SUPERVISOR DECLARATION

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure and Materials)"

Signature :……………………………………….

Supervisor :……………………………………….

Date :…………………………………….....

Signature :……………………………………….

2nd Supervisor :……………………………………….

Date :…………………………………….....

"I admit this report is my own work except each statement and passage already described the sources"

Signature : ……………………….

Author : Naemah Binti Ayub

Date : 16 May 2011

I would like to dedicate this report especially to my mom and dad, family and my friends.

ACKNOWLEDGEMENT

In the name of Allah, the most Gracious and most Merciful,

I am really grateful as I have completed this Projek Sarjana Muda (PSM) with help and support, encouragement and inspirations by various parties. All knowledge and information that they give are really helpful. Here I would like to express my gratitude to Dr. Hady Efendy for all his supports, comment and advices during completion of this project and thank you very much for becoming my supervisor.

I also would like to thanks my beloved parent and family who have giving me support and motivation throughout my project. I am very appreciating their understanding towards my commitment to finish this project. I also like to thank all my friends for their help and support in completing my PSM. Finally, thanks to the people around me, who has giving support directly or indirectly for the contribution in this work.

ABSTRACT

In this work, a non-asbestos friction material was developed using an agro-waste material base which is palm kernel shell (PKS), along with other constituents. This was with a view to exploiting the characteristics of the PKS, which are largely deposited as waste from palm oil production, in replacing asbestos which has been found to be carcinogenic. Five sets of brake pads with identical ingredients which using PKS as a base materials were produced following the standard procedure employed by the manufacturers. The properties of the brake pads with different PKS and aluminum oxide composition were then evaluated and tested using American Society for Testing and Materials (ASTM) testing standard while the microstructure were analyzed using optical microscope. PKS was better than the asbestos-based brake-pad in terms of lower specific gravity; lower percentage swelling, when wet; higher heat resistance, heat dissipation and coefficient of friction. Therefore, PKS is suitable for use as a material for friction material in automotive brake pad. Further study would enhance the value of PKS as an alternative material replacing the asbestos as a friction materials.

ABSTRAK

Dalam kajian ini, bahan geseran tanpa asbestos dibangunkan menggunakan bahan buangan pertanian iaitu tempurung kelapa sawit (PKS) sebagai bahan asas bersama bahan-bahan lain. Hal ini bermaksud, mengeksplotasi ciri-ciri yang ada pada PKS dimana ia merupakan sebahagian besar bahan buangan daripada pengeluaran minyak kelapa sawit bagi menggantikan penggunaan asbestos yang membahayakan kesihatan. Lima set pad brek dihasilkan megikut procedur piawaian dari pengilang dengan menggunakan bahan yang telah dikenalpasti dan PKS sebagai bahan asas utama produk. Ciri-ciri Pad brek yang mempunyai komposisi PKS dan aluminum oksida yang berbeza kemudian dinilai dan diuji dengan piawaian "American Society for Testing and Material" (ASTM), manakala struktur mikronya dikaji dengan menggunakan mikroskop pengimbas electron (SEM) dan mikroskop optik. PKS mempunyai ciri-ciri yang lebih baik berbanding bahan geseran yang berasaskan asbestos dari segi spesifik gravity yang rendah, kadar peratusan pengembangan yang rendah apabila basah, lebih tahan panas, depitasi haba tinggi serta mempunyai pekali geseran yang tinggi. Oleh sebab itulah ia sesuai sebagai bahan geseran dalam pad brek automotif. Kajian lanjut akan meningkatkan nilai PKS sebagai bahan alternatif bagi menggantikan asbestos.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

BOR	=	Modulus of rupture (kg/cm^2, N/mm^2)
W	=	Force (kg, N)
L	=	distance between 2 speciment supports (cm, mm)
b	=	Speciment width (cm, mm)
d	=	Speciment thickness (cm, mm)
D	=	Weight dry sample (after drying temperature 110^{o}C) (kg, gr)
W	=	Weight sample (kg, gr)
S	=	Weight wet sample after dipping into water at 24 hous (kg, gr)
ΔW	=	weight difference
V	=	Volume (m^3, cm^3)
ρ_O	=	initial density
ρ	=	density after crushing process
m	=	mass

CHAPTER 1

INTRODUCTION

1.1 Background

Brakes are one of the most important safety and performance components in automobiles. The major component in the brake pad is the lining materials, which are categorized as metallic, semi-metallic, organic and carbon-based, depending on the composition of the constituent elements.

Palm plantations in Malaysia is very broad and many factories that process the oil every day. Palm kernel is a material that is used in the production process, so that the tons of palm waste can be produced each day. Palm kernel shell waste has the physical characteristics and good mechanical hardness and density of high and low water absorption [12]. From these properties it has the potential of palm as an alternative to fiber reinforcement material of friction material non-asbestos brakes on canvas manufacture motorcycles. Two important factors in the manufacture of friction materials are to have a good friction performance and the price is relatively cheap.

