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Safer Alternatives to Asbestos in Asbestos-Free Brake Pad Manufacturing: A Review

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Abstract- *At present there are different materials that are well suited and are in use for making the brake pads, the most common being asbestos but there are serious carcinogenic effects associated with asbestos which led to its gradual phase out. With the phasing out of asbestos as automotive friction lining material a need arouse of finding its safer alternatives with the same properties which can be deployed in its place fulfilling the condition of a non-carcinogenic material. This led to onset of research in this field i.e. to find a material having the required properties and that performs the same task. This research gave birth to different composites having different composition and giving the required results. In this review paper different safer alternatives that are environment friendly with their approximate composition are studied which includes agricultural or natural wastes i.e. materials such as banana peels, palm kernel shells, groundnut shell, maize husk, jute, coconut shell etc. Different constituents of composite which includes filler materials, binders like epoxy resin, phenolic resin are also studied and composites are procured by varying the composition of these constituents.*

Keywords: *Automotive brake pads, asbestos, fillers, fibers, binder, phenolic, epoxy etc.*

1. INTRODUCTION

Braking system plays an important role for any automobile so as to deaccelerate it or stop it completely in case of any emergency. As soon as the driver applies the brakes, there is an engagement between the brake pads and the rotating disc- mounted to the tires of the vehicles. During this engagement there is friction generated between these two i.e. brake pads and the disc by converting kinetic energy into heat energy which slow down the vehicle and eventually the vehicle comes to rest. The brake pad should have properties such as high heat absorbing capacity, ability to withstand high temperature and should have high wear rate also to provide friction the brake pads must have possess high friction coefficient between the surface engagement of the brake pads and the rotating disc. As the surface wear out with use the friction provided by the brake pads should be consistent. Earlier asbestos was used as friction lining material because it possesses all the desired properties as well as it was available very easily i.e. asbestos is a naturally occurring mineral which is found in rocks.(1)

But later in 1970s carcinogenic effects of asbestos was realized and it was restricted in certain countries, however it took a longer time to restrict it because of no safer alternative available. After knowing this fact in 1970s research was carried out in this field to come up with a material which is safer and has all the required properties. As of now many new materials are emerging that perfectly fits into this picture of safer alternatives, moreover these materials have an advantage as emerging from agricultural waste. These materials are composites having constituents i.e. fillers, binders, reinforced fiber, frictional additives.(2)

In this review paper the role of different constituents and different formulations obtained by varying the composition are studied. The ill effects of asbestos are also explained -to why this went out of picture, despite having the desired properties.

2. LITERATURE REVIEW

Asbestos being an easily available resource and with all the desired properties, it was a well suited material and thus was utilized for making brake pads, but later in 1970s, its severe effects were realized and hence its used came to hold, it was even banned in several countries including Australia from 31 December 2003. According to the clean air and water association of the United States, amosite and crocidolite was already banned in European countries in 1985.(2)

This review paper presents the alternatives that are well suited and can replace asbestos completely. Also the use of agricultural wastes as constituent in framing the brake pad is studied.

K.K.Ikpambese(3) framed the brake pad material using palm kernel fibers (PKFs) as a filler because of its eco-friendly nature. The other constituents being $CaCO_3$, graphite and Al_2O_3 and epoxy resin was used as a binder. Composition of constituents is depicted through the chart below. Later the results were compared with the asbestos and it was found that PKFs can completely replace asbestos.

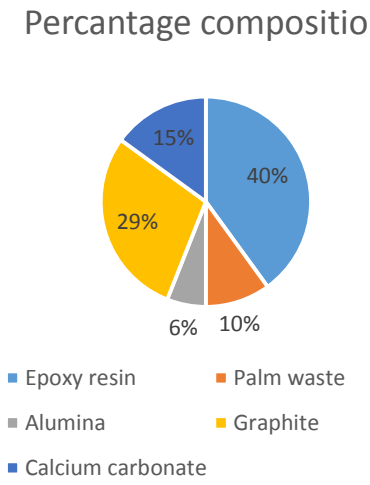

Chart 1: Pie chart showing the percentage composition of different constituents for a brake pad prepared by K.K.Ikpambese(3)

C.M.Ruzaidi(4) studied and framed the brake pad using palm slag as filler material- dolomite, calcium carbonate were also added to increase the performance to cost ratio. The other constituents being steel fibers, phenolic resin and other frictional additives. It was also seen that dolomite brake pads has more strength but shows poor wear rate, as compared to calcium carbonate and palm slag. Palm slag has better thermal stability in temperature range between 50°C to 1000°C. Phenolic resin can not be used at high temperature i.e. it can not be used as per the requirements for a brake pad.

C.M.Ruzaidi(5) has studied the mechanical properties of palm slag and found that it has suitable properties and can be used as filler material. The composite framed after the hand hydraulic pressing is then compacted and cured using a hot press at 150°C temperature with different processing pressure i.e. 10,20,40 and 60 tons of molding pressure for 5 minutes. It was deduced that hardness and compressive strength is good for the composite which is pressed under 60 tons of compression and wear rate is low.

