression strength test is also conducted on the materials. The result of the experiment concluded that the wear of commercial brake pad material (CAB1 and CAB2) had higher wear compared to phenol formaldehyde (2.59%, 22.07%), glass fiber (81.81%, 84.78%) composites respectively. Compression test on phenol formaldehyde (35%, 32.97%) and fiber glass (42.29%, 44.89%) composites respectively. By using eco-friendly coconut shell powder increases the compressive strength, Wear rate, Fair bonding, Thermal resistivity. by applying coconut shell powder as a constant filler material is one of the best compared to commercially available filler material and gives high compressive strength in glass epoxy resin matrix of 6% weight fraction of glass fiber.

1. Rudramurthy, Chandrashekara. K, Ravishankar R, Abhinandan. S natural fiber using coconut shell powder as a filler material. International Journal of Research in Mechanical Engineering & Technology Vol. 4, Issue 2, May - October 2014

Mr. Masrat Bashir et al [5] investigated the characteristics by varying the composition of filler material which is used in brake pad material. The formulation of material is done by adopting powder metallurgy technique, the size of powders used, are in the range of 50µm - 100µm and the fibres have length ranging from 0.97mm – 1.75mm. The fabrication of composites is made of twelve different material by keeping parent composition of 11 ingredients (65 wt.%) constant and varying two ingredients. phenolic resin and banana peel (modified binder - 35 wt. %). Total a handful of ten samples are made by varying the phenolic resin and banana peel powder, keeping the other, material filler, reinforcement and friction modifiers constant for the brake pad material. The brake pad material hardness increases by adding more banana peel powder and also was also observed that on increasing the temperature, the banana peel powder becomes more gelatinous and at higher temperatures. The increase in banana peel powder, has the better binding ability of resin at higher temperatures. Based on the different ten composition of the material the experiment is made with the help of reciprocating friction monitor digitally controlled machine for evaluation of friction and wear properties of the material under dry and lubricated conditions. The result obtained was highest in coefficient of friction 0.78. Sample which had a composition of 40wt% of phenolic resin and 60wt% of banana peel powder had better tribological frictional property. It showed highest fade coefficient 0.39 and moderate wear behaviour.

1. Mr. Masrat Bashir, Sheikh Shahid Saleem and, Owais Bashir friction and wear behaviour of brake pad material using banana peel powder. International Journal of Research in Engineering and Technology Volume: 04, Issue: 02 Feb-2015

J.Sam Charles et al [6] investigated tribological properties of brake pad material by using orange peel reinforcement polymer composite. The composite is comprised of four different material with different compositions as follows aluminium oxide (15%), orange peel (44%), carbon (10%) and phenol formaldehyde resin (31%). The composite is manufactured by Hand lay-up fabrication method. Further a test is conducted on this material is as follows, shore hardness number with average hardness number 79.3. wear test on the material is conducted using pin-on-disc wear testing machine and it is found that the wear of the material is 173.0 microns with speed of 300 RPM, time duration 20min with corresponding load 20N having coefficient of friction 0.3305 corresponding average frictional force 7.5N. The performance is almost equal to asbestos brake pads without any environment and health effects.

1. J. Sam Charles*, Devaprasad M.E. Development of brake pad using orange peel reinforcement polymer composite. Global journal of advanced engineering technologies and sciences, Charles 3(5): May, 2016

