ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 7, Issue 3, September 2017

Predict the tribological properties on brake pad using coconut shell/sugarcane/sic powder hybrid composites

Rajmohan.B[1], Dr.Arunachalam.K[2], Sundarapandian.G[3]
[2]Associate professor, Department of Automobile Engineering, Anna University MIT Campus, Chennai, Tamilnadu, India
[1,3]Research scholar, Department of Automobile Engineering, Anna University MIT Campus, Chennai, Tamilnadu, India

ABSTRACT: ***Aim of this paper is to identify the suitability of use of composite made up of coconut shell/sugarcane powder as a substitute for asbestos based material in automotive brake pad application. At present asbestos is used in brake pads which release a form of carbon monoxide powder. This powder leads to several sorts of hazards to both environment and human being. The use of coconut shell/ sugarcane powder, which is eco friendly natural product, as an alternative to asbestos based material for brake pads will not result in the emission of toxic gases during operation of the brake pads. Moreover in tropical country like India coconut shell/sugarcane powder can be obtained easily from the abundantly and easily available agricultural waste. Since wear rate and coefficient of friction are the 2 most important parameters to be considered for studying suitability of any friction material for the brake pad application. The wear test was conducted on 3 prepared samples and asbestos by using Pin on disc apparatus. The results were compared and analyzed. Also SEM analysis was conducted on the best sample to study surface topography and composition.***

Keywords: Coconut shell powder, Sugarcane powder, silicon carbide (Sic), Epoxy, Wear rate, SEM analysis.

I. INTRODUCTION

S.G.Amaren et al. Investigated the effect of periwinkle shell particle size on the wear behaviour of asbestos free brake pad .The asbestos free brake pad was produced by varying the periwinkle shell particles from 125 to 710 lm with phenolic resin as the binder[1] K.K.Ikpambese et al. Studied the properties such as friction coefficient, wear rate, hardness test, porosity, noise level, temperature, specific gravity, stopping time, moisture effects, surface roughness, oil and water absorptions rates and microstructure examination using epoxy-resin with palm kernel fibre composite [2].

However, medical research has proved that asbestos fibers can lodge in the lungs and induce adverse respiratory conditions [3].

R.Umamaheswara Rao et al. Reviewed the physical and tribological properties on banana peel brake pad that are made by varying compositions of filler, fibre, binder and possibility of replacing the existing formulations.[5]

Nuhu A.Ademoh et al. Observed that reduction of filler content increases hardness, Wear rate, tensile strength, compressive strength and thermal conductivity of the composite brake pad, while density, coefficient of friction water and oil absorption increases with increase Maize Husks filler content. The result when compared with those of conventional brake pad made of asbestos and other friction materials of past researches showed that Maize Husks particles are an effective replacement for asbestos in automotive brake pad manufacture [7]. Darlington Egeonu et al. Studied three different samples produced by varying mass compositions of palm kernel shell and coconut shell. Sample A has equal mass of palm kernel shell (PKS) and coconut shell(CNS). Sample B has higher mass of PKS(83.03%) and lower mass of CNS(12.68) while sample C has lower mass of PKS(14.79) and higher mass of CNS(35.92)[8]. A.L.Craciun et al determined a tribological study to characteristics of the friction product by using coconut natural fibres reinforced in aluminium composite. In this sense, two different laboratory formulation were prepared with 5% and 10% coconut fibre and other constituents like binder. Friction modifiers, abrasive materials and solid lubrificant behaviour in a standard pin on disc tribometer. To know the wear behaviour of composite materials will determine the parameters that characterize their tribological properties [9]. Brijendra Gupta et al. Reviewed the advantages of several alternative materials to be used as brake lining material. Aramid can be used as an alternative brake pad lining material. Since it possess the required characteristics of other friction pad materials. [10]. From the above literature leads to the conclusion that coconut shell/sugarcane/Sic powder based composite possesses certain required tribological properties for being used as automotive brake pad material. Therefore this paper study the suitability of coconut shell/ sugarcane/ Sic powder / Epoxy resin composite material to be used as brake pad material in automobiles. Once the test is got conducted the results are compared with that of asbestos.

