Mechanical Characterization of Asbestos Free Polymer based Brake Liners

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***Abstract* - Automobile sector is rapidly growing sector and the brake systems are considered as one of the key components for the performance of any vehicle. Asbestos was the most common fiber used in the manufacturing of break liners. Asbestos having the properties suitable as base material of friction liners but it is hazardous to health. It is carcinogenic in nature. So, there is a scope for its replacement of asbestos as base material for break liner materials. A break lining material must have good mechanical properties to sustain itself on high loading applications. Natural fibers are the most popularly used fibers in natural composites along with Nano materials. Nano materials are having good mechanical characteristics and blending with natural fibers can be used as alternate for the asbestos free break liners. Thus, to reduce or to completely eliminate the health risk posed by asbestos in break liners and to reduce the cost of break liners.**

The present work was aimed to develop an asbestos free brake liner material by polymer base matrix with natural fiber and Nano material composites. The specimens were prepared for the composites with varying the reinforcement volume fraction. The prepared samples were tested for mechanical properties like tensile, compression, flexural, impact, and hardness. It was observed that α composition were shows the good characteristics compared to β composition. Later water absorption test was carried on both the samples and β composition absorbs less water compared to α composition samples.

Keywords—Bbraking systems, brake liners, polymer matrix, Natural fibers

I. INTRODUCTION

A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level in each other.one constituents is called the reinforcement phase and the one in which it is embedded is called the matrix. Composites are one of the most advanced engineering materials. The composite material can provide superior and unique mechanical and physical properties because it combines the most desirable properties. The primary function of the matrix is to transfer stresses between the reinforcing fibers particles and to protect them from mechanical properties such as strength, stiffness etc.

During the application of brake friction between brake pad and rotating disc causes to stop the vehicle by converting kinetic energy of vehicle into heat energy[1,2]

A. Matrix Material.

Some the resins are phenol formaldehyde resins (PF) are synthetic polymers obtained by the reaction of phenol or substituted phenol with formaldehyde. Used as the basis for brake liners, PFs were the first commercial synthetic resin (plastics). They have been widely used to produce molded products including billiard balls, laboratory countertops, and as coating and adhesives. There are two main production methods. One reacts phenol and formaldehyde directly to produce a thermosetting network polymer, while the other restricts the formaldehyde to produce a prepolymer known as novolac which can be molded and then cured with the addition of more formaldehyde and heat. There are many variations in both production and input material that are used to produce a wide variety of resins for special purposes.[3,4]

B. Reinforcement

Reinforcement agents are added to the resin to improve the mechanical properties and failure rates of the material. For the present work ridge gourd fiber, tamarind seed powder is used to as reinforcements.

Tamarind seeds powder mostly available during dry season, tamarind seed contains phosphorus, magnesium, vitamin c, potassium, calcium and amino acids. Tamarind seeds are shiny black in colour and have numerous nutritional and health benefits. Extraction of tamarind seeds powder, seeds are crushed by using iron hammer through hands for round then it grinds into areca grinding machine and it take 6 hours to make it as smaller size of 650 microns. The same is used for present investigation. Powder is soaked in a beaker containing NaOH solution of 10 percentage of volume fraction for 4 hours and after washed with distilled water [5].

Ridge gourd fiber, among all the natural fiber reinforcement materials, ridge gourd fiber appears to be a promising material because it is inexpensive, abundantly available, a very high perennial crop. Ridge gourd was prepared using resole resin PF-108 as the reinforcement with and without alkali treatment and glass fiber as a co-reinforcement. The natural bi-layer fabric of ridge gourd vegetable belonging to the cucurbitaceous family was treated with 2% aqueous NaOH solution. The tensile strength, modulus and percent elongation values of untreated and alkali treated ridge gourd fabric reinforced composites and glass, ridge gourd fabric hybrid composites in the absence and presence of two coupling agents were also determined. It is having high compressive strength and tensile property. extraction of ridge gourd fiber, usually the moisture content thereby increasing its strength, also chemical treatment enhances the mechanical properties and clear all impurities and stabilizes the molecular orientation.in view of this, the ridge gourd fiber is pre-heated with a base solution NaOH having 0.1narmality. After chemical treatment, the fiber is washed with de-ionized water to remove the residues of the chemical content on it and dried at room temperature, after they are sized into required size of 3-4 mm.