R. Umamaheswara Rao et al [5] studied the tribological properties of alternate materials for asbestos brake pads by using processed agriculture waste as filler materials. phenolic resin, palm slag, calcium carbonate, dolomite, graphite, steel fiber and alumina along with the filler materials palm kernel fiber, banana peel powder and flax fiber. The composite material is made with varying compositions of the following materials. The test is conducted for the materials based on the density, specific gravity, wear rate, friction coefficient, hardness and compressive strength. A comparison was made between asbestos based brake pad and natural fiber based brake pads. Density (g/cm^3) test results showed that the palm kernel shell, bagasse, banana peels uncarbonized at 25% resin and banana peels carbonized at 30% resin had a closer density value of 1.65, 1.43, 1.26 and 1.20 compared to that of asbestos based having density (g/cm^3) of 1.89. Brake pad test rig was used to determine the pads wear, disk temperature rise and disk stopping time. The wear rate (mg/m) was recorded with the values 4.40, 4.20, 4.15 and 4.67 compared to that of asbestos brake pad having ware rate (mg/m) of 3.80 and corresponding friction coefficient 0.440, 0.420, 0.40, 0.35 compared to that of asbestos brake pads having friction coefficient of 0.3-0.4. and the compression test (N/mm^2) is conducted for the natural fiber based brake pad material had values of 103.5,105.6, 95.6 and 61.20 which is close to that of asbestos brake pad having compression test value of $110N/mm^2$.

1. R. Umamaheswara Rao1, G.Babji alternate materials for Asbestos brake pads and its characterization, International Research Journal of Engineering and Technology. Volume: 02 Issue: 02 May-2015

Rajmohan.B et al [8] investigated tribological properties of modern brake pads using hybrid materials by using coconut shell/sugarcane/sic powder/ epoxy resin/ silicon carbide(grains). Three samples are made with different varying compositions in order to obtain different tribological properties of different samples and their behaviour. The samples are manufactured by hand-lay-up process and the material is cured for 48hrs at room temperature. Test is conducted on the hybrid composite using pin-on-disk apparatus, the test was conducted for two different loads as a result different values are obtained for the wear test with load 20N, corresponding sliding distance 300m and for 4000 seconds, sliding diameter 30mm, sliding velocity 2m/s regardless of three samples the first samples of composition coconut shell powder, sugarcane powder, silicon carbide(06/02/0.5, in grams) has exhibited better performance compare to second and third samples having ware rate of 3.55*10^-6 mg/m and corresponding coefficient of friction 0.448 compared to asbestos wear of 3.1&coefficient of friction 0.367. The same test is conduced for the samples with different conditions, load of 10N, sliding diameter 30mm, sliding distance1000m, sliding velocity 2m/s and corresponding time 1000sec. the first sample showed better wear of 3.5*10^-6 mg/m and corresponding coefficient of friction 0.452 when compared to asbestos wear 3.2 & coefficient of friction 0.371. The lower value of wear rate and higher value of coefficient of friction are due to the addition of silicon carbide (Sic) in the mixture of coconut shell/ sugarcane also due to the toughness of Sic at room temperature and higher temperatures helps the composite to give low wear. The values exhibited by the hybrid composite material is quite similar or close to that of asbestos with similar tribological properties and also eco-friendly to nature and non-hazardous to the environment.

1. Rajmohan.B, Dr. Arunachalam.K, Sundarapandian.G, tribological properties on brake pad using coconut shell/sugarcane/sic powder hybrid composites. International Journal of Engineering and Innovative Technology Volume 7, Issue 3, September 2017

P.Pathmanaban et al [9] studied the tribological properties of natural fiber reinforced composite for brake pad material. The composite constitutes of coconut shell, aluminium oxide, graphite, epoxy resin all are in terms of percentage. The coconut shell is reduced into fine fibers of size 100 micrometres. And in order to match with the commercial brake pad, the composition of the natural fiber reinforced composite is varied, all in percentage. The material is split into four different compositions, and the composition is varied as follows. For sample 1 coconut shell, aluminium oxide, graphite had a composition of (10,20,35) the sample 2 had composition of coconut shell, aluminium oxide, graphite of (20,15,30). The sample 3 had composition of coconut shell, aluminium oxide, graphite (30,10,25). The fourth composition had coconut shell, aluminium oxide, graphite of composition (40,5,20) and 35% of epoxy resin is kept constant for all the four samples. The composite is manufactured by compression moulding process. The composite material subjected to a test based on wear rate, compressive hardness, coefficient of friction all the test were conducted keeping the load 20N constant. The wear rate test was conducted by pin-on-disc setup where the speed varied from 150-450 RPM. The outcome concluded that sample 2 and 3 had better wear rate compared to sample 1 and 4. The compressive hardness test, the variation of hardness with speed is determined by using an inertia dynamometer. The hardness determined from the experimentation is the time taken by the brake pad to return to its normal state from maximum stress. The output concluded that the sample 4 had high hardness as compared to that of other samples, simultaneously the sample 4 had high coefficient of friction compared to other samples.