II. EXPERIMENTAL METHODOLOGY

A. Preparation of constituent materials

1. Coconut shell powder

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 7, Issue 3, September 2017

The coconut shell is made to powder by breaking them to small pieces and finely powdered using milling machine to get fine grains. Coconut shell powder is preferred to other alternate materials available in the market because of its uniformity in quality and chemical composition and better properties in respect of water absorption and wears resistance.

Table .1 Chemical composition of coconut shell powder [12]

Composition	Percentage (%)
Cellulose	34
Hemicellulose	21
Lignin	27
Starch	0
Protein	2
Fat	5

Fig 1. Coconut shell powder

2. Sugarcane powder

The waste of the sugarcane obtained after the extraction of juice is dried until all the moisture from the waste is got dried up. After they get completely dried these fibers are powdered to a fine coarse.

Table 2 Chemical composition of sugarcane powder [14]

Composition	Percentage (%)
Cellulose	38.8
Hemicellulose	27.6
Lignin	24.1
Ash	3.8
Moisture content	NIL

Fig 2 Sugarcane powder

3. Epoxy resin

Epoxy resins are low molecular weight pre-polymers or higher molecular weight polymers which normally contain at least two epoxide groups. The epoxide group is also sometimes referred to as a glycidyl or oxirane group[15].

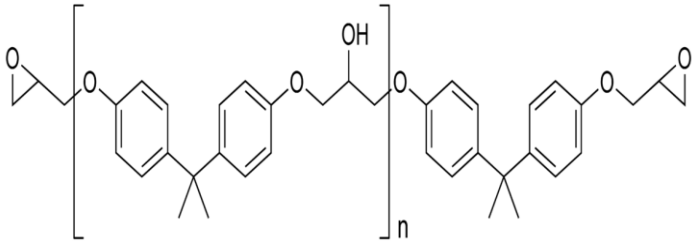


Fig 3 Structure of Epoxy resin

Where, n - denotes number of polymerized subunits

Fig 4 Epoxy resin and hardener

4. Silicon carbide (SIC)

Silicon carbide is a compound of Silicon and Carbon with its chemical formula Sic. Grains of Sic can be bonded together by sintering to form very hard ceramics that are widely used in applications requiring high endurance such as automobile brakes and clutches.

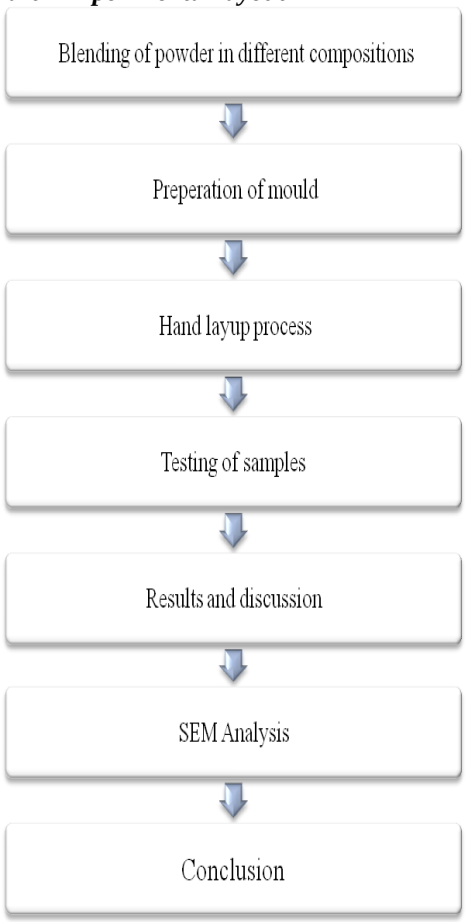
ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 7, Issue 3, September 2017

Fig 5 Silicon carbide (SIC)

III. FABRICATION

The samples (1, 2 and 3) are fabricated in the following way

Flow Chart - Experimental layout



A. Making up of different compositions

The various proportions of different constituent materials were taken to get different compositions for preparing 3 different samples. Various proportion and compositions has been explained clearly in the following table.

