Experimental Study on the Morphology of Keratin Based Material for Asbestos Free Brake Pad

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Abstract: This research was carried out to investigate the friction and wear of automotive materials using a pad on disk type friction tester to study the synergistic effects of bagasse (residue from sugarcane) and cow hooves dust (keratin based material). The friction materials were based on a simple formulation with three ingredients (phenolic resin, cow hooves dust and bagasse). Friction stability, hardness, compressive strength, flame resistance and oil absorption were measured. Microscopic observation of the friction material showed that the cow hooves adhered to the bagasse providing heat resistance and strength to the friction film at the rubbing interface. The beneficial synergistic effect from the two fibrous ingredients however was significantly diminished when only one of them was employed.

Keywords: Hardness, compressive strength, cow hooves, Bagasse.

INTRODUCTION

A brake is a device by means of which artificial frictional resistance is applied to a moving machine member in order to retard or stop the motion of a machine [1]. Disc brakes are devices for slowing down the rotation of a wheel while it is in motion. The friction of the pad against the disk is however responsible for the majority of stopping power [2]. A disc brake is usually made of cast iron but may in some cases be made of composites such as reinforced carbon or ceramic matrix composites [3]. According to [1], the materials for brake linings are such that they should have a high coefficient of friction with minimum fading, have a low wear rate, a high heat resistance and should have adequate mechanical strength and should not make noise.

The need for the development of an asbestos free brake pad cannot be over emphasized as the health hazards posed by the use of asbestos in friction materials is not bearable and the current world trend towards the use of more environmentally friendly cars would necessitate the total phasing out of asbestos based brake pads.

Friction material for an automotive brake system should satisfy a number of requirements such as good wear resistance, stable friction force, low noise level and little vibration wide variations due to temperatures, pressures, velocity changes. A great deal of efforts has being given to reduce the use of asbestos brake pad while encouraging the use and development of non-asbestos brake pad.Among many ingredients currently used in the friction material, reinforcing fibers play crucial role in determining the friction characteristics during braking. The reinforcing fiber commonly used for automotive brake friction materials are bagasse, metallic fiber, acrylic fiber and others. In general commercial friction materials contain 5.25vol% of fibrous ingredients and the types and the relative amounts of the fibers affect many aspects of brake performance and wear life.

Among many investigations on the role of reinforcing fibers on friction and wear characteristics, bagasse in particular has attracted much attention since bagasse fiber shows an increase in impact strength and hardness when reinforced with composites as the fiber volume fraction increased [4]. Also mechanical properties of biodegradable composites reinforced on bagasse fiberand with alkali treatment have reportedly shown improvements in tensile strength, flexural strength and impact strength [5].

On the other hand cow hooves contain fibrous and structural protein called keratin which is a natural hydrophobic biopolymer and is suited for those applications where water entering the composites can lead to degradation [6].

In this work, friction materials with different composition of cow hooves and bagasse were investigated using different sieve grade sizes. This is because the brake performance and wear resistance is

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ISSN: 1814-8085 / E-ISSN: 1927-5129/12

often related to the friction film at the rubbing interface and the fiber serves as an important ingredient for the film formation. The effects of properties tested were investigated based on the different sieve grade sizes.

EXPERIMENTAL DETAILS

The relative amounts of ingredients in the friction material specimen and the physical properties measured after fabrication are shown in Table **1**. The friction materials were manufactured by first sieving the ingredients with different sieve grade sizes and then mixing them in the proposed proportions for each sieve grade sizes. The friction materials were manufactured by first mixing, pre-forming, hot press mounting and post curing. The mix was performed at 140 degrees Celsius and at 140KN/cm^2 pressure for two minutes. Plates 1to 4 showed the microstructure of the friction material taken at three different locations. The friction material samples were mounted in Bakelite and mechanically grounded progressively on grades of SiC impregnated emery paper (80-600grits) using an optical microscope with built-in camera and this revealed the dark spot like regions for resin and light brownish regions for the combination of bagasse and cow hooves dust. The size of the friction material specimen for friction test was 20mm by 20mm by 10mm.