1. P.Pathmanaban, A. Musharath Aalam, 1A.selvaganesh , S.Sr,iamrish, Testing of Coconut Shell Reinforced Brake Pads. International Journal of Scientific Research and Engineering Development. Volume 2, Issue 5, Sep – Oct 2019

N.S.Devoor et al [8] studied the tribological properties of brake pad material by using organic based composite material. The composite is comprised of Simaruba shell and coconut shell powder (matrix), and Iron powder, Alumina oxide, Silicon carbide and calcium carbonate (reinforcements). The powders are mixed by powder metallurgy technique and phenolic resin is used as a binder. The composite material made into five more samples naming from A-E, each with varying compositions. The sample A,B,C&D had Base material as Simarouba, Coconut shell of 0%, 5%&5%, 10&10%, 20&20%, 25&25%. modified binder (phenolic resin) of 60%50%,40%,20%,10%, filler (calcium carbonate) of 10%,10%,10%,10%,10%. friction modifier (silicon carbide, Aluminium oxide) of 5% each for 5 samples and reinforcement (iron powder) of 20% each for five samples. The following samples have undergone some test based on wear rate, coefficient of friction and density. The reduced weight test is done on a pin-on-disc set up, all the five samples are run for 6min of time and speed varied from 1000-1125 RPM. And the result showed that difference in weight to the original weight of sample is 0.001gm and maximum value is 0.005gm. the wear rate test is conducted on the sample with same duration of time, speed is varied from 28.2743m/min to 32m/min. the result showed that material B,C had higher ware rate as compared to other samples of values 0.01957*10-3 and 0.01957*10-3 gm/min. the coefficient of friction test showed that the material A had least coefficient of friction and material C had highest coefficient of friction with values of 0.259(material A),0.456(material E). the density of the material gradually decreased in according to the compositions and coefficient of friction gradually increased.

1. N. S. Devoor, Prasad Sagar &D. Ramesh, Wear Behaviour of Brake Pad Material using Organic based Composite Materials. International Journal of Science Technology & Engineering. Volume 5, Issue: 1st July 2018

N.S.Devoor et al [8] studied the tribological properties of brake pad material by using organic based composite material. The composite is comprised of Simaruba shell and coconut shell powder (matrix), and Iron powder, Alumina oxide, Silicon carbide and calcium carbonate (reinforcements). The powders are mixed by powder metallurgy technique and phenolic resin is used as a binder. The composite material made into five more samples naming from A-E, each with varying compositions. The sample A, B, C&D had Base material as Simarouba, Coconut shell of 0%, 5%&5%, 10&10%, 20&20%, 25&25%. modified binder (phenolic resin) of 60%50%,40%,20%,10%, filler (calcium carbonate) of 10%,10%,10%,10%,10%. friction modifier (silicon carbide, Aluminium oxide) of 5% each for 5 samples and reinforcement (iron powder) of 20% each for five samples. The following samples have undergone some test based on wear rate, coefficient of friction and density. The reduced weight test is done on a pin-on-disc set up, all the five samples are run for 6min of time and speed varied from 1000-1125 RPM. And the result showed that difference in weight to the original weight of sample is 0.001gm and maximum value is 0.005gm. the wear rate test is conducted on the sample with same duration of time, speed is varied from 28.2743m/min to 32m/min. the result showed that material B,C had higher ware rate as compared to other samples of values 0.01957*10-3 and 0.01957*10-3 gm/min. the coefficient of friction test showed that the material A had least coefficient of friction and material C had highest coefficient of friction with values of 0.259(material A),0.456(material E). the density of the material gradually decreased in according to the compositions and coefficient of friction gradually increased.

