Development & Tribological Analysis of New Asbestos Free Break Lining Friction Material

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ABSTRACT :

Frictional brake lining materials are broadly made of asbestos as their constituent. But asbestosis dangerous for handling due to health hazardous. Asbestos has ample physical, mechanical and tribologicalproperties. The material replacing it should have all these properties with no undermine. In this study on asbestos base and asbestos free brake lining material is presented. Purpose behind this is combine the demeritsof asbestos free and asbestos base materials with comparable properties. Some organic waste from farm like banana peel, palm karnel shell, were also tested for the replacement of asbestos and they found worth throughcomparison with each others. Base on above comparative study a composite material made up of asbestos free brake lining material, can developed to investigate Tribological and Mechanical properties of pista shell. Test set-up is proposed to do that for a drum brake 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 PS liningformulation is recommended in order to have a comparable wear rate at higher vehicular speeds.

Keywords: Friction materials,pista shell, brake pad,Asbestos Free,Tribological Properties etc

I. INTRODUCTION

Friction material of brake lining converts kinetic energy into heat which is must be dissipated so that the friction device does not overheat. Friction materials are applicable for braking and transmission in various machines and equipment. Their composition keeps changing to keep pace with technological development and environmental/legalrequirements. Any brake system must be able to slow or stop the vehicle when in motion and it must be able to holdthe vehicle in position when stopped on a slope. For example, in the automotive brake, the force input by the driver is multiplied by the actuationsystem and enables the energy of the vehicle's motion to be transferred to the brake drums or rotors when friction converts it into heat energy and stops the vehicles. In the past decade, friction materials were made from asbestos because of its heat absorbing properties and quiet operation. Asbestos is a mineralcomposed of a mixture of silicates, mainly magnesium and iron silicates. The property of asbestos that makes it attractive for use in friction material industry is its fibrous nature, which combines strength and flexibility with resistance to heat and chemical, however, friction materials composition changed dramatically when it‟s main composition, asbestos, was found to be carcinogenic [3].

II. LITERATURE REVIEW

In order to understand the current developments in asbestos-free brake friction materials, various researchers have investigated the tribological behaviour, material composition, and performance of alternative eco-friendly brake linings. The following review summarizes key contributions that highlight evaluation methods, material constituents, and performance outcomes reported in previous studies.

Yun et al. [7] applied extensive evaluation method to rank the friction materials using multi-parameter criteria, including friction, wear, thermal stability, cost of raw materials, and parameters from the brake effectiveness evaluation procedure (BEEP) assessment. Eco-friendly brake friction materials were formulated without copper, lead, tin, antimony trisulfide, and whisker materials, to minimize their potential negative environmental impacts. A combination of scanning electron microscopy with energy dispersive microanalysis, profilometry, and thermo- gravimetry allows successful analysis of friction surface and thermal stability of friction materials. Kumar et al. [8] examined the influence of increasing amount of three commercially popular metallic fillers (steel fiber, brass fiber, and copper powder) on the tribological performance of friction composites including the sensitivity of μ towards load and speed. They concluded that inclusion of metal contents led to enhancement in friction performance of the composites but at the cost of wear resistance, in general. From μ sensitivity point of view, composites with higher metallic contents and hence thermal conductivity (TC) showed better performance. They observed that copper powder based composite (with 10%) proved as the best performer from both friction and wear point of view. H. Jang et al. [9] investigated the effect of different metallic fibers upon friction and wear performance of various brake friction couples. Based on a simple experimental formulation, friction materials with different metal fibers (Cu, steel, or Al) were fabricated and then evaluated using a small-scale friction tester. Two different counter disks (gray cast iron and aluminum metal matrix composite (Al-MMC)) were employed for friction tests. The friction tests were carried out at two different temperature ranges: ambient and elevated
temperatures. The test results also showed that the friction material with steel fibers was not compatible with Al- MMC disks due to severe material transfer and erratic friction behavior during sliding at elevated temperatures.