X-ray Diffractometer for the ingredients of the friction material was done using the Radicon MD10.00μm with automated power diffractometerCuK

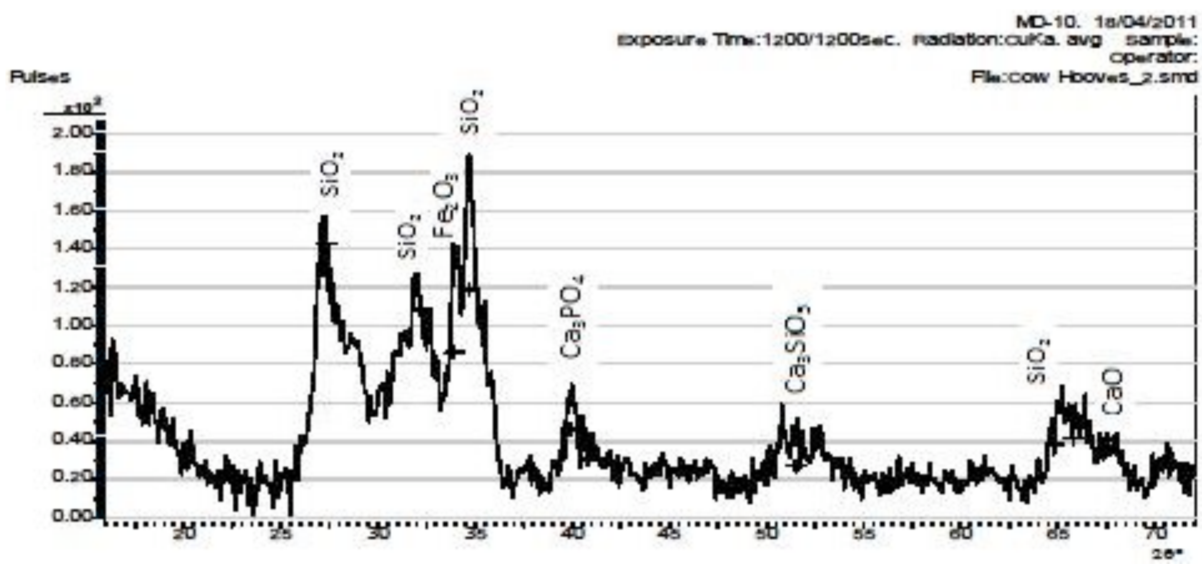


Figure 1: XRD spectrum for bagasse.

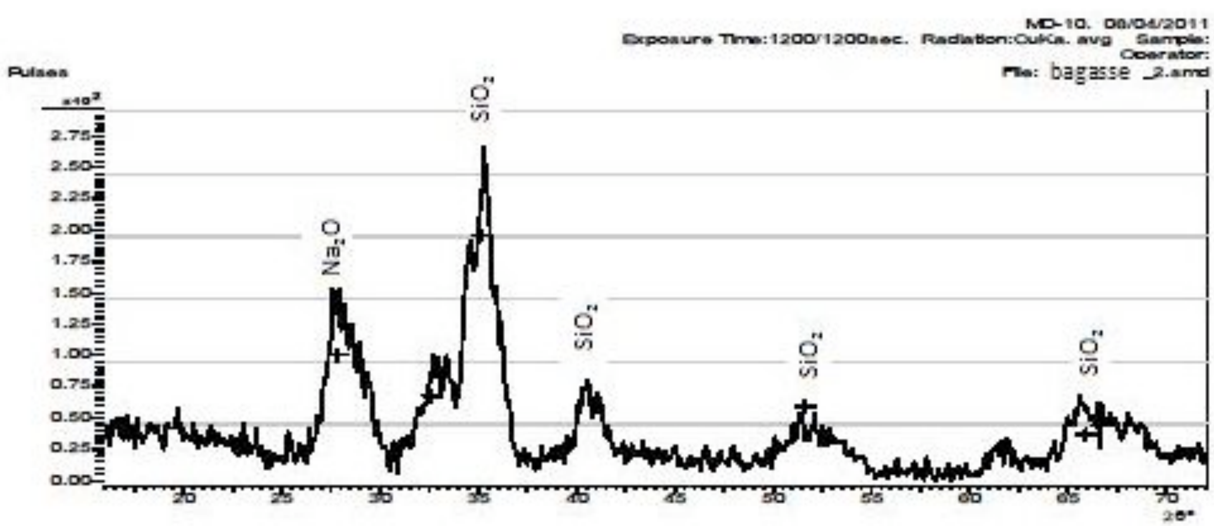


Figure 2: XRD Spectrums for Cow Hooves.