In general, the main substances in friction materials consist of fibers, fillers and binder. The binder consisting of various types of resins such as phenolic, epoxy, silicone and rubber. The resin serves to bind the various constituent substances in the friction material. Binder can form a matrix at relatively stable temperature. Powder work to increase the coefficient of friction and increase mechanical strength of materials. For example glass, aramid, potassium titanate, copper, brass, steel, stainless steel and rock wool, Cu-Zn, Cu-Sn, Zn, Fe and Al. Solid lubricant usually added to the friction material to prevent micro-stick against the rotor. Some solid lubricant on the market such as graphite, MoS_2, Sb_2S, Sn_2S, PBS, ZnS and mica. To modify the level of friction and motor surface cleaning abrasive materials such as $Al_2O_{3,}$ SiO_2, MgO, Fe_3O_4, Cr_2O_3, SiC, $ZrSiO_4$ and kianit/Al_2SiO_5 (Lu Y, 2001) added. This abrasive is also used to control the wear rate and stabilize the friction coefficient. They are divided into two main categories: (i) lubricants, which decrease the friction coefficients and wear rates, and (ii) abrasives, which increase friction coefficients and wear rates. It is also important to note here that certain frictional additives may be loosely regarded as fillers by certain manufacturers if they are present in large quantities. As their name suggests, frictional additives affect the frictional characteristics of brake friction materials greatly. Filler material is used to improve the production process and acts as a lubricant. These filler materials consist of two types of organic materials and inorganic filler. Organic fillers such as CNSL (Cashew Nut Shell Liquid/ oil), dust and crumb rubber while inorganic fillers such as vermiculate, $BaSO_4$, CaCO, $Ca(OH)_2$ and MgO (Robinson, JW et al, 1990).

Manufacture of friction materials must contain the type of building block of which consists of binder, fiber materials and filler materials. Friction materials in the structure containing metal powders called semi metallic friction materials. Further friction materials in the structure contains asbestos which is asbestos friction material, while that does not contain asbestos is asbestos-free friction materials. More than 33 countries like USA, UK, Columbia, Japan, China and other countries have banned the use of asbestos as a friction material, because of it weakness that can cause cancer risk for workers and users (Jacko, 2003). In the semi metallic friction materials, the addition of metal content aimed at increasing the coefficient of friction often causes damage to the vehicle tromol. Therefore, the palm waste can be used as an alternative to reinforce fiber friction materials.

Fiber in the composition of friction material is very influential on his strength. Effect of interaction between the raw materials can be determined experimentally. The model formulation consists of two component of binder (binder) and ingredients (materials) are the best way to understand some of the effects of performance friction material. The model formulation consists of three components of a binder and two ingredients is a simple way to determine the effect of interaction between the two materials. Anderson (1967) and Dong (1996) using a mixture of two phenolic bond to assess lapinus cashew and fiber. This approach will result in the combination formulation for selecting the material system used in the formulation of brake material Friction Assessment and Screening Test (FAST).

1.2 Objectives of the Research

The research objective was to determine the optimum content of palm waste powder on the friction material in the manufacture of motorcycle brake pad and to determine the effect of composition on physical properties (structure and topography of the surface) and friction materials mechanical properties (hardness and wear).

Specifically, the objectives to be achieved from this research are:

1. To prepare sample of brake pad materials with reinforcement of powder from palm waste.
2. To study the characteristics of palm waste and a powder product from palm waste in brake pad products including; mechanical properties (compression and bending strength), density, porosity, particle bonding and surface structure.
3. To apply skill powder form palm waste for powder reinforced in motorcycle brake pad products.
4. To study the characteristics of the matrix that forms the brake pad product, including aggregate in combination with carbon, resin and oxide by experiment.

1.3 Scope

This final project research was done by limiting the problem as follow:

- Research conducted at the Laboratory of Materials Science UTeM.
- Material used is Palm Kernel Shell.
- Binder types used is Phenolic Resin.
- The process of curing in this research was done by steam curing method.

- Testing of the mechanical properties of friction materials with various composition and palm kernel shell that include specific gravity, compressive strength, and flexural strength.
- Testing of the physical properties include density and porosity testing.

1.4 Problem statement

The need of alternative material to replace asbestos base materials use in manufacturing of friction materials has rapidly increasing lately. This is due to the awareness of health risk of using asbestos that can be harmful to human. New materials must be develops to replace asbestos. As we know, in Malaysia the Palm oil plantation is one of the biggest industries that produce tons of waste which can be sources of an organic friction material. Used of palm waste as an alternative materials has been seen as a good replacement of the asbestos.

CHAPTER 2

LITERATURE REVIEW

2.1 Friction Materials

Friction material is material attached to the brake shoe that wears against the inside of the brake drum to slow and stop the vehicle. The friction between the brake pads and rotor is the key to stopping in a disc brake system. Eventually, however, the rubber shoes of a bicycle and the brake pads of a car will wear down and severely compromise the operator's safety [32].