1. N. S. Devoor, Prasad Sagar &D. Ramesh, Wear Behaviour of Brake Pad Material using Organic based Composite Materials. International Journal of Science Technology & Engineering. Volume 5, Issue: 1st July 2018

A L Craciun et al [7] studied the tribological properties of non-asbestos brake pad material by using coconut fibre. The composite material constitutes of Aluminium, Graphite, Zirconia oxide, Silicon carbide, Titanium oxide, Phenolic resin, Coconut fibre. The composite material was made into two samples with varying compositions, composites containing seven ingredients which maintaining five ingredients (around 75%) constant and varying two ingredients, aluminium and coconut fibre (around 25 %). Based on the material test were conducted to find the tribological properties of the material and wear behaviour. Wear test was conducted with the pin-on-disc set up, the tribological experiments consists on pressing the composite pin on the surface of a rotating iron disc. The test was conducted for two different loads of 5N and 10N for the length of 4km, the weight and thickness of samples were measured before and after the trial. The result concluded that the material having load of 10N showed more wear also variation in height of composite pin with respect to time, with test force of 5N and 10 N, loss is less for composite 2, with 10 % coconut fiber. mass loss increases along with time for the corresponding composite with 10%, the wear test of the composites indicate that wear is comparatively less in the composite with 10% coconut fibre. A thermography camera was used to check the temperature of both the iron disc and pin, as a result the iron disc had higher temperature compared to the pin, composite had better heat distribution which is quite good. This concludes that the both composite brake pad material had similar properties, that of an asbestos brake pad material also the composite is eco-friendly towards nature and can be used as a brake pad material for future automobiles.

1. A L Craciun, C Pinca-Bretotean, D Utu and A Josan, Tribological properties of non-asbestos brake pad material by using coconut fiber. International Conference on Applied Sciences

Muzathik A. M et al[3] This research aimed to examine properties of Boron mixed brake pads by comparing them with the commercial brake pads. Friction coefficient of Boron mixed brake pads and commercial brake pads were significantly different and increased with the increase in surface EFFECTS OF FIBER, FILLERS AND BINDERS ON AUTOMOBILE BRAKE PAD PERFORMANCE roughness. The abrupt reduction of friction coefficient is more significant in commercial brake pad samples than in Boron mixed brake pad formulations. Fade occurred in commercial brake pad sample at lower temperatures. Boron formulations are more stable than their commercial counterparts.

A local semi-metallic commercial brake pad (ZMF) was used as a benchmark. Aluminum Oxide abrasive material which existed in ZMF formulation was taken out. It was replaced by consistently different weight percentage of Boron (0.6, 1.0, 1.5 and 2.0%) and then mixed into the ZMF formulation. Material grouping were made based on these variations. The five groups were referred to as ZMF, ZMF + B0.6%, ZMF + B1.0%, ZMF + B1.5% and ZMF + B2.0%.

The normal and hot friction coefficient test results were summarized from average four samples of Boron and commercial brake pad formulation individually. The results demonstrated that the formulations using Boron mixed brake pads produced higher normal and hot friction coefficient value than commercial brake pad. This is a good feature of Boron mixed brake pads as they can provide better braking capability during normal or after long trips.

The friction coefficient of Boron mixed brake pads and commercial brake pads were significantly different. The average friction coefficient of all Boron mixed brake pads was 0.495 (0.065 higher than the commercial brake pads). There was no significant difference in friction coefficient between all Boron formulations shown by CHASE test result. Friction coefficient increased with the increase in surface roughness. The abrupt reduction of friction coefficient (fade) was more significant in the commercial brake pad samples than in Boron mixed brake pad formulations. Fade occurred in commercial brake pad sample at the lower temperature. All Boron formulations were more stable and constant than their commercial counterparts; the study reported only a slight reduction of friction coefficient.