Table 1: Characterization for Brinell Hardness

Grade Size (μm)	Load (N)	Area (mm^2)	Brinell Hardness (BHN)
100	3000	25	97.34
250	3000	25	90.56
350	3000	25	52.45
400	3000	25	50.09

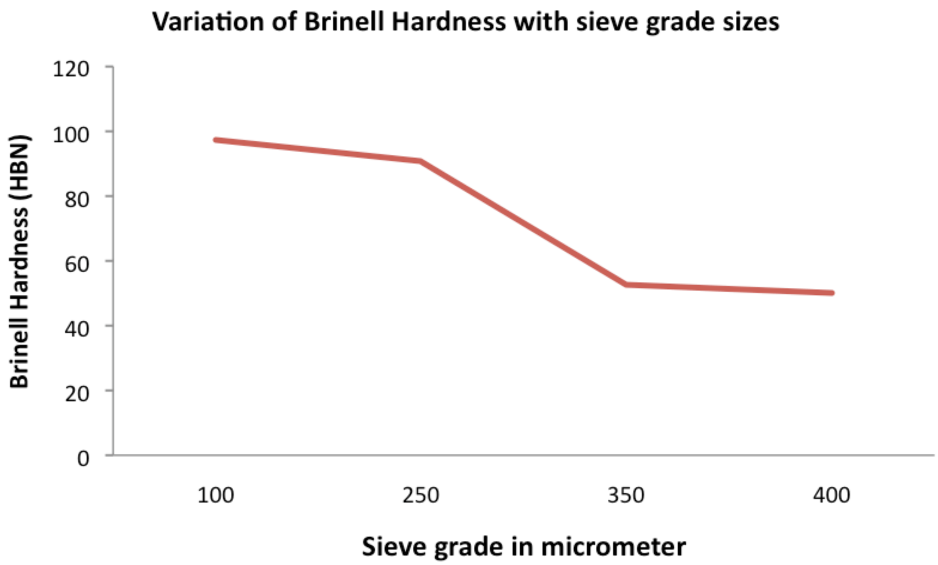


Figure 3: Variation of Brinellhardness with sieve grade sizes.

alpha. The hardness property test was carried out on the friction material using Frank WelltestBrinell hardness with model number 38506. The compressive strength of the friction materials were done with the aid of Avery Denilsoncompressive strength testing machine with a capacity of 500KN.

RESULTS AND DISCUSSION

In Figure **1**, the X-ray Diffractometer spectrum for bagasse revealed that sodium oxide at 27.80° peak and silica are at 34.66°, 40.75° and 67.45° peaks respectively. In Figure **2**, Iron oxide at 33.88°, calcium phosphate at 39.80°, harturite at 51.43°, calcium oxide at 67.48°, and silica at 32.52°, 40.54° and 65.81° peaks for the cow hooves.

Brinell Hardness

For the Brinell Hardness test Figure **1** results showed that when cow hooves and bagasse were combined using the finest sieve grade size better results were obtained than using cow hooves and bagasse at lower percentages and higher sieve grade sizes.

In Table **1**, the results showed that the 100 micrometer sieve grade size gave the best properties of all HBN at 97.34, followed by the 250um at 90.56 HBN, 350um at 52.45 HBN and 400um at 50.09HBN. The Brinell hardness of 100um sieve grade suggested that two disparate materials play complementary roles in determining the friction characteristic of the component.

Compressive Strength

Figure **4** shows the variation of compressive strength with sieve grade sizes showing that the 100μm sieve grade size gave the best properties of all with a compressive strength of 107.02N/mm^2 also showing that cow hooves and bagasse played a vital role in determining the compressive strength of a friction material.

Oil Absorption

Figure **5** shows that 100μm sieve grade size gave the best property of all in terms of absorptivity with absorption of 0.458% compared with other sieve grade sizes with absorption of 0.875%, 0.833% and 0.708%.