Palm slag was one of the alternates that was found suitable, the compactness achieved by pressing it under a molding pressure of 60 tons enhanced its properties such as mechanical properties, wear rate which ultimately led to its extensive use in making asbestos free brake pads.(5)

Adegbola(6) came out with another alternative i.e. cow bone. Adegbola prepared a brake pad composite material using molding pressure technique with a composition having 65% cow bone particles and 35% phenolic resin as a binder constituent. The compactness achieved using molding pressure technique increased the interfacial bonding as the size of cow bone particles reduced from 850µm to 250µm, with 250 µm particles showing improved mechanical properties, this was an another alternate to asbestos. After experimental procedure it was concluded that the cow bone increased the wear rate while the density and hardness of the brake pad decreased. The friction coefficient of the brake pad developed lies within normal range and can be used in automobile as a brake pad.

Olabisi(7) examined another material i.e. pulverized cocoa bean shells (CBS) as filler material with epoxy resin as a binder to develop asbestos free brake pad. After this brake pad composite was procured its properties were examined and it was concluded that it can be used as substitute for asbestos. As its properties were examined it was observed that wear rate, tensile strength, compressive strength increased as the CBS content as a filler material decreased on the other hand the coefficient of friction increased as the weigh percentage of the CBS increased. Further it was concluded that it can replace asbestos in preparing in brake pads.

Ma(8) studied the mechanical properties of bamboo fiber reinforced friction material with phenolic resin as binder for brake pads. The properties were studied using a constant speed friction tester. The presence of carbonized bamboo fiber reduced the wear rate and noise level of the brake pad procured also it provided a constant coefficient of friction which is desirable.

Another asbestos free brake pad was studied by Solomon. Solomon(9) developed and examined brake pad framed using groundnut shell particles. Groundnut shell as a filler materiel and phenolic resin as a binder were taken to prepare the brake pad, to examine its properties two samples were prepared by varied GS with 45% and 55% content of phenolic resin as binder separately.

It was observed that as the filler material size decreased, the compressive strength and density increased. Hence it

was established that groundnut shell can be used as a good replacement to prepare asbestos free brake pads(9).

Ishola(10) developed and examined the properties of brake pad using palm kernel shell and phenolic resin as binder using compressive moulding by varying the particle size of PKS i.e. the PKS was sieved into particle size of 100µm, 200µm, 300µm. After examine it was observed that the properties of brake pad such as compressive strength, wear rate and hardness were influenced by the grain size of PKS. It was established that brake pad produced using 100µm grain size showed the best results. Hence it was established that PKS can be used as an alternate to replace asbestos.

Arnab Ganguly(11) fabricated a new composite with its constituents including phenolic resin along with epoxy resin to act as toughners to overcome the brittle behavior which is because of phenolic resin. Graphite and silica flour are added to act as anti-wear additives while silicone resins were added to act as fire retardant. The cashew nut resins were added to make the composite temperature resistant. The composite procured was characterized using scanning electron microscopy technique, the sample was subjected to various tests to check its wear rate and other properties. It was found to exhibit extremely good properties which were well suited to replace asbestos in making asbestos free brake pads.

IDris(12) prepared another brake pad sample using banana peel waste and using phenolic resin as a binder. The composition of resin was varied from 5% wt to 30% wt with an interval of 5% wt. Different properties of the brake pad obtained were studied. After examine it was observed that compressive strength, hardness and specific gravity increased as the wt% of resin increased while other properties like oil soak, water soak, wear rate and percentage charred reduced as wt% increased. The sample containing 25 wt% uncarbonized banana peel and 30 wt% carbonized banana peels was best suited and showed extremely goo results. Hence it was concluded that banana peels can be used to replace asbestos in brake pads.

Ademoh and Olabisi(13) used maize husk as filler and epoxy resin as a binder. The mechanical, chemical and tribological properties of the sample procured was examined. It was observed that as the wt% of maize husk was decreased, properties like wear rate, compressive strength, tensile strength and hardness increased on the other hand properties like density and coefficient of friction increased as the wt% of maize husk increased. Hence it was concluded that maize husk can replace asbestos in preparing brake pads. Also it is eco-friendly which gives an add on advantage.

A.O.A. Ibhadode(14) examined palm kernel shell (PKSs), an agricultural waste using it as friction lining material in making brake pad. When compared to other agricultural products like hyphaene thebacia kernel shell (HTKS) and deleb palm kernel shell (DPKS) it was observed that PKS shows better results after a series of test. The physical and mechanical properties showed good results when compared with commercial asbestos based friction material. It performed well and showed good results under static and dynamic condition, it can be concluded that it is a good substitute to replace asbestos as brake friction lining material. However further refinement of the PKS material is required to have comparable wear rate at higher speed of the vehicle.

In below section mechanical and chemical treatment for different materials is discussed.