III. EXPERIEMENTAL SET-UP

- **Processing technique**

The processing technique is described in Fig1

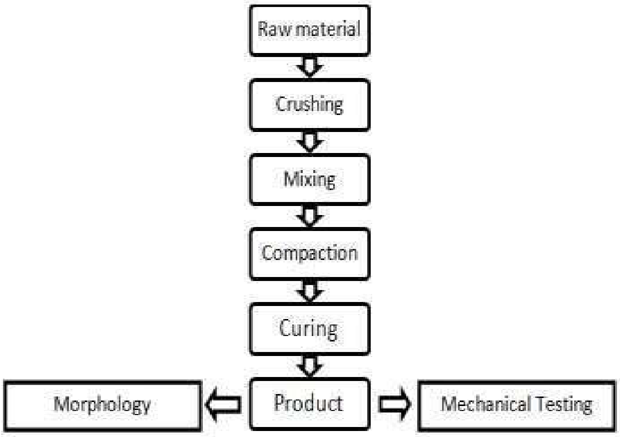


Fig.1 Flowchart of processing technique

- **Crushing**

  Crushing of pistachio shell is carried in a domestic mixer as shown in Fig. 2

Fig.2 crushing of pistachio shell

- **Carbonization**

For producing carbonized powder burning of pistachio shell is carried out in the electricfurnace at a temperature of 370°C as shown in Fig.3 Contents of pistachio shell are given in Table 1. Also, the physical appearance of carbonized pistachio shell powder isshown in Fig.4

Fig.3 Carbonization

Fig. 4 Photograph of carbonized pistachio shell powder

Table 1 Content of pistachio shell

SN	Content	Uncarbonized Pistachioshell powder	Carbonized Pistachio shell char
1	Moisture	5.3	-
2	Carbon	45.5	68.74
3	Hydrogen	5.4	3.38
4	Ash element	1.2	0.608
5	Sulphur	0.1	0.07
6	GCV (MJ/Kg)	17.0	2.70

- **Sieve analysis**

A sieve analysis (or gradation test) is a practice or procedure used to assess the particle size distribution of a material. A typical sieve analysis involves a nested column of sieves with wire mesh cloth (screen) asshown in Fig 5. A representative weighed sample is poured into the top sieve which has the largest screenopenings. Each lower sieve in the column has smaller openings than the one above. At the base is a roundpan,called the receiver. The column is typically placed in a mechanical shaker. The shaker shakes the column, usually for some fixed amount of time. Used sieves were 120microns,60microns, 40microns and sieving time was10 minutes. Vol. (%) for three different compositions are given in Table 2.

Fig.5 Sieve Shaker

Table 5 Vol. (%) for three different compositions

SN	Ingredients	Composition Vol. (%) S1	Composition Vol. (%) S2	Composition Vol. (%) S3
1	Phenolic resin	25	30	35
2	Copper	25	25	25
3	Graphite	9	7	5
4	SiO2	6	8	10
5	Pistachio shell Powder	35	30	25
	Total	100	100	100

- **Mixing**

A ball mill, a type of grinder, is a cylindrical device used in grinding (or mixing)materials like ores, chemicals, ceramic raw materials, powders.
The main body of the ball mill is a low-speed rotary cylinder mounted horizontally as shown in Fig. 3.13. Ball mills rotate around a horizontal axis, partially filled with the material to be ground plus the grinding medium. The ball mill‟s rotary part is driven at reducing speed by a motor through speed reducer and gearwheel or by the low-speed synchronous motor. Different materials are used as media, including ceramic balls and stainless steel balls. The medium will be lifted to certain height under the action of centrifugal force and friction and drop or fall.

- RPM- 120
- Time- 4 hours
- No. of Balls- 6stainless steel balls with 10mm diameter and 2 balls with 5mmdiameter (Nicoated)

Fig. 5 Ball Mill

- **Preparation of die**

To estimate the tribological properties of the compositions it is necessary to prepare the cylindrical pins for the pin and disc experimental set up. Hence for the preparation ofpins, die is manufactured. The die is manufactured according to the required pin size. Thedesired size for the cylindrical pin is 30 mm height and10 mm diameter. Die is consisting of with top and bottom punch as shown in Fig.5 and also it split cylinderwith bolting arrangement so the prepared pin can be easily removed.