1. Muzathik A. M, Mohd Nizam Y. B, Ahmad M. F and Wan Nik W. B Department of Maritime Technology, University Malaysia Terengganu, Malaysia Department of Mechanical Engineering, Faculty of Engineering, South Eastern University of Sri Lanka, Oluvil, Sri Lanka. Received 28 September 2012; accepted 19 April 2013

Oluwafemi E. Ige et al [9] This review work seeks to explore research using combinations of fillers and fibers at different ratios with a view to further studying their effects on brake pad properties using various mixtures for the production. The influence of different binders such as phenolic resin, epoxy resin and others were also investigated. Natural waste has been used to produce fillers and fibers, including palm kernel shell and fiber, groundnut shell, maize husk, rice straw and husk, jute, coconut shell, cotton, and cellulose. In order to obtain better physical properties,palm kernel fiber and coconut fiber brake pads were studied and the composition percentage was optimized.

Filler materials are mainly used for brake pad production to improve brake manufacturability and reduce production costs and as functional modifiers. A small amount of filler is usually added to improve or optimize performance of bake pad material. Harder particles, for instance Al2O3 is added to increase the COF (μ) which is the force of friction caused by the scraping the surface of the material and the disc. Binders hold all the components together in the brake pad application, thereby reducing the component shear rate. Binder contributes to the brake pad friction and wear rate. The binder offers mechanical unity to the friction materials by firmly combining the other three components in order to improve the composites properties. In the past fifty years, phenolic resins (unmodified or modified) have been employed as binders in the preparation of the friction materials due to their good thermal and mechanical properties in addition to lower costs.

The Raw Materials Preparation

The existing agricultural waste cannot be used directly in the formulation of the final brake pad. Therefore, some treatments such as mechanical and chemical treatments are required earlier in the brake pads composition. The following are some of the natural fiber treatment methods proposed according to the literature.

Palm Kernel Fiber

Several studies such as Achebe and Ikpambese used palm kernel fiber as a filler in brake pad applications. The palm kernel fiber (PKF) was prepared by being suspended in caustic soda solution for 24 hours after the extraction to remove the leftover red oil. Then, the fiber was washed thoroughly with water and dried in the sun for a week. Dried palm kernel fibers were ground into a powder by hammer mill and then sieved using < 100 µm opening grade size sieve.

Banana Peel: The banana peels used by Idris were dried and milled at 250 rpm in the ball mill to banana powder form non-carbonized (BUNCP). The powder was poured into a crucible furnace and fired up at a temperature of 1200 °C in an electric resistance furnace to became banana peel ash carbonized (BCp).

The collected coconut fiber is washed thoroughly with ethanol inorder to remove the impurities. A crusher machine was used to sieve the ground fiber into fine powder ranging from 100 µm to 200 µm size. Four different mixtures were prepared (BP1,BP2, BP3 and BP4) using powder metallurgy technique by varying the coconut fiber contents at 0, 5, 10 and 15 percentage volume fractions as well as binders, abrasive materials friction modifiers, and solid lubricants to produced natural fiber brake pad materials reinforced with aluminium. In this composition, coconut fiber was employed as a filler material. A mixing process method was used for obtaining metallurgy powder uniformity. All materials were in powder form. The produced samples were heated and compressed at 170 °C in a hot compacting mould using a holding time of 20 kg load for 60 seconds. A hydraulic press machine was used for compaction at a fixed temperature and pressure, after which the material was sintered at 200 °C for 5 hours in an oven.

Groundnut Shell: Groundnut shell was collected and washed with water to remove sand and put in a sodium hydroxide solution having a composition ratio of 1:15 with water to remove impurities such as lignin and pectin. After this, the GS was washed in distilled water to reduce the sodium hydroxide in the shell and sun dried till all the moisture content in the shell dried up. The dried shell was ground in a grinding machine to reduce its size, after which the shell was sieved into a 150 and 350 um sieve size. The shell particles were then mixed in a two-roll mixing mill together with other constituents.

