

# Application of Pulp Fiber for Automotive Brake Lining

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## Abstract

Mechanical and/or chemical pulp fiber is usually used for papermaking and other kind of paper products. In fact, physical properties of chemical and/or mechanical pulp showed that it can be utilized as filler of automotive brake lining. Mechanical pulp is non-asbestos cellulosic fiber with high heat absorption rate which can fit into criterion of good quality brake lining. Pulp fiber was defiberation mixed with some other composite materials can create high fiber bonding with some hardness, friction materials, clutching, heat and dust retainer fiber which is free of asbestos fiber. Current automotive brake lining uses asbestos fiber as main filler, which is in fact known as cancer triggers. A series of study and assessment in using pulp fiber in a specified composition as brake lining filler have been carried out. The research and field experiment revealed that a mixture of pulp fiber can be further examined and feasible for brake lining prototype filler application which is ready for automotive vehicles operation. The development and application fiber brake lining filler has been tested on two wheeled vehicles with considerable result.

**Keywords :** mechanical pulp, brake lining, non-asbestos fiber.

## Introduction

Using pulp fiber material for paper or paperboard industry is common and typical in pulp and paper. However, the using of pulp as raw material with different function such as filler is a breakthrough which is still promising. The use of pulp as something unusual is a breakthrough as an effort to diversify products that are useful and have a competitive economic value. One of the components of vehicles that are needed and have a broad market ranging from urban to the rural areas is canvas motorcycle brakes.

In fact, brake lining material is still obtained from materials original from imported components in the form of finished goods, while the usage percentage of this product is huge and still rely on imported components (Arief 2009).

Based on visual observations on the brake lining, there is a range of filler that can be engineered as needed and still consider the factor of safety of the wearer. Empty oil-palm fruit bunches (EOFB) which is by products of oil palm plantation are fiber sources for chemical, mechanical, and semi-chemical pulp (Kabul *et al.* 1995). The pulp can be used as fillers or mixed with other motor vehicle brake components. A particular type of pulp is expected to qualify technically and economically as a brake through manufacturing and engineering efforts such as through mixing process that results in a composite that has a strong power fiber bundle with a high frictional resistance which produces accurate grip. The type of pulp to be considered in the making is the pulp that is suitable and can be mixed with the additive as a binder composite material through the stages of pressing using particular temperature variations. Manufacturing a motorcycle brake for medium-scale industries in the future is a great business opportunity given the number of motorcycle users in Indonesia showed a very sharp increase to 10 times each year. No studies have been done in the use of pulp as raw material for brake while in

fact it is possible to be done considering the pulp structure meets the requirement of the component.

However, in the process of mixing, other ingredients are required like hardeners and composites to increase the frictional resistance and resistant to heat. Thoughts and ideas for diversification of products from pulp sparked efforts to research the use of pulp as raw mixture in the motorcycle brake components.

The series of this research are expected to answer the challenges of technological process of making motorcycle brake from natural cellulose fiber of empty fruit bunch. The combination of optimal composition of various materials is expected to reduce the component of imported materials currently used. As it makes progress, in accordance with the process of running the motor vehicle brake pads made from a mixture of biomechanical/mechanical pulp of oil-palm empty fruit bunches or low mass wood species, it is expected that it can be produced in Indonesia. Method of manufacturing technology and research results can then be applied to small-medium industries (SMI) with the production of reference materials that have been tested through the technical and economic studies.

## Non-asbestos Brake Lining

Brake lining made from non asbestos material usually consists of 4 to 5 types of fibers such as Kevlar, steel fiber, rock wool, cellulose and carbon fiber which have long fiber. Asbestos brake material has only 1 type of asbestos fiber which is a component that is carcinogenic. Asbestos-containing brake has a disadvantage in wet conditions. Asbestos consists of only 1 type of fiber which is on wet condition the material will experience the effects of slippery like swiping a finger on the wet glass (slippery/no grip). Non-asbestos brake lining material has some kind of fiber that can resolve the slick effects. Given the asbestos brake uses only up to 6 types of raw materials while non asbestos

material uses more than 12 types of material, asbestos can only be maintained until the temperature of 200°C (Geoffrey 2006). Medium non-asbestos material can withstand temperatures up to 360°C. This means that while the asbestos will be free from tension brake (fading) at temperatures of 250°C, the non-asbestos tends to be stable (no tension). Asbestos brake lining prices are relatively cheap because it only consists of 6 kinds of materials with low quality. Brake dust containing asbestos tend to be mild and easily attached to the rim and hard to clean while non-asbestos dust is heavy so do not tend to stick to the rim and easy to clean. The weightlessness of asbestos dust causes asbestos dust to be easily inhaled and easy to stick to the hands so that it can easily fit in our digestive tract with food, while the non-asbestos brake is known as environmentally friendly (Kaminski *et al.* 1999).