Fig. 5 Manufactured die for preparation of pin

- **Compaction**

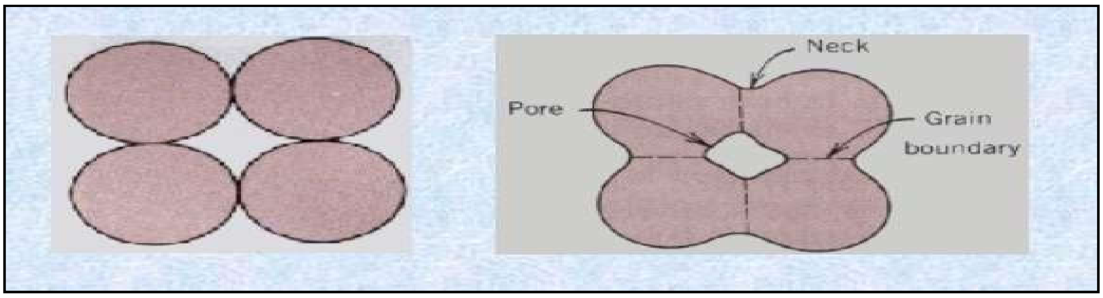
The composite powder from ball mill is taken out after ensuring proper mixing. the powder is poured intodie for manufacturing of pins. For compaction compressiontesting machine is used as shown in Fig. 6

- Die and punch were lubricated with Hydraulic 68 anti-wear oil.
- The mixture was then poured into the die and quasi-statically compacted up to350MPa atatmospheric pressure and temperature.
- The material was kept for 15 minutes under this pressure condition.

Fig.6 -compressing testing machine

- **Sintering**

Sintering is a heat treatment applied to a powder compact in order to impart strength and integrity. The principal goal of sintering is the reduction of compact porosity as shown in Fig. 7. The temperature used forsintering is below the melting point of the major constituent of the Powder Metallurgy materials. After sintering, neighboring powderparticles are held together by cold welds, which give the compact sufficient green strength. Electric furnace was used for operating temperature of 150°C.



Before sintering After sintering

Fig. 7 Effect of sintering Fabricated pins of three different compositions

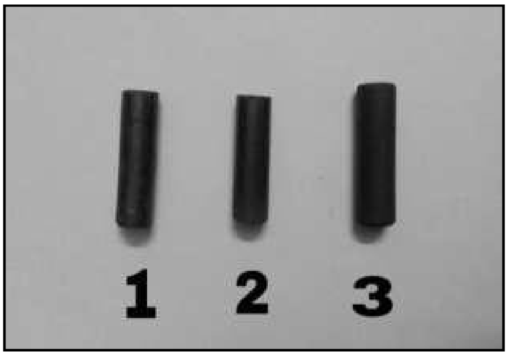


Fig. 8 carbonized pistachio reinforced pins

IV.TESTING

- **Water and oil absorption test**

Water and oil absorption test are used to determine the amount of water and oil absorbed under specified conditions. Factors affecting water absorption include type of material, additives used. Test Procedure is followed according to ASTM D570-99. For the absorption test, the specimens are dried in an oven for a specified time and temperature and then allow cooling.The water and oil (SAE 20W/50) absorption of the samples were determined by soaking the samples in water and oil for 24 hours as shown in Fig. 9,10,11.Theinitial weight of each specimen was taken and recorded as W_0before soaking in oil and water. After 24 hours,specimens were brought out of oil and water, thoroughly cleaned to remove water and oil on surfaces, reweighed and recorded as w_1. Differencesin initial and final weights for each specimen were then used to determine absorption rateof absorption.

Specimen size: rectangular specimen with dimension 15.4 mm × 36.2 mm as shown in Fig. 4.2The formula for measurement is given as;

Percentage absorption = (w1-w0)/w0
w1 = mass of specimen after removing from water or oil
w0 = mass of specimen in air


Fig. 9 Specimen for water


Fig. 10 water absorption test


Fig. 11 oil absorption testand

- **Flame resistance**

Burning or combustion is a chemical process which occurs when oxygen combines or reacts with another substance producing sufficient heat and light (exothermic reaction) to cause ignition. The chemical process is called oxidation. Oxidation of materials takes place continuously so long as the material is exposed to oxygen (or an oxidizing agent –e.g. air). At normal temperatures, the rate at which oxidation occurs is slow,and the heat generated negligibly small and is naturally conducted away from the material by the immediateenvironment. As the temperature rises above ambient, the oxidation rateincreases, the heat being released becomes significant, and Pyrolysis takes place; this is the decomposition of materials by the action of heat. A good brake pad should possess good resistance to high heat and temperature. The flame resistance of the brake pad material was determined by placing in the furnace as shown in Fig 12. The specimens weight before and after burning were taken after 10 min after burning.

