A Review Paper on Asbestos Free Friction Material for Brake Pads

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Abstract— Studying about asbestos-free materials for brake pads is necessary as the asbestos brake pads causing the health hazardous effects and these are phased out. There are so many alternatives for asbestos are investigated from different journals. In this review paper some of the most suitable environment friendly and best performed compositions are presented. Fibers made up of agricultural wastes like banana peels, palm kernel shells, palm wastes, rock wool, aramid fibers, flax fibers etc are studied. Different alternatives for filler materials, Different binders like phenolic resin, epoxy resin are also studied and it effect on the performance of brake pads are presented. Formulations that are made by varying compositions of filler, fiber, binder etc and possibility of replacing the existing formulations and its effect on the physical and tribological properties of the brake pad are studied.

Key words: Asbestos, Fiber, Filler, Binder, Palm Kernel Fibers

I. Introduction

Friction lining is an essential part of braking system. Friction materials have their significant role for transmission in various machines. Their composition keeps on changing to keep pace with technological development and environmental requirements. Earlier asbestos has been used as a friction material because of its good physical and chemical properties. But later researchers eyed that there are many health hazards associated with asbestos handling. The average disk temperature and average stopping time for pass is increased and it has poor dimensional stability. Hence it has lost favor and several alternative materials are being replaced these days. In this work a non-asbestos bio-friction material is enlighten which is developed using an Agro-waste material palm kernel shell (PKS) along with other Ingredients. Among the agro-waste shells investigated the PKS exhibited more favorable properties. Taguchi optimization technique is used to achieve optimal formulation of the friction material. The developed friction material is used to produce automobile disk brake pads. The developed brake pads were tested for functional performance on a specially designed experimental test rig. Physical properties of this new material along with wear properties have been determined and reported in this paper. When compared with premium asbestos based commercial brake pad PKS pads were found to have performed satisfactorily in terms of amount of wear and stopping time.

II. Literature review

K.K. Ikpambese et-al[1] prepared brake pad material using natural fiber called palm kernel fibers (PKFs) for its eco friendly nature with CaCO3, graphite and Al2O3 as other constituents. Epoxy resin is used as binder. Composition of 40% epoxy-resin, 10% palm wastes, 6% Al2O3, 29% graphite, and 15% calcium carbonate gave better properties than other composition. The results were compared with commercial asbestos, palm kernel shells.Results shown that PKF can be suitable for replacement of asbestos brake pads with epoxy resin as a binder.

C.M.Ruzaidi et-al[2] incorporated the waste material, palm slag as filler material along with CaCO3 and dolomite in brake pad material to increase the performance to cost ratio. The final composition is made using steel fibres, phenolic resin and other friction additives. Results shown that even though the dolomite brake pad composite had the highest strength, it showed poor wear behavior compared to calcium carbonate and palm slag. Thermal stability of the palm slag material shown the better performance compared to other two filler material in the range of 50oC to 1000oC. It is proven that phenolic resin cannot be used at high temperatures since curing of binder starts at a temperature of 150oC caused for the weight loss.

A.O.A. Ibhadode et-al[3] used palm kernel shells (PKSs), an agro waste material as friction lining material for the application of brake pads. Among other agro wastes like hyphaene thebaica kernel shell (HTKS); and deleb palm kernel shell (DPKS) PKS shown better performance after a series of tests. The mechanical and physical properties compare well with commercial asbestos-based friction lining material. Its performance under static and dynamic conditions compare well with the asbestos-based lining material. However, further refinement of the PKS lining formulation is recommended in order to have a comparable wear rate at higher vehicular speeds.

IDris et-al [4] produced a new brake pad using banana peels waste to replaced asbestos and phenolic resin as a binder was investigated. The resin was varying from 5 to 30 wt% with interval of 5 wt%. Morphology, physical, mechanical and wear properties of the brake pad were studied. The results shown that compressive strength, hardness and specific gravity of the produced samples were seen to be increasing with increased in wt% resin addition, while the oil soak, water soak, wear rate and percentage charred decreased as wt% resin increased. The samples, containing 25 wt% in uncarbonized banana peels (BUNCp) and 30 wt% carbonized (BCp) gave the better properties in all. The result of this research indicates that banana peels particles can be effectively used as a replacement for asbestos in brake pad manufacture.