### Metal-based Composite Brake Blocks Containing Lead and Asbestos

On the use of composite products in industry, safety issues often receive less attention both from users and management of the company due to limited knowledge of the dangers in its use. One example is the canvas brake metal-based composite that had a researcher checked the composition in the field and found the content of lead, Chromium and Zinc while the technical material tender should be free of the compounds of Cr, Pb and Zn. Level of Pb contained in metal-based composite brake blocks is more than 100 ppm. It is very dangerous for passengers and people who happened to be passing by around the train when "braking" performed by railway train drivers. Canvas-based metal composite brake lining contains heavy metals and asbestos since the main raw materials/ fillers are made in the form of mineral fibers and asbestos-containing material of follow-ferrous (inert) and in the form of metal oxide-containing compounds of PbO<sub>2</sub>, Cr<sub>2</sub>O<sub>3</sub> and ZnO (Adelmann 1995; Geoffrey 2006).

### Materials and Methods

Research scope includes the process stages of the suitable mechanical pulp and seeking for mixing variations in accordance with the physical properties. The work of binding of materials, resin and the pulp as filler on canvas brakes were carried out as follows, selection of mechanical pulp fiber/ reconditioning, selection of material mixing, tests for chemical properties and other materials, pulp and composite blending technique, evaluation and improvement of the mixing method tests on the parameters observed using Indonesian National Standard (SNI) and ASTM standard. The procedures for the testing of test samples were carried out with applicable method standards such as SAE J 661:1997 Brake lining quality control test procedure, and SNI-09-0143-1987 for Classification, Dimension and Friction (SNI). Data quality test results were compared to national standard (SNI) brake canvas quality

as well as commercial materials on the market ranging from cheapest price to the most expensive. The results of data comparison were evaluated by considering the best and optimum product quality control to SNI brake lining. Analysis of research data for each parameter was carried out by testing the relationship between one parameter with other parameters using correlation research design, such as:

- composition of the pulp mixture to a standard power brake canvas
- type of pulp used for good quality canvas brakes
- relationships with other filler materials of pulp on the quality of brake canvas

Non wood pulp, NaOH, Aquadest, Phenolphthalein, KJ, Fiber glass, Friction dust, NBR Powder, Barium sulfat, Calcium hydroxider, Grafit, Stell fiber, Phenoic resin. Rockwool, Carbon black and Glue hardener.

Fiber or similar material was mixed in a special instrument (mixing chest) with 2 different rotation and motion between the outer and inner. Fiber material was stirred until uniform and then other components of 6 items or more were added. The whole homogeneous blend of brake lining raw material mixture was ready to be fabricated.

### Experimental Stages

The process or stages of research can be seen in Figure 1 below.

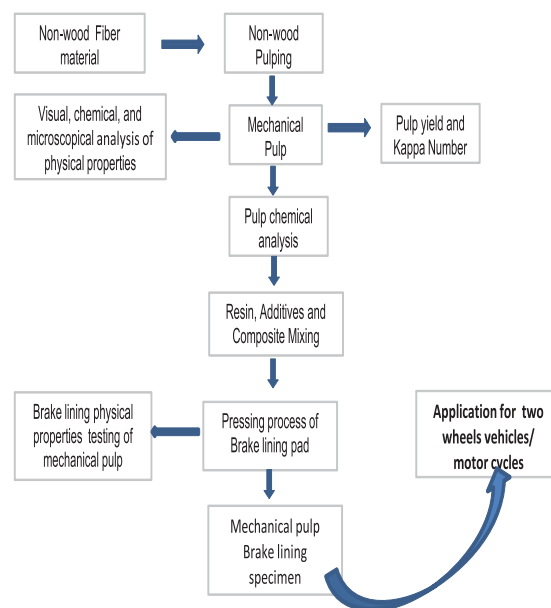


Figure 1. Research flow chart of fiber pulp for brake lining.