Table 3 Composition of samples

Sample	Coconut shell powder (grams)	**Sugarcane powder (grams)**	**Sic (grams)**	**Resin-hardener mixture (grams)**
Sample1	6.0	2.0	0.5	20
Sample 2	4.0	4.0	0.5	20
Sample 3	2.0	6.0	0.5	20

B. Blending of powder

Required amount of coconut shell powder, sugarcane powder and Sic is measured using physical balance machine with digital accuracy of even 0.1cm. They were mixed together by manual blending for 45-60 min with the help of using mortar.

C. Preparation of mould

The mould is made up of PVC pipe of 40mm long and 10mm diameters, for each sample, the surface on which the mould should be prepared is to be cleaned separately because there should not be any sort of impurities that will mix with the sample prepared. Once the powers are mixed. It is filled in the tube along with resin and hardener and it is tightly packed with help of cellophane tape.

D. Hand lay-up process

The resin and hardener were taken in a conical flask and stirred thoroughly using a stirrer. Then it is added to the blended powder and mixed until all the 3 components get mixed thoroughly with resin and hardener mixture finally the mixture is packed inside the pvc pipe and tightly packed with the help of cellophane tape to arrest any sort of leakage of resin from the mould. The samples prepared in this way were cured at a room temp for 48 hours.

Fig 6 Samples in mould

IV. TESTING OF SAMPLES

Various tests were conducted to determine the parameters such as co-efficient of friction, wear rate and surface roughness.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 7, Issue 3, September 2017

A. Pin on disc test

The pin on disc apparatus one of the most commonly used arrangement to find the wear rate and coefficient of friction values. It is widely available in India.

Wear result are reported as volume loss in cubic millimetres in weight loss in milligram for the pin and the disc separately. Coefficient of friction is determined mathematically.

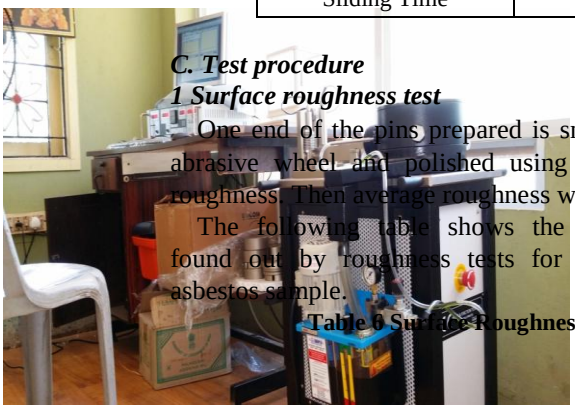


Fig 7 Pin on disc test apparatus

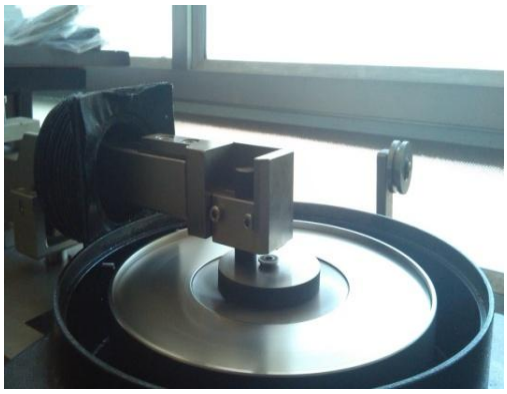


Fig 8 conducting the test

1. Specifications of pin on disc apparatus

The test was conducted on DVCOM pin on disc apparatus at CAX solutions, Hasthiaparam, Chennai. The software used in calculation is winducom 2010.

B. Testing parameters

In order to arrive at the exact result 2 sets of test parameters were taken while conducting pin on disc test on 3 samples.

The following table give details of the parameters used for conducting tests

Table 4. Parameters for Test 1

Sliding Diameter	30mm
Load Applied	20N
Sliding Distance	4000m
Sliding Velocity	2m/s
Sliding Time	2000sec

Table 5 Parameters for Test 2

Sliding Diameter	30mm
Load Applied	10N
Sliding Distance	1000m
Sliding Velocity	2m/s
Sliding Time	500sec

C. Test procedure

1 Surface roughness test

One end of the pins prepared is smoothened using an abrasive wheel and polished using sand paper to test roughness. Then average roughness was calculated.