Maize Husk: Maize husk (MH) collected and cleaned to remove impurities and dried in the sun on a screed surface. Subsequently, it was pulverized in a hammer mill into powder and were sieved with 300 µm aperture sieve size to produce fine powder. Chemicals experimental were categorized and placed in clear-labelled glass bottles for simple identification. The wear rate improved with the addition of filler material in the brake pad sample preparation. Wear rate of the developed composite also affected by the speed significantly. The smaller quantity of the filler, binder and fiber material had effect on the composite wear rate and gave better.

The performance of the composite material such as mechanical and physical properties have been reported to be affected by the filler materials in the composition. In addition, various studies so far have found that as the composite filler material content decreases the properties for examples hardness, compressive strength, thermal conductivity and tensile strength, of the composite produced increase, while the density, oil and water absorption of the developed brake pad sample increases when the filler content of the composite increases.

1. Oluwafemi E. Ige*, Freddie L. Inambao and Gloria A. Adewumi, Effects of fiber, filler and binders on automobile bake pad performance, International Journal of Mechanical Engineering and Technology (IJMET) Volume 10, Issue 06, June 2019, pp. 135-150, Article ID: IJMET 1006008

A.M.Muzathik et al[3] studied the friction material in a brake system, which plays an important role for effective and safe brake performance. Brake materials contain mainly Alumina and other ingredients. This research attempts to examine mechanical properties of Boron mixed brake pads. Five groups of semi-metallic composite materials were studied. Friction coefficient of Boron mixed and commercial brake pads were significantly different. Average friction coefficient of Boron mixed pads was 0.495, 0.065 higher than commercial pad. Abrupt reduction of friction coefficient which is known as fade was more significant in the commercial pad samples than in Boron mixed pads. Fade occurred in commercial pad sample at the lower temperature as first fade was at 204oC and second was at 159oC resulted from earlier softening and degradation of Alumina material. All Boron pads were more stable and constant than their commercial counterparts. The study shows a slight reduction of friction coefficient at a temperature of 204oC during the first fade and 238oC on the second for Boron mixed pads. Both commercial and Boron mixed brake pads showed normal recovery stage in that they returned to their pre-fade friction coefficient levels with little temperature reduction. Properties of Boron mixed brake pads are better than Commercial brake pads.

The friction materials play an important role for effective and safe brake performance. A single material has never been sufficient to solve performance related issues such as friction force and wear resistance. Commercial brake friction materials contain mainly Alumina and other ingredients. The ingredients contained binders, reinforcing fibers, solid lubricants, abrasives, fillers, additives and metal powders. The current research attempts to examine the mechanical properties of Boron mixed brake pads by comparing the with the commercial brake pads.This study investigates the effect of the Boron on the friction characteristics. Based on the impact factors obtained from this study, it is possible to modify a specific tribology property of a brake friction material by changing the amount of Boron in a systematic manner while expecting possible changes in other tribological properties. Friction coefficient of Boron mixed brake pads and commercial brake pads were significantly different. The average friction coefficient of all four Boron mixed brake pads was 0.495(0.065higher than the commercial brake pads). There was no significant difference in friction coefficient between all four Boron formulations shown by CHASE machine test result. The abrupt reduction of friction coefficient which is known as fade was more significant in the commercial brake pad samples than in Boron mixed brake pad formulations. Fade occurred in commercial brake pad sample at the lower temperature; i.e. the first fade was at 204oC and the second was at 159oC resulted from the earlier softening and degradation of Alumina material. All Boron formulations were more stable and constant than their commercial counterparts. For Boron mixed brake pads, the study reported only a slight reduction of friction coefficient at a temperature of 204oCduring the first fade and 238oC on the second. This was resulted from high thermal conductivity of Boron material. Both commercial and Boron mixed brakepads showed normal recovery stage in that they returned to their pre-fade friction coefficient levels with little temperature reduction.