Graphene is a semi metal with a small overlap between the valence and the conduction bands it is an allotrope form of carbon consisting of single layer of carbon atoms arranged in a hexagonal lattice. Graphene is a crystalline allotrope of carbon with 2-dimensional properties. Its carbon atoms are densely packed in a regular atomic-scale hexagonal pattern. This perspective was successfully used to calculate the band structure for a single graphite layer using a tight-binding approximation. [6-9]

II. SPECIMEN PREPARATION

The composite material is done according to the mould prepared for two composite materials with respect to the composition calculated. The composition is termed as α and β. Mould is prepared as per the ASTM standards for the test to be conducted present study utilizes different composition of α and β percentage of phenol formaldehyde resin and reinforcements we weighed the reinforcement. Table 1 shows the composition of the specimen, for each percentage composition, volume fraction is calculated and then by compared with densities of each reinforcement, the inside surface of the mould has to be initially applied with a releasing agent wax to prevent the composition from sticking onto the mould wall. The ridge gourd which is chopped and tamarind seeds powder along with phenol formaldehyde resin were weighed according to percentages of composition then mixed in a container followed by stirring process for 5-7 minutes after closed the moulds air tightly then applied pressure on the mould to avoid the bulging of composites. The prepared samples are kept for drying at room temperature. Then those samples are removed from the moulds. Samples are cut into specimens as per the ASTM standards. The SEM image of the sample is as shown in Fig 1.

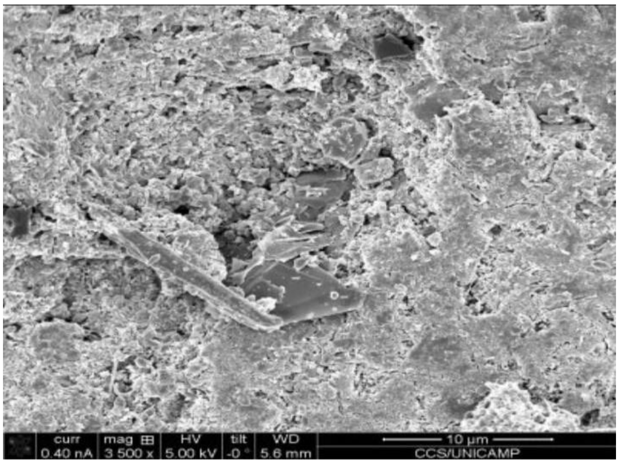

Fig 1: SEM image of composition

Table 1: Composite composition

Composition	Phenol formaldehyde resin (%)	Tamarind seed powder (%)	Ridge gourd fiber (%)	Graphene powder (%)
A	60	29.5	9.5	1
B	60	30	9.5	0.5

A. Tensile test specimen

Tensile test specimen prepared according to ASTM D3039 standards. The photographic view of the specimen is shown in fig. 2. The specimen used is a rectangular bar of size 250 mm lengths, 25mm width and 10mm thickness.

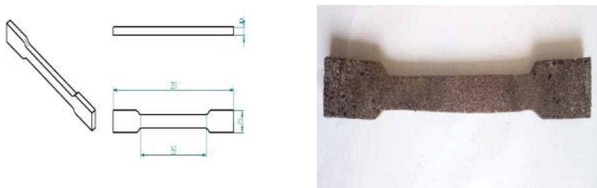

Fig 2: Tensile test prepared specimen

B. Compression test specimen

Compression test specimen was prepared according to ASTM D695 standards. The photographic view of the specimen is shown in fig. 3. The specimen used is a rectangular bar of size 24.5 mm lengths and 12.7mm width.

Fig 3. Compression test prepared specimen

C. Flexural test specimen

Flexural test specimen prepared according to ASTM D790 standards. The photographic view of the specimen is shown in fig. 4. The specimen used is a rectangular bar of size 130 mm lengths, 25mm width and 9mm thickness.

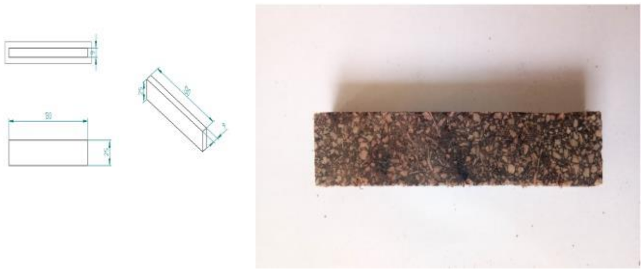

Fig 4. Flexural test prepared specimen

D.Hardness test specimen

Hardness test specimen prepared according to ASTM D785 standards. The photographic view of the specimen is shown in fig. 5. The specimen used is a rectangular bar of size 10mm length, 10mm width and 8mm thickness.