Table 2: Characterization for Compressive Strength

Grade Size (µm)	Load (N)	Area (mm^2)	Compressive Strength (N/mm^2)
100	2675.5	25	107.02
250	2512.6	25	100.5
350	1526.25	25	61.05
400	1332.25	25	53.29

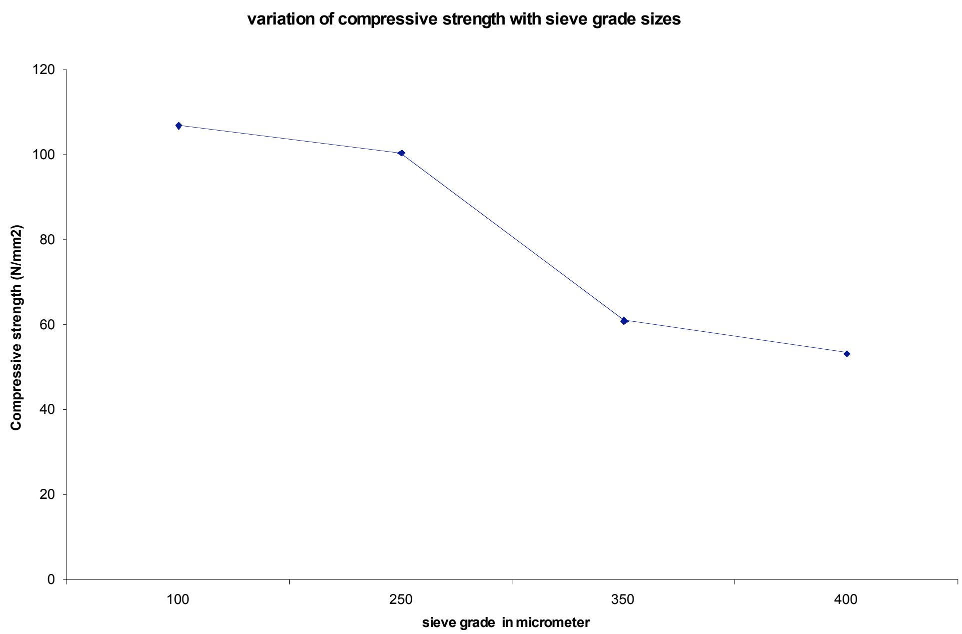


Figure 4: Variation of compressive strength with sieve grade size.

Water absorption also showed that the 100µm sieve grade size absorbed the least following through with a range of 3.00%, 8.91%, 11.08% and 9.08%.

Flame Resistance

Figure **6** shows the variation of sieve grade size with flame resistance whereby the friction material have been charred under flame for 10 minutes with a Bunsen burner and the mass of material measured. Again the 100µm sieve grade size gave the best property of all with a flame resistance of 4.10%, while the 350µm of sieve grade size gave the least Flame resistance of 7.1%.

Microstructural Analysis

The results from the optical microscopy revealed the microstructure of the friction material for the four different sieve grade sizes showing that the 100um sieve grade gave the best microstructure. Plates **1**, **2**, **3** and **4** show the different microstructures taken from 3 different parts for all the sieve grades.

The discussion of the brake friction material was affected by the heat resistance of the ingredients. The synergistic effect is mainly attributed to the high temperature resistance of the bagasse and the unique nature of the fibrillated cowhooves. The synergistic

Table 3: Characterization for Oil Absorption

Grade Size (µm)	Mass before (g)	Mass after (g)	Oil Absorption (%)
100	0.94	1.05	0.458
250	0.94	1.15	0.875
350	0.97	1.17	0.833
400	1.10	1.27	0.708