The following table shows the average roughness found out by roughness tests for 3 samples and an asbestos sample.

Table 6 Surface Roughness values

specimen	R_a Value
Sample 1	0.589
Sample 2	0.568
Sample 3	0.431
Asbestos	0.571

Fig 9 Roughness testing apparatus

Once the average roughness is calculated the pins were ready to be fixed on the pin holder and run the tests. To get accuracy the values of digital and physical balance were taken up to 3 decimal places.

The pin holder was then fixed to stationary arm of the pin on disc apparatus. The arm of the apparatus was moved such that the sliding diameter of 30mm was achieved. The arm was then allowed to move down freely such that the pin is just in contact with the disc. The load of 2ON was added using weights. The parameter such as sliding distance of 2m\s was inputted to the machine. The total running time of the apparent was calculated to the 2000 seconds and the spin was found to be 1273.89 rpm once all the parameters were entered and the apparatus was ready to run. Then the machine was started. Now the software was able to calculate the wear and plot the

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 7, Issue 3, September 2017

result. After the test is completed the pins were removed from the holder and were weighted again to find out wear.

Thus the same procedure was followed for second set of parameters. The other 2 samples were also tested in the same way.

V. RESULTS AND DISCUSSIONS

The following table shows the consolidated results obtained while testing 3 different samples and an asbestos sample.

Formulae

Wear rate = $\Delta W/S$

$\Delta W = W_0 - W_1$

Where,

S = Sliding Distance

W_0= Initial weight of the sample, W_1 = Final weight of the sample

Coefficient of friction (μ) = tan θ = Opposite / Adjutant.

Test 1 S = 4000

Table 7 Wear rate (test 1)

Sample. No	W_0	W_1	ΔW	S	Wear Rate $*10^{-6}$ mg/m
Sample 1	5.098	5.0838	0.0142	4000	3.55
Sample 2	5.210	5.1934	0.0165	4000	4.13
Sample 3	6.156	6.1405	0.0154	4000	3.87
Asbestos	6.895	6.8826	0.0124	4000	3.11

Table 8 coefficient of friction (test 1)

SampleNo	Opposite	Adjustant	θ	μ
Sample 1	10.05	24.85	24.15	0.448
Sample 2	10.05	25.33	23.48	0.434
Sample 3	10.05	27.45	21.58	0.395
Asbestos	10.05	29.76	20.15	0.367

Test 2 S = 1000

Table 9 Wear rate (test 2)

Sample.No	W_0	W_1	ΔW	S	Wear Rate $*10^{-6}$ mg/m
Sample 1	5.0838	5.0803	0.0035	1000	3.5
Sample 2	5.1934	5.1893	0.0041	1000	4.1
Sample 3	6.1405	6.1367	0.00382	1000	3.82
Asbestos	6.8826	6.8794	0.0032	1000	3.2

Table 10 coefficient of friction (test 2)

Sample.No	Opposite	Adjustant	θ	μ
Sample 1	10.25	25.05	24.33	0.452
Sample 2	10.25	26.00	23.39	0.432
Sample 3	10.25	28.10	21.53	0.394
Asbestos	10.25	29.90	20.34	0.371

The above test results were obtained with help of the software Winducom 2010. The software calculated the wear by measuring change in height of the arm. The wear measured was enumerated in micrometers.

From the results of wear rate in table 7, it is observed that sample 1(6:2:0.5:20) is best among the 3 samples. Also it's wear rate very close to that of asbestos based brake pad which is being used in two wheelers at present.

From table 9 it is concluded even though the parameters were changed the result is same that is sample 1 gives best wear rate value and its wear rate is comparable with that of asbestos.

As per the observed values given in table 8, it is found that sample 1 has high coefficient of friction compared to other 2 samples and asbestos sample.

The test values of table 10 shows that even if the test parameters were varied the sample 1 gives the same coefficient of friction which is higher than that of other two samples and asbestos sample.