### Results and Discussion

#### Organic Brake Lining

Type or kind of brake lining that was made in this study lead to brake lining organic, i.e. brake lining was produced from cellulose bound together with other materials using

heat-resistant phenolic resin. Asbestos with its high heat resistance was initially used for brake pad. However, due to its carcinogenic properties, asbestos was replaced by Kevlar, fiber glass, and mineral filler. Organic pads have a coefficient of friction (COF) which is good for lighter pedal effort, work well at low temperatures and not noisy (Arief 2009). Organic pad does not work well on high performance use since it will diminish fast, fade at high temperature, be easily oxidized and destroyed, and the pad does not create a worn rotor.

Brake test results of the first stage of pulp (first base line) against the friction and the friction coefficient from 1 to 20 times usage from brake lining brake type A and type B showed nearly the same strength. This shows that the friction strength and the friction coefficient are almost equal to the amount of pulp added to the type A or type B. Even though there are differences of both types, the value has no effect on the performance of the brake lining.

Brake lining testing were carried out after the first stage and then tested in the second stages. The results show that

using once to eight times power differences in friction, the friction power for type A is better than type B. The temperature usage is higher in type B with a coefficient of friction decreases.

Physical testing of pulp material with canvas brakes after moving away then conducted a second test, and so on with the results shown in Table 5.

Pulp fiber brakes lining test from once to 100 times usage showed the same value of friction strength, friction coefficient. This result indicates that the composition of the pulp in type A and type B gives good braking performance up to 100 times of use.

The next testing phase is carried out on pulp brake lining after a recovery phase 1 and then conducted tests on the recovery phase 2 with 5 times experiment. The results showed that the friction on type A and B still has the power of friction above 250 and the temperature reaches 300°C due to friction with friction coefficient 0.4 to 0.5.

Table 1. Pulp brake lining test results of phase 1.

First base line	Force (N)		Friction Force (N)		Temp (°C)		Coefficient of Friction (CoF)		Hardness (HRS)
	Type A	Type B	Type A	Type B	Type A	Type B	Type A	Type B	
1	584	587	296	256	90	67	0.51	0.49	Disc pad 94 Brake shoe 75
5	579	518	287	291	88	68	0.50	0.47	
10	578	564	291	274	111	92	0.50	0.49	
15	585	549	310	289	90	91	0.53	0.53	
20	590	540	319	293	95	92	0.54	0.53	



Figure 2. Pulp brake lining specimen disc type (Source: howstuffworks.com & Wawan KH and Posma RP).



Figure 3. Specimen of pulp fiber brake lining testing, brake shoe type (Source: howstuffworks.com & Wawan KH and Posma RP).

Table 2. Pulp fiber brake lining testing of brake shoe.

No	Properties	Brake shoe 1	Brake shoe 2	Brake shoe 3	SNI 09-143-1987
1	CoF, 100°C	0.25	0.22	0.20	0.30~0.50 ± 0.10
2	CoF, 150°C	0.25	0.27	0.24	0.25~0.50 ± 0.10
3	Wear degree, 100°C	0.32	0.84	0.12	1.02 ± 0.10
4	Wear degree, 150°C	0.44	0.12	0.12	0.30~0.50 ± 0.10
5	Characteristic classification	Type 1	Type 1	Type 1	Type 1
6	Using Classification	Class 1B	Class 1B	Class 1B	Class 1B
7	Hardness, HRS	7.8	7.5	7.5	-

Table 3. Brake lining testing result phase 2.

First fade	Force (N)		Friction Force (N)		Temperature (°C)		Coefficient of Friction		Hardness HRS
	Type A	Type B	Type A	Type B	Type A	Type B	Type A	Type B	
1	505	572	297	325	94	94	0.50	0.48	Disc pad 94 Brake shoe 75
2	485	554	288	332	122	120	0.60	0.51	
3	472	564	299	328	150	150	0.63	0.49	
4	460	560	334	343	178	170	0.73	0.52	
5	463	559	316	348	200	206	0.68	0.53	
6	472	561	328	349	234	234	0.68	0.53	
7	480	557	344	328	202	262	0.72	0.50	
8	470	559	337	300	200	290	0.72	0.46	

Table 4. Pulp fiber brake lining testing of brake shoe type.