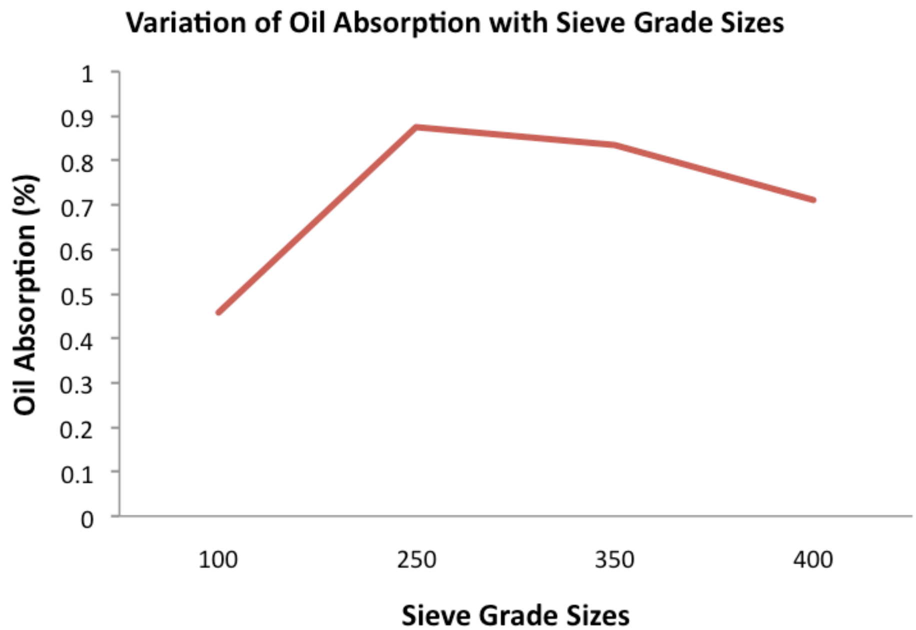


Figure 5: Variation of Oil Absorption with Sieve Grade Sizes.

Table 4: Characterization for Flame Resistance

GRADE SIZE (µm)	Mass before (g)	Mass after (g)	Flame resistance (%)
100	0.80	0.41	4.10
250	0.94	0.44	5.5
350	0.90	0.19	7.1
400	0.98	0.56	4.2

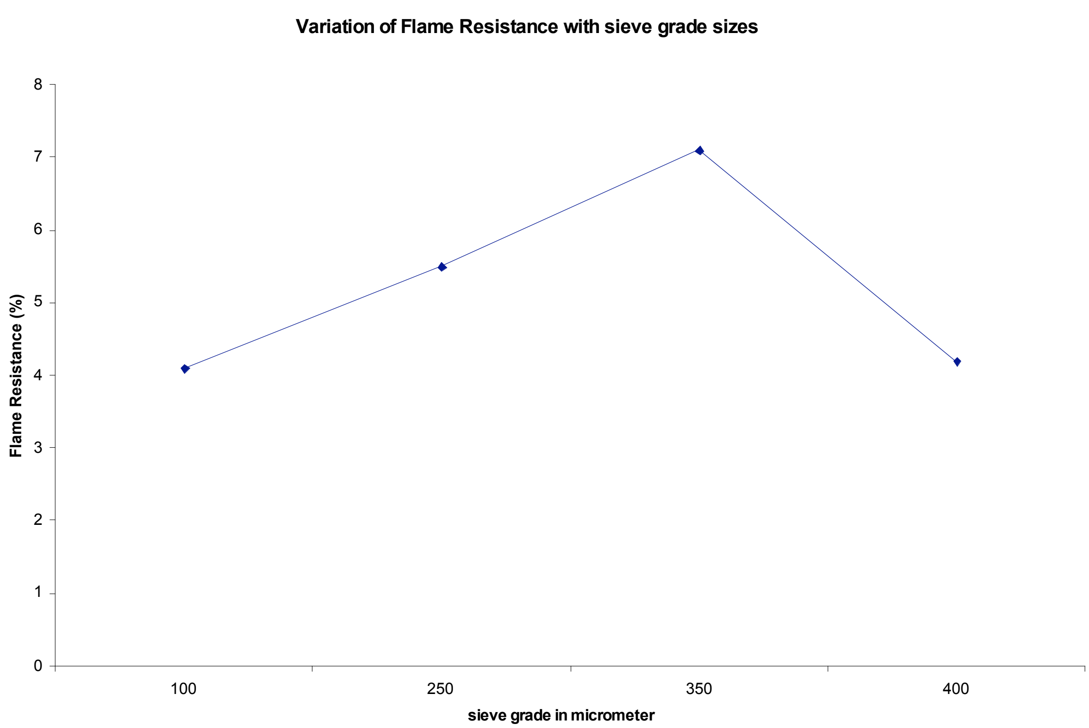
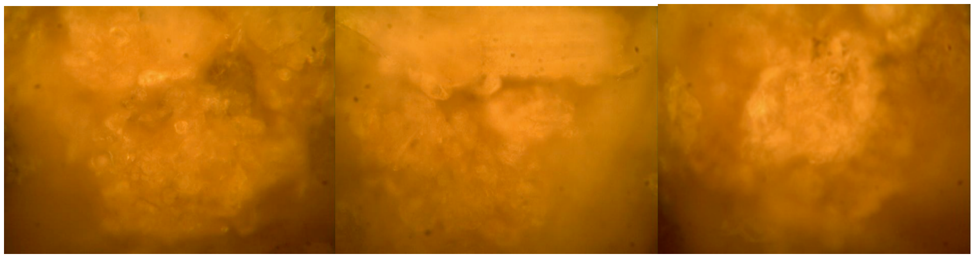
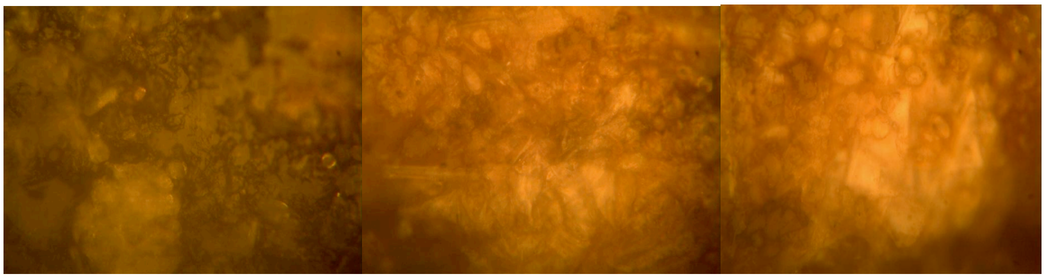