$$\text{Flame resistance} = \frac{W1 - W0}{W0} \times 100$$

w1 = mass of specimen after removing from the furnace
w0 = mass of specimen in air


Fig. 12 Furnace used for the flame resistance test

- **Wear and COF**

The TR-20LE, Wear and friction monitor apparatus represents a substantial advance in terms of simplicity and convenience of operation, ease of measurement, both wear and friction force. Tribometer is an instrumentthat measure wear and coefficient of friction and frictional force i.e. tribological properties between two surfaces in contact. Theequipment designed to apply load up to 200 N and speed starting from 200 to 2000 RPM.Provision made to conduct tests under dry as well as wet conditions. The normal load, rotational speed& wear track diameter can vary to suit test conditions. Normal friction force and wear has monitored with electronic sensors and recorded on a PC. In this setup pin is made up of soft material and the disc is made upof a hard material such as MS or CI. The pin is stationary part and which is held by pin holder and the disc is a rotating part. Following are the technical specification of the pin on disc tribometer;

- **Water and oil absorption test**

Water and oil absorption percentage decreased as the vol. % resin increases as shown in Fig. 13,14 which can eventually be attributed to the decreased pores because of the close interface packing achieved. Also increased the interfacial bonding between the resinand the Pistachio shell will lead to decreased in the porosity level. Reading are described in table 6

Table 6-Water and oil absorption (%) of composite specimens

Composition	Water			Oil		
	W0 (g)	**W1(g)**	**Absorption (%)**	**W0 (g)**	**W1 (g)**	**Absorption (%)**
1	6.97	7.65	9.75	6.77	7.01	3.54
2	6.64	7.17	7.98	5.94	6.10	2.69
3	7.21	7.64	5.96	7.27	7.38	1.51

The swelling that occurs during the water and oil absorption is the sum of two components:

- Swelling by hygroscopic particles (Hygroscopy is the ability of a substance to attract water molecules from the surrounding environment through either absorption or adsorption.)
- The release of compression stresses imparted to the brake pad composites during the pressing of material. The release of compression stresses, known as spring back, is not recovered when the brake pad composites are in a dry state.

- **Hardness**

Table 7- Hardness values of three composites

Composition	S N	Hardness Value (HRB)	Average HardnessValue (HRB)
Composition 1	1	85.3	85.03
	2	84.8	
	3	85	
Composition 2	1	84.7	84.3
	2	84	
	3	84.2	
Composition 3	1	86.6	86.86
	2	86.9	
	3	87.1	

It was observed that hardness of the material varied non-uniformly as the epoxy resin percentage weight increased in the formulation, i.e. hardness decreases as binder content increased from 25 vol. % to 30 vol. %,and later increased as binder amount increased from 30 vol. % to 35 vol. % as shown in Fig 5.4. The high hardness from the increase of phenolic resin is due to the fact that the binder resin is a thermosetting polymershowing high strength after curing. Also, the higher value was attributed to increasing in bonding and close packing. Reading are described in table 7

V.CONCLUSION

The contents of composite material like copper, silica, graphite and Phenolic resinwere selected based on the literature survey. A number of materials were identified as organic filler material for composite but the pistachio shell was selected for study as no research has been done till now.

- A friction composite was successfully prepared with pistachio shell particles as filler material by using compression molding.
- The density of composite is increased as the volume percentage binder resin in thecomposite increases. The increase in density can be attributed to the increases in bonding achieved i.e. increased packing of ingredient particles.
- Water and oil absorption percentage is decreased as volume percentage the resin increases. Alsoincreased the interfacial bonding between the resin and the Pistachio shell will lead to decreasedin the porosity level.
- The hardness value obtained for composite compared favorably over the conventional model. The high hardness from the increase of Phenolic resin is due to the fact that the binder resin is athermosetting polymer showing high strength after curing.

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