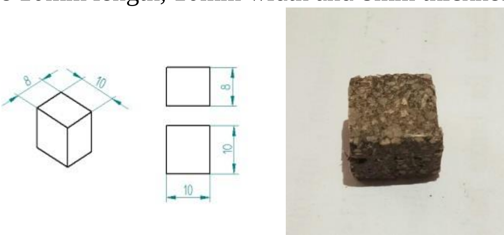

Fig 5. Hardness test prepared Specimen Size

E. Impact test specimen

Impact test specimen prepared according to ASTM D610 standards. The photographic view of the specimen is shown in fig. 6. The specimen used is a rectangular bar of size 63.5 mm lengths, 12.7mm width and 10mm thickness.

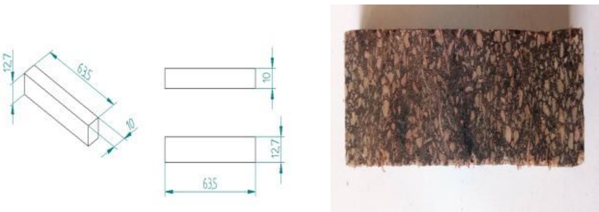

Fig 6. Impact test prepared specimen

F. Water Absorption test specimen

Moisture absorption test specimen prepared according to ASTM D5229 standards. The photographic view of the specimen is shown in fig. 7. The specimen used is a rectangular bar of size 45 mm lengths, 25mm width and 6mm thickness.

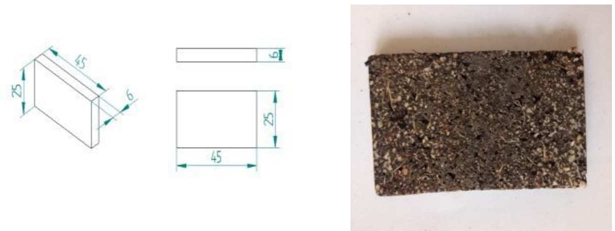

Fig 7. Water absorption test prepared specimen

III. RESULTSANDDISCUSSIONS

A. Tensile Strength of Composites

The prepared specimens of the α and β composition, were tested for the Tensile parameters in universal testing machine. The tensile properties data are shown in table 2 and values are as shown in fig 8.

Table 2: Tensile Testing Results

Load applied (*0.1KN)	**Deformation for α composition (*0.01mm)**	**Deformation for β composition (*0.01mm)**
1	25	10
2	45	21
3	71	42
4	96	61
5	115	78
6	125	91
7	--	118

Note: α – Composition: PF-60%, TP-29.5%, RF-9.5, GP-1% β –Composition: PF-60%, TP-30%, RF-9.5, GP-0.5%

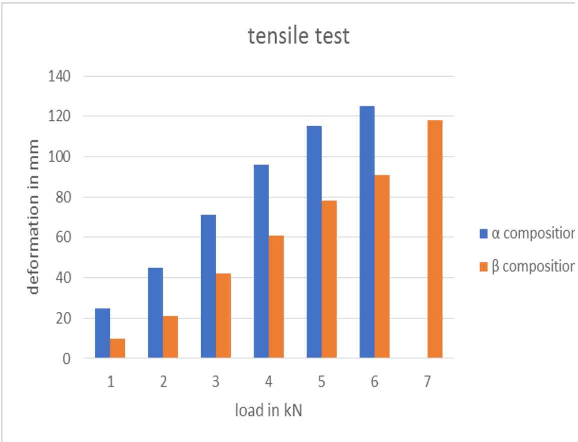

Fig. 8. Effect of treated fibers and filler contents with PF on the tensile strength specimens of natural composites

This is may be due to gap between the fiber and matrix can be filled by adequate amount of powder particles. So that voids can be avoided and hence when the load is applied to the specimen, stress can be easily transferred from matrix to fibers and gives the higher tensile strength. However, the tensile strength of the β compositions gives slightly lesser than α composite tensile strength.

B. Bending Strength of Composites

The Bending test results of a prepared composite specimen tested in universal testing machine (UTM), as shown in the table 3. The flexural strength of untreated composites at two different percentage compositions of fiber and filler content is shown in the fig.9.