Poh Wah lee et-al[5] studied the friction and wear performance of Cu-free and Sb-free environmentally friendly automotive brake friction materials with natural hamp fibers and geo polymers as a fraction replacement of synthetic kevlon fibers and phenol resins respectively. Using geopolymer in the brake materials reduced the amount of phenol resin, which will release volatile organic compounds (VOCs) when pads are subjected to temperatures higher than 300oC. The Dynamometer results shown that the modified samples had better performance when compared to the T-baseline(Cu, Sb based). However, the modified samples exhibit higher wear rate than the T-baseline.

Yun Cheol Kim et-al[6] investigated the tribological properties of phenolic resin, potassium titanate whiskers, and cashew nut shell liquid (CNSL) cured by aldehide using a pad-on-disk type friction tester. Mixture of aramid pulp, rock wool, potassium titanate is used as fiber. But in this study, only the effects of phenolic resin, potassium titanate, and CNSL on the physical properties of the friction material were investigated. The average coefficient of friction is decreased when the amount of potassium titanate is increased. Phenolic resin increased coefficient of friction but causes for the high noise propensity. While noise occurrence reduced by increasing the CNSL and potassium titanate as friction material.

C.M.Ruzaidi et-al[7] investigated the development of asbestos free brake pad composites using different fillers (palm slag, calcium carbonate and dolomite) with phenolic as binder, metal fiber as reinforcement, graphite as lubricant and alumina as abrasive. Three types of composites were prepared by compression molding of mixture of three separate fillers. The result showed that palm slag has significant potential to use as filler material in brake pad composite. The wear rate of palm slag composite was comparable with the conventional asbestos based brake pad. The result also supported by SEM micrograph. Palm slag and calcium carbonate ($CaCO_3$) brake pad composite shown better wear properties than dolomite and comparable with the conventional asbestos based brake pads.

M.A.Maleque et-al [8] used natural fiber reinforced aluminum composite, coconut fibers as filler or fiber along with aluminum composite with phenolic resin as binder. Composite is made using powder metallurgy technique. The better properties in terms of higher density, lower porosity and higher compressive strength were obtained from 5 and 10% coconut fiber composites. The compressive strength showed the 10% coconut fiber exhibited higher strength to withstand the load application and higher ability to hold the compressive force. From the morphological study of the materials, it was found that the coconut fibre well distributed to the matrix and acts as filler in the friction materials.

Zhezhen fu et-al[9] developed Eco-friendly brake friction composites which are composed of plant flax fiber, mineral basalt fiber, and wollastonite as reinforcements, natural graphite as solid lubricant, zircon as abrasive, vermiculite and baryte as functional and space fillers, and cardanol based benzoxazine toughened phenolic resin as binder. Vermiculite acts as noise reduction agent. The friction sample without flax fibers shows slightly higher friction coefficient than the samples containing flax fibers at lower temperature. Also the effect of temperature on friction coefficient indicates that the fade phenomenon appears at higher temperature and higher content of flax fibers. Therefore, the optimal amount of flax fibers led to the stable and suitable friction coefficient. It is evident that at higher temperature, the wear resistance of friction samples containing flax fibers was enhanced significantly due to ductile fracture and char formation of the natural fibers at elevated temperature.

III. Aim and Objectives

- To identify which factors affect the pad material, wear of brake and noise.
- To select the best pair material for brake disc and brake pad.
- To introduce a new alternative for NAO (Non-asbestos organic) material for brake pad.
- To minimize the wear rate and increase the life of braking pad and disc rotor.
- Experimental verification of selected material at different temperatures.
- To determine significant parameter affecting wear and coefficient of friction.
- To reduce contact braking pressure, braking squeal, vibration.
- Study of worn surfaces of tested samples using SEM (Scanning electron microscope).
- Comparative study of developed composite material with commercial asbestos based brake pad material.

IV. Problem Specification

The compositional design of friction materials is a well-known problem of multi criteria optimization which involves not only the complications of handling the different categories of ingredients but also reaching at a suitable and desired level of performance. Thus this paper presents the formulation using Taguchi optimization technique, development of a new friction material and testing of it in order to achieve better functionality as a friction material by doing investigation on the selection of ingredients and their composition levels.