Mohammed Tiamiyu Ishola et al[7]In this research paper there is a serious health repercussions/risks such as asbestosis and mesothelioma have engendered automakers to earnestly consider the use of non-asbestos organic (NAO) brake pads in contemporary manufacturing. On this account, sustainable agro waste with higher heating value compared to other lignocellulosic biomass is considered as a better alternative to asbestos. As a result, palm kernel shell (PKS) is chosen and employed as a friction lining material for the designed NAO-based brake pad. The friction material was based on a simple formulation with five ingredients; PKS as base material while phenolic resin, steel slag, iron waste and carbon black were other additives. Mixtures of these constituents were obtained at varying compositions by using PKS ofgrade sizes 100 μm, 200 μm and 350 μm respectively. A mild steel mould shaped like that of a Pathfinder Jeep's brake pad was fabricated for compacting the formed composite. The produced samples were subjected to tests such as hardness, compressive strength, wear, flame resistance, porosity, density and water absorption tests. The results affirm that grain size has substantial effects on compressive strength, hardness, porosity, ash content and wear rate of the brake pad. 100 μmgrain sizes of PKS produced the optimum brake pad. Thus, the results show that PKS can be efficiently used for asbestos replacement in brake pad production. One of the indispensable components of a braking system is the brake pad. Brake pads are essential for smooth retardation or speed control and eventual stoppage of a vehicle on the application of pressure to the vehicle's brake pedal. In reality, brake pads facilitate the conversion of kinetic energy of a vehicle to thermal energy by friction and the effectiveness of brakes and performance of brake pads are exclusively dependent on the frictional material used in the production of the brake pads. However, contemporary brake pads are known to be polymer matrix composites due to the presence of several macroscopic and microscopic constituents in them. The blend of these constituents to form a suitable formulation is carried out in order to obtain brake pads with good synergetic attributes such as prolonged life, improved wear rate, water resistance and increased strength at a wide range of operating conditions. Thus, frictional material selection and development are still ongoing areas of research in improving brake pad. As a result, this work focuses on the use of palm kernel shell (PKS) in developing brake pads as well as its grain/particle size effect on mechanical properties and wear rate. The materials used for the formulation of the non-asbestos organic based brake pad are palm kernel shell powder (PKS), phenolic resin, steel slag, iron waste and carbon black. The representations of these materials. About 30kg of PKS was obtained, ground and utilized for the entire research work. 5 litres of phenolic resin were purchased and employed as an unsaturated polyester binder for the mixture. Steel slag and iron waste obtained from the production of pig iron were employed as reinforcement fractions/constituents in order to offer additional necessary wear resistance, thermal stability, mechanical strength, rigidity and integrity at high temperature to the resultant composite material. However, the obtained iron waste from the blast furnace, although waste, possesses characteristics similar to that of calcium carbonate; this was included to serve as filler material for the composite matrix. Equally, carbon black was used as a major constituent of the composite material because of its good lubrication properties. Ground fine charcoal was utilized as carbon black for the research. The materials used for the formulation of the non-asbestos organic based brake pad are palm kernel shell powder (PKS), phenolic resin, steel slag, iron waste and carbon black. The representations of these materials. About 30kg of PKS was obtained, ground and utilized for the entire research work. 5 litres of phenolic resin were purchased and employed as an unsaturated polyester binder for the mixture. Steel slag and iron waste obtained from the production of pig iron were employed as reinforcement fractions/constituents in order to offer additional necessary wear resistance, thermal stability, mechanical strength, rigidity and integrity at high temperature to the resultant composite material. However, the obtained iron waste from the blast furnace, although waste, possesses characteristics similar to that of calcium carbonate; this was included to serve as filler material for the composite matrix. Equally, carbon black was used as a major constituent of the composite material because of its good lubrication properties. Ground fine charcoal was utilized as carbon black for the research.