3. RAW MATERIAL PREPARATION

The material selected for final formulation in brake pad can not be used as such. Some chemical and mechanical treatments are necessary to be performed on them so that they are good to use. Treatments for several material are as follows.(15)

K.K.Ikpambese(3) used as Palm Kernel fiber as a filler material to fabricate brake pad. To remove the remnant of red oil the extracted PKF was suspended in caustic soda (NaOH) i.e. sodium hydroxide for twenty hours. The fiber is then washed in water properly so that to wash away the remains of caustic soda and is dried in sun for one week and grounded to powdered form using hammer mill and therefore sieved by using sieve of size<100µm aperture.

Another material used by Idris(12) was banana peel which was examined and gave positive results to replace asbestos. The banana peels were dried and ball mill at 250 rpm to form banana powder uncarbonized (BUNCP).The powder was then poured into crucible furnace and fired up at a temperature of about 1200°C in an electric resistance furnace to become banana peel ash carbonized (BCp).

Maize husk was yet another material being used by Ademoh and Olabisi(13) to procure a material which can replace asbestos in brake pad manufacturing. It was first cleaned to remove impurities and then dried in the sun on a screed surface. Further it was pulverized in a hammer mill to obtain fine powder and was sieved using 300 µm aperture sieve size.

4. COMPOSITE PREPARATION

After performing all the chemical and mechanical treatments, final composite is prepared with the help of all the required ingredients which includes fiber, filler, frictional additive, binder and all the other constituents in different formulations.

Process for composite preparation using palm slag as a raw material. A homogenous mixture is prepared and further the mixture is compacted with a pressure of 15-17 MPa with the help of a uniaxial, hydraulic hand press machine for the green body of the brake pad composite, the green body is further compacted with a hot press at 150℃ with 60 tons of compressive molding pressure for about 5 minutes, after this the samples are taken out and allowed to cool to room temperature and is further cured in air oven at constant temperature of 150℃ for four hours.(11)

This process of brake pad composite preparation may vary from material to material. Though the base process is same the figures and formulations might differ for different materials.

5. TESTING AND ANALYSIS

The different tests performed to determine the mechanical properties of the brake pad sample procured includes- coefficient of friction test, wear resistance test, water and oil absorption test, density test, hardness test, tensile test, compression test, thermal conductivity test.

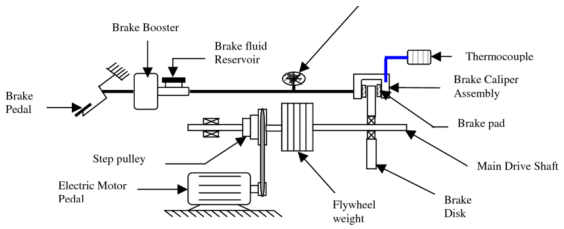

Fig 1: Test rig set up to check the performance of brake pad(14)

The schematic diagram above shows a set up to test the brake pad. After the above mentioned tests of the specimen are done then the specimen is tested as a working brake pad in the above set up, this is done to know how the brake pad will react to actual working conditions. The main components includes the 2.2KW electric motor to drive the shaft, Step pulley is there to vary the load and to apply the brake, brake pedal is provided. The disc is mounted on the main shaft to which power is provided through electric motor and the disc rotates at the speed of the wheel to which disc is mounted in an automobile, then the brake pedal is pressed which activates the braking mechanism and the brake pad is pressed over the rotating disc to stop it, the time duration which the brake pad requires to stop the disc, the temperature of the disc and brake pad material lost is noted, then again the whole process is repeated out but with different speeds of electric motor and different loading conditions. The speed ranged from 6.66 m/s to 13.82 m/s and brake line pressure ranged from 0.2 to 0.6 MPa for test conditions.(14)

6. CONCLUSION

Despite asbestos having all the required properties to be used in brake pad manufacturing there is a big disadvantage attached to it which is its carcinogenic effects. After gaining some knowledge of braking system, brake pads and material used to fabricate brake pad it can be inferred that braking system is an essential and a very important part for an automobile and selection of material is of utmost importance. Using of asbestos may be a compulsion earlier because of its advantages and easy availability but its ill effects cannot be ignored, also now many composites can be framed and are being framed by varying the composition of sub components i.e. binders, fillers, reinforcing fibers and abrasives. Fillers or space fillers have an important role to play, having a brief knowledge about fillers it can be deduced that fillers are cost reducing factor and also plays an important role to improve the manufacturability, filler is the performance deciding factor for a composite and further for the brake pad. Also the content of filler in composite has a varying effect on the factors deciding the performance of brake pad i.e. if the filler material content decreases properties like hardness, compressive strength, thermal conductivity and tensile strength increases while the increase in the measure of filler material increases properties like density, oil and water absorption of brake pad.

As of now agro waste products like banana peel, maize husk, coconut shell has gain importance for making the composites, one can have a set of different composites by varying the composition of sub components. The advantage of using these agro based products over asbestos are that, they are available in abundance, also they are cheaper and the most important advantage is that they are non-carcinogenic not like asbestos.

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