V. Results and Discussions

A. Density and porosity of brake pad composite with coconut fibers [8]

A density measurement test has been carried out on a laboratory scale to examine the density of the material after sintering. Density is depends upon the ingredients in the pad material. A metallic element will have a higher density than an organic element. Friction elements often exist in combination of various elements. The results shown in Figure 3 are the average density of three readings for each formulation. It is seen from Figure 1 that the density of the 15 % coconut fibre(BP4) composite shows lower than 0% coconut fibre(BP1) which have more coconut fibre. However, formulation BP1 has better properties because of having higher density with the value of 2.176 g/cm³. This formulation has no coconut fibre in its constituents, hence, shows higher density of this composite material. The formulation, BP2 shows the second highest density with the value of 2.099 g/cm³.

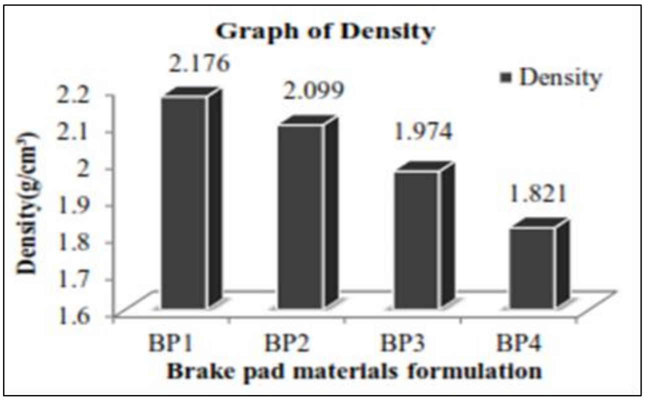

Fig. 1: Density of materials

Figure 2 shows the porosity test results for all formulations of brake pad materials. Porosity plays an important role in automotive brake pad materials .The function of porosity is to absorb energy and heat. This is a very important for the effectiveness of the brake system. Theoretically, lower porosity will result in higher friction coefficient and wear rate due to higher contact areas between the mating surfaces. Brake pad should have a certain amount of porosity to minimize the effect of water and oil on the friction coefficient and increasing porosity by more than 10% could reduce the brake noise. Porosity, a gross measure of the pore structure, gives the fraction of total volume which is void. The pore structure should be preserved during specimen grinding and polishing. Distortion by excess working will smear material over the pores, giving the appearance of a low porosity (German, 1997). From the porosity results as shown in Figure 2 it can be seen that two brake pad formulations such as, 5 and 10 % of coconut fibre composite shows lower percentage of porosity compared to other two.

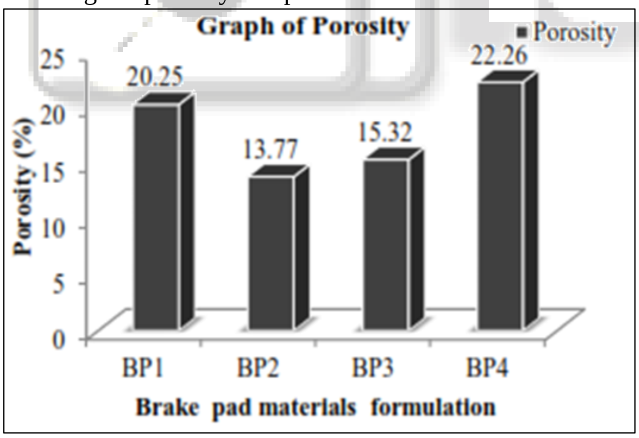

Fig. 2: Porosity of materials

VI. Conclusion

Friction lining is an essential part of braking system. Friction materials have their significant role for transmission in various machines. Their composition keeps on changing to keep pace with technological development and environmental requirements.

1) Brake pads with increased lubricant content show increased stability of the friction coefficient.
2) Brake pads with increased abrasive content show increased friction coefficient variation (instability).

Therefore it is important to achieve a compromise between the amount of lubricants and abrasives in brake friction material.

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