Table 3: Bending test results

Load applied (*0.1KN)	Deformation for α composition(*0.01mm)	Deformation for β composition(*0.01mm)
1	6	2
2	30	25
3	75	68
4	96	70

The figure 9 clearly indicates that, the variation in the weight fraction of filler content does not have greater effect on the load bearing capacity and ability to withstand bending of composites. But it withstands the load if the reinforcement's percentage is greater. Here α compositions withstands the more load when compared to the β compositions.

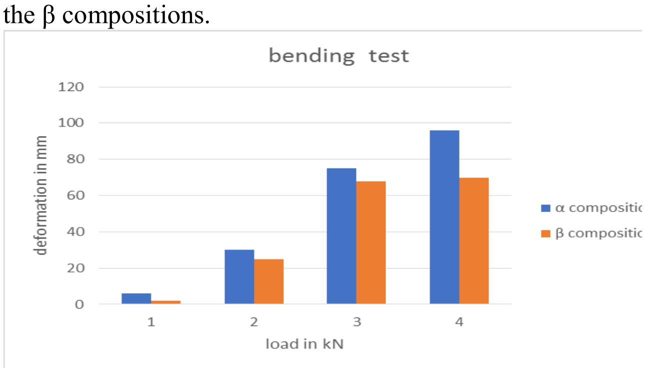

Fig. 9. Effect of treated fibers and filler contents with PF resin on the bending strength specimens of natural composites.

C. Compression Strength of Composites

The prepared specimens of the α and β composition, were tested for the compression parameters in universal testing machine. The compression properties data are shown in table 4.

Table 4: Compression strength results

Load applied (*0.1KN)	Deformation for α composition(*0.01mm)	Deformation for β composition(*0.01mm)
5	3	2
10	20	13
15	38	22
20	49	31
25	68	46
30	76	60
35	89	78
40	94	89
50	112	97
55	125	113

From the Figure 10, it is observed that all two composites exhibit different strength, in that composite specimen having β the gives more compressive strength when compared to α composition.

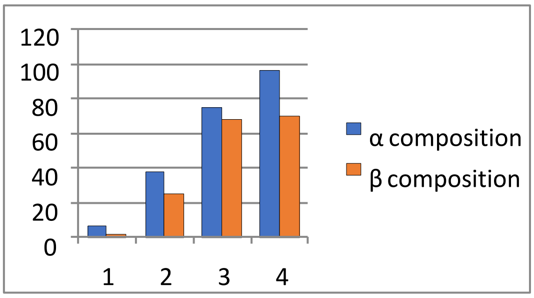

Fig. 10. Effect of treated fibers and filler contents with PF resin on the compression strength specimens of natural composites

This results in better interfacial bonding between reinforcement and matrix. Hence it exhibits better compressive strength as compared to compositions.

D. Water absorption test

Table 5 shows the water absorption test results for the river water. The above figure is plotted based on the PH value of the absorbed water. From the plotted graphs, it can be observed that the amount of moisture in the composite increases with time and later levelled off at longer period, which is an indication of saturation. From the graph, we can say that β composite absorbs less water than α composition. It gives the better results of PH value. β composition gives very nearer values and gives good results.

Table 5: The percentage of moisture absorption.

No of soaking days	Absorption of water by α volume%	Absorption of water by β volume%
1	0.21	0.24
2	1.48	1.48
3	1.56	1.57
4	1.72	1.71
5	1.91	1.92
6	2.04	2.05
7	2.30	2.31
8	2.50	2.49
9	2.66	2.65
10	2.66	2.65

This is due to the change in surface topology of the fiber due to chemical treatment. The chemical treatments had removed most of hemicelluloses and lignin and thus reinforcements become more hydrophobic and the composite absorbs less water. The fig. 11 shows the results and effect on water absorption test results.