1. Mohammed Tiamiyu Ishola1 , Ojo Olatunji Oladimeji and Kaffo Omoniyi Paul, Development of Eco-friendly Automobile Brake Pad Using Different Grade Sizes of Palm Kernel Shell. Powder Current Journal of Applied Science and Technology 23(2): 1-14, 2017; Article no.CJAST.35766

D. Lenin Singaravelu et al[9]In this research paper the brake is a mechanical component used to convert kinetic energy to thermal energy by friction. Friction is generated by the contact of friction material with the mating surface, which may be liner and drum or brake pad and disc [1]. Brake materials are generally classified as organic, metallic and ceramic. Organic brake materials are further classified into low-metallic and semi-metallic based on the percentage of metallic contents in its composite formulation. Brake friction materials consist of 10-15 ingredients classified as binders, reinforcement fibres, friction modifiers and fillers. Binders are used to bind other ingredients together by forming a matrix. Reinforcement fibres provide strength to friction materials; not only mechanical strength; sometimes it enhances its thermal as well as tribological behaviour. Friction modifiers are used to vary friction that may be a lubricant which reduces friction and wear (or) abrasive, which enhances friction. Fillers are added to enhance a particular function or reduce cost. Fillers are further categorised as functional fillers and inert fillers. Fillers are added to friction material to reduce overall cost, improve manufacturability and impart certain properties.

Simple method to remove all organic compounds is when subject into heat. The thermally processed crab shell powder was produced based on the procedure as follows. The crab shell collected was cleaned in distilled water to remove dirt. The cleaned crab shell was dried for 48 hours at room temperature conditions. The dried crab shell was crushed and heated in a crucible furnace at a temperature of 300°C for 15 minutes. Finally, it was ground in a mortar until it was converted to powder then sieved in a range of 200-250 BSS using standard brass sieves. The sieve was considered in that range as it is an optimal size range used as per standard industry practice. The properties of chemically treated and thermally processed CBS powders are shown in Table 1 that were analysed to provide the general specifications of varying key ingredients.

The methodology involved in manufacturing the friction composites is weighing, mixing, curing, post curing and finishing. In mixing, it was done in a plough shear mixer possessing three choppers and one shovel rotating at 3000 and 140 rpm respectively. Curing was done on a compressing moulding machine that has eight-cavity die, and where condensation polymerisation occurs in this process, intermittent breathings were given to remove gases evolved during the process. Post curing was done to remove residual stress formed during the curing. This process also helps to further cure some uncured resins in the curing stage. The finishing operation involves grinding using a belt grinder to get the required thickness (15 mm) while the centre cut was given using the diamond wheel cutter. The developed brake pads that were made as per the standard size that could fit in an Indian vehicle. In this study, eco-friendly friction materials were developed by varying chemically treated and thermally processed crab shell powders as fillers in comparison within CBS powder free sample. The developed composites were tested for its physical, chemical, thermal, mechanical characteristics as per Industrial standards. The fade and recovery behaviour were studied using the Chase test.

Conclusion.

i. The removal of fat, protein, and other organic constituents from the CBS was effectively done by the thermal processing. It drastically reduced the time from 24 hours in the case of chemical treated one to 15 minutes as well as the cost involved in the production.

ii. Thermally processed CBS powder and its friction composite showed better thermal stability compared to others. It also showed high hardness, density and loss on ignition characteristics.

iii. The performance, normal and fade friction coefficient was higher for thermally processed CBS powder-based friction composites due to its abrasive nature and stable thermal nature.

iv. The hot and recovery friction coefficient was higher for chemically treated CBS powder-based composites due to it being coarse and another constituent behaviour.

v. Fade rate percentage was lower while the recovery rate percentage was higher for chemically treated CBS powder-based friction composites.

vi. Wear resistance was high for chemically treated CBS powder-based friction composites than for the others.

1. Development and Performance Evaluation of Eco-Friendly Crab Shell Powder Based Brake Pads for Automotive Applications. D. Lenin Singaravelu, Rahul Ragh M, Vijay R, S. Manoharan and Mohamed Kchaou. international Journal of Automotive and Mechanical Engineering. Volume 16, Issue 2 pp. 6502-6523 June 2019