Table 11 Comparison of results exiting asbestos free brake pads. [2, 13]

S. No	Test conducted	Laboratory formulation					
		Present work (coconut shell / sugarcane / Sic powder)	Present Work (Asbestos)	Palm kernel shell	Palm kernel fibres	Banana peel	Baggase
1	Wear rate	3.5	3.11	4.400	3.98	4.67	4.2
2	Coefficient of friction	0.448	0.367	0.43	0.33	0.35	0.42

In order to differentiate the present research work from the earlier works a comparison of wear rate and coefficient of friction values has been made in table 11.

The wear rate of sample 1 (6:2:0.5:20) of present work is less compared to the previous research samples at the same time it is little above the value of wear rate of commercially available asbestos brake pads in market.

Similarly the coefficient of friction of sample 1 of the present research is higher compared to the earlier research results.

Surprisingly the coefficient of friction of sample 1 is higher than the asbestos based brake pads.

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

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 7, Issue 3, September 2017

rate and higher coefficient of friction even after changing the test parameters.

Fig 10 Brake pad made up of sample 1 composition

VI. SEM ANALYSIS

SEM Analysis is very useful for micro analysis and failure analysis for solid materials. It is performed at high magnification. It generates high resolution images and precisely measures vary small features and objects in the sample.

SEM test was conducted for sample 1 which was most suitable sample for being used as brake pad. Sample 1 fulfils the requirement of brake pad and resembles the asbestos brake pad material.

The SEM test reveals about the distribution of coconut shell powder, sugarcane powder and silicon carbide (SIC) powder in the sample.

The test was conducted after tempering the sample to 200'c at the magnification of 100x and 200x using 100x and 200x lenses respectively. The result obtained shows uniform distribution of coconut shell powder, sugarcane powder and silicon carbide (SIC) powder in the sample one.

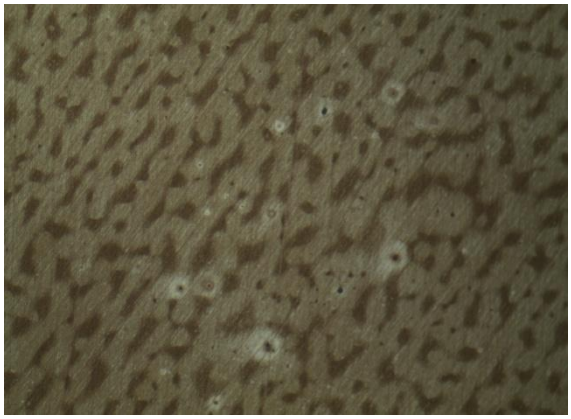


Fig 11 Mag 100x

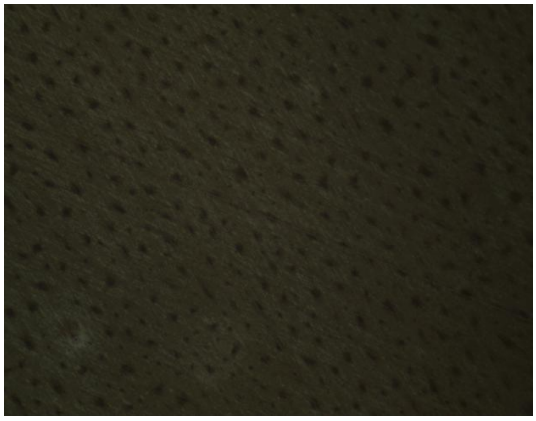


Fig 12 Mag 200x

VII. CONCLUSION

It is clear that the combination of coconut shell, sugarcane and Sic powder along with epoxy resin in the ratio of (6:2:0.5:20) satisfies the necessary standards required for being used as raw material for manufacturing the brake pad. The comparison between sample 1 (6 : 2 : 0.5 : 20) and asbestos shoes that variations in the values of wear rate and co efficient of friction are very less and the values are almost similar. Thus it is concluded that the eco friendly natural fibre based composite made up of coconut shell / sugarcane / Sic powder and epoxy resin can be used as an alternative material in the place of asbestos for manufacturing brake pads. It is also concluded that the environment can also be protected by eliminating the use of asbestos in automobiles.