Figure 6: Variation of flame resistance with sieve grade sizes.



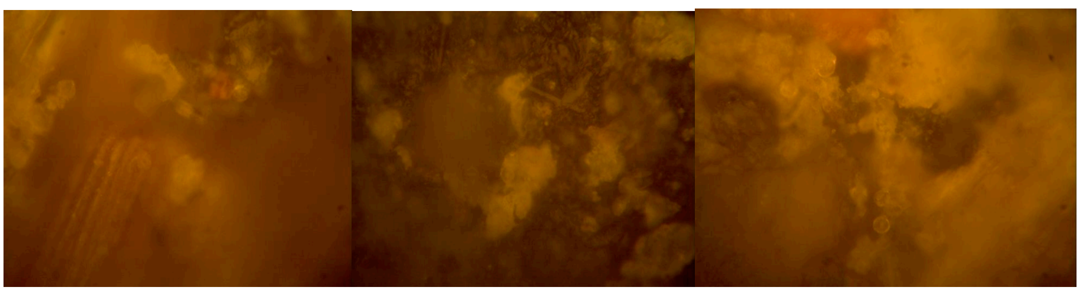
Part 1 Part 2 Part 3

Plate 1: Optical microscopy (X500) for 100µm sieve grade sizes at three different Parts (100µm sieve).



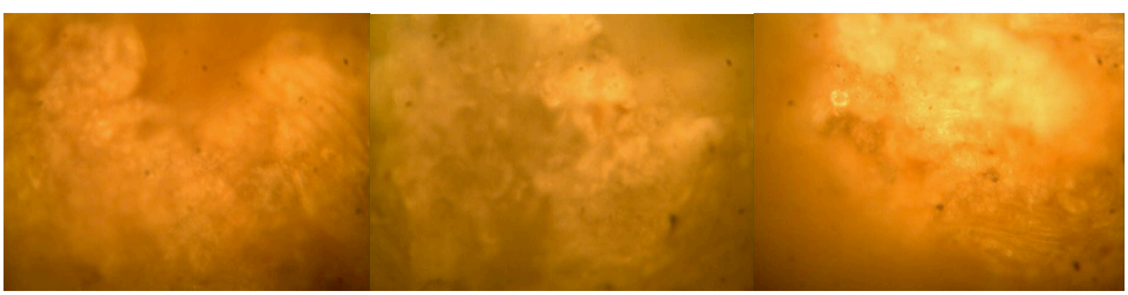
Part 1 Part 2 Part 3

Plate 2: Optical microscopy (X500) for 250µm sieve grade sizes at three different Parts (250um).



Part1 Part 2 Part 3

Plate 3: Optical microscopy (X500) for 350µm sieve grade sizes at three different Parts (350um).



Part 1 Part 2 Part3

Plate 4: Optical microscopy (X500) for 400µm sieve grade sizes at three different Parts (450um).

effect requires homogenized mixture of the two fibers without segregation of one type of fiber

CONCLUSION

Friction characteristics of bagasse and cowhooves in the automotive friction material were investigated using Brinell hardness tester and a compressive strength machine. The results showed that the reinforcing fibers had strong synergistic effects providing friction stability.

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Received on 20-03-2012 Accepted on 17-04-2012 Published on 16-05-2012

http://dx.doi.org/10.6000/1927-5129.2012.08.02.08