No	Parameter	Disk A	Disk B	Commercial Disk (average)	SNI 09-143-1987
1	CoF, 100°C	0.30	0.24	0.25	0.30~0.60 ± 0.10
2	CoF, 150°C	0.27	0.23	0.21	0.25~0.60 ± 0.10
3	Wear Degree, 100°C	0.48	1.95	0.84	0.20 ± 0.10
4	Wear Degree, 150°C	0.41	-	-	2.04 ± 0.10
5	Characteristic Classification	Type1	Type 1	Type 1	Type 1
6	Using Clasification	Class 1B	Class 1B	Class 1B	Class 1B
7	Hardness, HRS	10.52	0.95	0.87	-

Table 5. Testing result of fiber pulp brake lining phase 3.

Phase 3 (First- recovery)	Force (N)		Friction Force (N)		Temp (°C)		Coefficient of Friction		Hardness HRS
	Type A	Type B	Type A	Type B	Type A	Type B	Type A	Type B	
1	547	518	317	204	200	260	0.58	0.39	Disc pad 94 Brake shoe 75
2	535	510	219	208	193	203	0.54	0.41	
3	538	546	285	237	148	148	0.53	0.43	
4	529	570	280	277	94	94	0.53	0.49	

Table 6. Result of the brake test pulp use.

WearTest	Force (N)		Friction Force (N)		Temp (°C)		Coefficient of Friction		Hardness (HRS)
	Type A	Type B	Type A	Type B	Type A	Type B	Type A	Type B	
1	662	639	388	338	212	209	0.59	0.53	Disc pad 94 Brake shoe 75
19	652	654	364	357	205	200	0.56	0.55	
20	594	653	356	372	222	201	0.60	0.57	
30	616	655	344	362	213	203	0.56	0.55	
40	652	656	333	357	198	198	0.51	0.54	
50	652	642	350	350	218	200	0.54	0.55	
60	650	652	348	652	213	203	0.54	0.54	
70	651	661	353	661	198	198	0.54	0.55	
80	653	661	353	661	199	202	0.54	0.55	
90	664	651	350	651	217	208	0.53	0.55	
100	665	651	364	651	213	213	0.55	0.56	

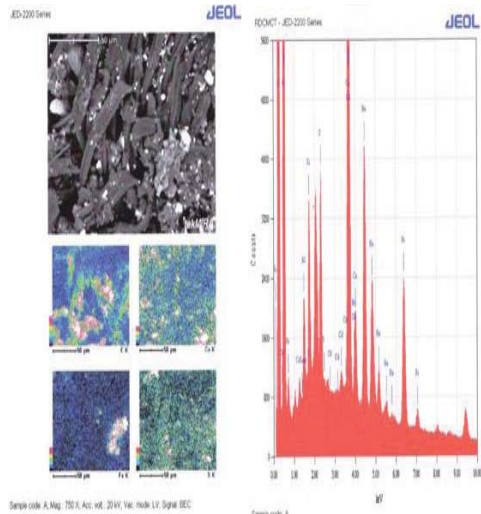


Figure 4. SEM testing of pulp fiber brake lining A.

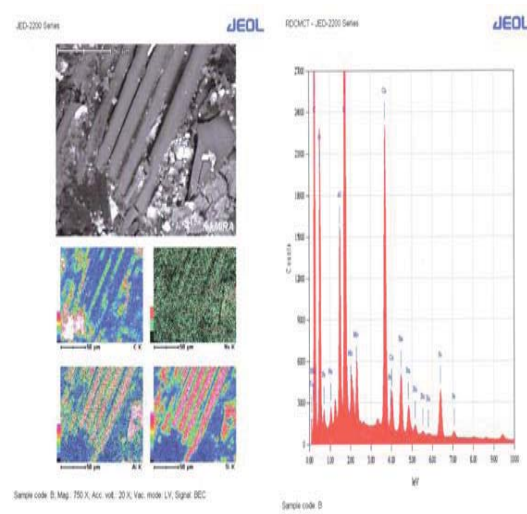


Figure 5. SEM testing of pulp fiber brake lining B.

Table 7. Result of recovery test brake pulp phase 2.