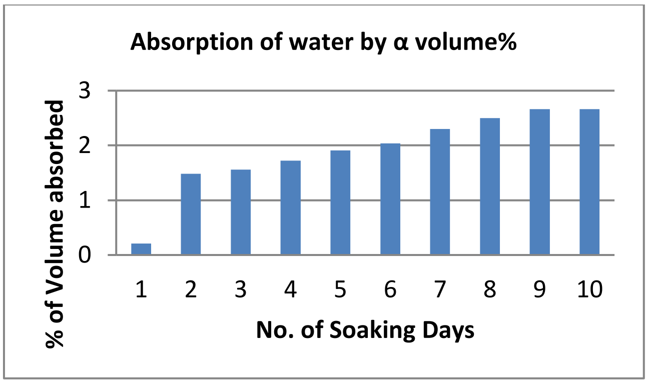

Fig. 11: Effect of treated fibers and filler contents with PF resin on the water absorption test specimens of natural composites

E. Impact Strength of Composites

In the case of alkali treated composites the specimen of composition PF gives higher impact strength as compared to other two compositions as shown in fig 12. This may due to adequate amount of fiber and powder present in the specimen that may leads to proper wet ability between the reinforcement and matrix, which helps in proper stress transfer between the reinforcement and matrix. The results for the sdame are as shown in table 6.

Table 6: Impact strength results for different compositions

Energy consumed per length (joules/mm^2)	Different percentage of composition
3	A
3.25	B

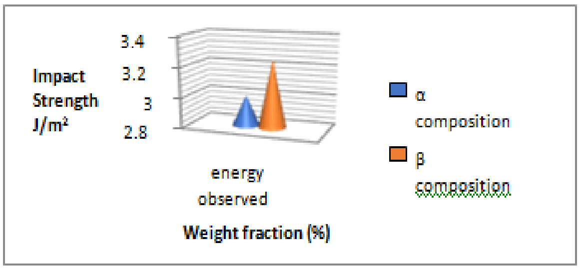

Fig 12: Effect of impact strength of different compositions

F. Hardness of Composites

The hardness test results of a prepared composite specimen tested in Brinell hardness testing machine, as shown in the table 7

Table 7: Hardness test results

Load applied (kg)	Hardness for α composition(*0.01mm)	Hardness for β composition(*0.01mm)
100	40	39
100	38	40
100	41	41

From the fig 13. It can be observed that the hardness value increases with increase in filler content in the composite. This may be due to less filler content present in the composites that makes matrix harder which leads to reduction in the elasticity.

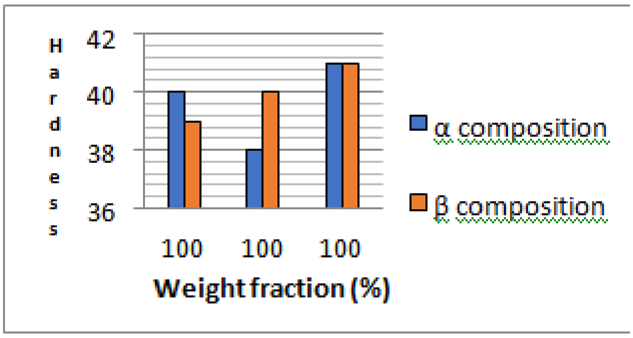

Fig. 13: Variation of hardness values for different composite percentages

IV. CONCLUSION

Natural fiber reinforced with polymer matrix composites was synthesized for the application of break liner used in automobile to replace the asbestos. Along with natural fiber graphene is also used as a reinforcement, Tamarind seed powders and Ridge gourd were used in Phenol formaldehyde as matrix.

The conclusions from the present investigation are as follows:

Tamarind seed powder and ridge gourd fiber, these are the natural fibers which can be available around the world. These may be used as reinforcement materials to produce polymer-matrix composites (PMCs). Alternate composite material is prepared to replace the Asbestos break liner, since asbestos is health hazardous. α and β compositions were formed to synthesis the samples with varying volume fraction. β Composition gives the good compressive strength than other composites and greater than ordinary brake liners, which is taken as reference. There is good disposability of reinforcement particles phenol formaldehyde resin which improves the hardness of the matrix material and the tensile behaviour of the composite. The result of this is increase in interfacial area between the matrix material and reinforcement particles leading to increase in strength appreciably. The Graphene are having good strength and the samples in the present work shows very good mechanical properties. It was found that the compression strength, bending strength, impact strength increases with increase in the weight fractions of reinforcement. The α composites exhibits higher water absorption resistance as compared to other composites. But for the tensile strength α composition gives good sustainability than β compositions. The ductility of composite decreases with increases in the weight fraction of reinforcements and decreases with increase in the particle size. Cost of making composite material might less, because of easy and abundant availability of natural fiber reinforcements.

Finally, the investigation revealed that β - composition specimens, gives good mechanical properties than other α composition samples.

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