VIII. FUTURE SCOPE

This project can be further developed by making the composition of coconut shell powder and the sugarcane fibre powder to exact decimal places so that the results obtained would be much more better and accurate. Apart from this, several other types of natural fibres can also be got mixed with coconut shell powder at different proportions and the results can be compared. As the problem of environmental hazards gets increased, the implementation of this type of brake pads in automobiles can be one among the solution to the problems caused due to automobiles.

REFERENCES

[1] S.G. Amaren D.S. Yawas, S.Y. Aku," Effect of periwinkles shell particle size on the wear behavior of asbestos free brake pad", Elsevier-Results in Physics (2013) Vol.3 PP109–114.

[2] K.K. Ikpambese , D.T. Gundu, L.T. Tuleun, "Evaluation of palm kernel fibers (PKFs) for production of asbestos-free automotive brake pads", Journal of King Saud University – Engineering Sciences (2016) Vol.28, PP110–118.

[3] Aigbodion V, Akande U, Hasssn SB, Asuke F, Agunsoye JO, "Development of asbestos- free brake pad using bagasse", J Trbol Industry (2010) Vol.32 PP 12 -18.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 7, Issue 3, September 2017

[4] Dagwa IM, Ibhadode AOA. "Determination of optimum manufacturing Conditions for asbestos-free brake pad using taguchi method". Nigerian J Eng Res Dev (2006) Vol.5 (4) PP 1–8.

[5] Dr.R.Umamaheswara Ra, G.Babji, "A Review paper on alternate materials for Asbestos brake pads and its characterization", International Research Journal of Engineering and Technology (2015) vol.2 PP 556-562.

[6] Gurunath PV, Bijwe J. "Potential exploration of novel green resins as binders for non-asbestos-organic (NAO) friction composites in severe operating condition". Wear J (2009) Vol.267 (5–8) PP 789–796.

[7] Nuhu A. Ademoh, Adeyemi I. Olabisi, "Development and Evaluation of Maize Husks (Asbestos-Free) Based Brake Pad", Industrial Engineering Letters (2015)Vol.5, No.2, PP 67-80.

[8] Darlington Egeonu, Chukwumaobi Oluah, Patrick Okolo. "Production of Eco-Friendly Brake Pad Using Raw Materials Sourced Locally In Nsukka", Journal of Energy Technologies and Policy (2015) Vol.5, No.11, PP 47-54.

[9] A L Craciun, C Pinca-Bretotean, D Utu and A Josan, "Tribological properties of nonasbestos brake pad material by using coconut fiber",Materials Science and Engineering(2017) Vol.163.

[10] Brijendra Gupta, Ashish Jashvantlal Modi, "Review of Automotive Brake Friction Materials", International Journal of Advance Engineering and Research Development (2015) Vol.2, PP218-223.

[11] F. N. Onyeneke, J. U. Anael , C. C. Ugwuegbu, " Production of Motor Vehicle Brake Pad Using Local Materials (Perriwinkle and Coconut Shell)",- The International Journal Of Engineering And Science (2014) Vol.3, Issue.9, PP 17-24.

[12] Andrzej K. Bledzki, Abdullah A. Mamun, Jürgen Volk "Barley husk and coconut shell reinforced polypropylene composites: The effect of fibre physical, chemical and surface properties"- Composites Science and Technology (2010) vol.70 PP 840–846.

[13] Adeyemi Ibukun Olabisi, Ademoh Nuhu. Adam, Okwu Modestus Okechukwu "Development and Assessment of Composite Brake Pad Using Pulverized Cocoa Beans Shells Filler" - International Journal of Materials Science and Applications (2016) vol. 5(2) PP 66-78.

[14] Ricardo Jose Brugnago, Kestur Gundappa Satyanarayana, Fernando Wypych, Luiz Pereira Ramos, "The effect of steam explosion on the production of sugarcane bagasse/polyester composites" – Elsevier Composites: Part A (2011) vol.42 PP 364–370.

[15] https://en.wikipedia.org/wiki/Epoxy.