Second Recovery	Force (N)		Friction Force (N)		Temp (°C)		Coefficient of Friction		Hardness (HRS)
	Type A	Type B	Type A	Type B	Type A	Type B	Type A	Type B	
1	525	543	251	179	312	311	0.48	0.33	Disc pad 94 Brake shoe 75
2	484	533	275	228	258	256	0.57	0.43	
3	523	527	292	244	202	202	0.56	0.46	
4	503	516	274	247	149	147	0.54	0.48	
5	501	560	291	280	94	92	0.58	0.50	

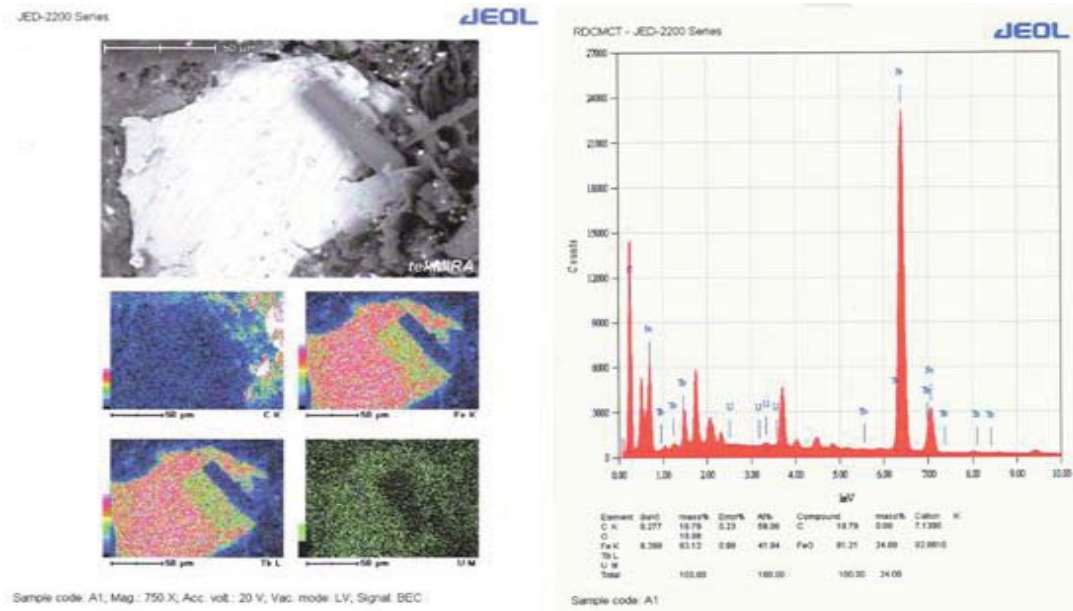


Figure 6. SEM testing of pulp fiber brake lining A1.

### Using of Lower Resin and Process Positive Moulds

The study on the use of low resin with a "positive mold" on disc brake pads show that fading does not occur. This is due to positive mold process which is the best way to produce the disc pad and this process is widely used by brake manufacturers original equipment manufacturer" (OEM). During the process of positive mold hot press, the brake lining material placed into the cavity of the dies hot press and then pressed so that the average density occurs on the brake (Masmui 2003).

Brake product that uses the system process of "mold flash", the resins and brake material content must be excessive so that the resin can flow out. High resin content can easily lead to tension brake due to high temperatures (fading) when braking occurs. Since this fading can cause increased braking distances of 50% or more, it can result in an unavoidable accident due to tension brake. This can happen on the brake canvas made from raw asbestos brakes with high resin consumption between 15 ~ 20%. None of 9 ~ 10% hence in high temperature braking, tension brake problems or canvas fading brakes can be anticipated (Arief 2009).

### Conclusions

The optimum composition of pulp fiber in addition of non-wood pulp fiber as a substitute for asbestos in vehicle brake canvas was between 15 ~ 40% by weight.

Pulp fiber brake for two wheeled vehicles produced good friction power quality and had a heat resistance up to 300°C braking effect on the optimum composition of the pulp.

Optimization of fiber pulp brake lining manufacture can be implemented with the addition of a number of other filler materials in accordance with the composition of the pulp. Pulp fiber brake lining type A and type B were the experimental results that have been applied to the automotive industry scale.

Non-wood pulp fibers can be used as filler canvas brakes as a replacement to asbestos fibers. Trial results on an industrial scale by making 1000 pairs of brake drum type and disc type has been implemented in the automotive industry.

Test results of pulp fiber brake canvas products for two-wheeled vehicles, in compliance with SNI 09-0143-1987 met the commercial brake canvas. The patent of canvas pulp fiber brake for vehicles has been registered as Patent No. ID P0029623 in Indonesia.

Socialization and installation of fiber pulp canvas brakes on two wheels vehicles in the community such as students, households, workers and taxi motor has been implemented with encouraging results.

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