Brake pads as shown on figure 2.1 were originally made with organic ingredients such as asbestos and carbon, held together by a strong resin. The use of asbestos was eventually banned, but some non-metallic or organic brake pads are still sold. Only vehicles designed for organic brake pads can use them, however. The same material used in bulletproof vests, Kevlar, has replaced asbestos in non-metallic brake pads due to it good physical and mechanical properties.

Most of brake pads sold today are considered semi-metallic. Manufacturers often guard their actual formulas, but in general semi-metallic brake pads use copper, brass and steel wool shavings held together in a resin. Because they are primarily metallic, these brake pads can last for thousands of miles. Their main drawback for drivers is a higher incidence of grinding noises. This is largely unavoidable since the metal shaving must rub against steel rotors every time the brakes are applied. Some after-market brake pads are marketed as quieter than the standard semi-metallic brands. Good friction materials must fulfill these criteria which are:

- The two materials in contact must have a high coefficient of friction.
- The materials in contact must resist wear effects, such as scoring, galling, and ablation.
- The friction value should be constant over a range of temperatures and pressures
- The materials should be resistant to the environment (moisture, dust, pressure)
- The materials should possess good thermal properties, high heat capacity, good thermal conductivity, withstand high temperatures
- Able to withstand high contact pressures
- Good shear strength to transferred friction forces to structure
- Should be safe to use and acceptable for the environment.

Figure 2.1: Brake Pad

2.2 Material

2.2.1 Asbestos

Friction materials were made from many type of material. Friction material was developing rapidly as fast as the technology change. Asbestos become the major material for friction material composition over eight decade and become more widespread during the industrial revolution in 1866. Asbestos were from Greek word which mean "unquenchable" or "inextinguishable” is a set of six naturally occurring silicate minerals exploited commercially for their desirable physical properties. They all have in common their asbestiform habit, long, (1:20) thin fibrous crystals.[18] Long term exposure to asbestos is more likely to cause health problems, as asbestos exists in the ambient air at low levels, which itself do not cause health problems. The inhalation of asbestos fibers can cause serious illnesses, including malignant lung cancer, mesothelioma (a formerly rare cancer strongly associated with exposure to amphibole asbestos), and asbestosis (a type of pneumoconiosis).[19] Asbestos became increasingly popular among manufacturers and builders in the late 19th century because of its sound absorption, average tensile strength, and its resistance to heat, electrical and chemical damage but due to it health risk the need of material to replace it was increasingly developed.

Figure 2.2: Asbestos

2.2.2 Kevlar or Aramid

The use of non-metallic friction material seems to become the solution for the asbestos friction material. Friction material made from Kevlar or aramid fiber. Aramid fiber (a generic expression denoting fiber made from the condensation product of isophthalic or terephthalic acids and m-or p-phenylenediamine such as Kelvar fibres are also widely used as reinforcing fiber, but they are a different class of fiber in that they are relatively soft fiber. They are very light and exhibit excellent thermal stability, with a very good stiffness to weight ratio. According to Smith and Boydof R.K. Carbon Fiber, aramid fibers have superior anti-fade properties compared to asbestos. Aramid fiber in pulp form have also been utilized in maintaining the uniformity of the brake pad material mixture during the processing of a moulded brake pad. Another property they have is that of superior wear resistance. Due to their relative softness, however, it is unlikely that they will be the only fiber supporting the braking load; there would most probably be other harder fiber such as metallic fiber in the friction lining.

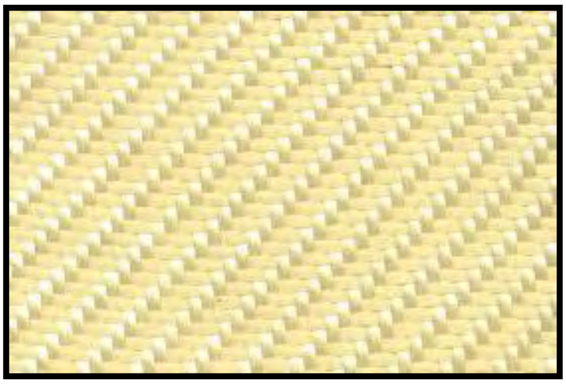

Figure 2.3: Kevlar friction material

2.2.3 Fibertuff

Fibertuff is a product designed to give the wear of a ceramic facing, yet have the engagement and disengagement qualities of an organic material. Fibertuff intended to wear against its mating surfaces like organic material. Used primarily in the stamped steel and 14"cast units, this product offers greater life than organic material with many of the same qualities that organic friction has traditionally offered. Around-town delivery trucks and mid-range applications find that this product works best.

Figure 2.4: Fibertuff

2.2.4 Ceramic

Ceramic fibers are a relatively new addition in brake pads compared to metallic fibers such as steel. They are typically made of various metal oxides such as alumina (aluminium oxide) as well as carbides such as silicon carbide. With a high thermal resistance (melting points ranging from 1850 to 3000 °C), lightweight and high strength, they are very suitable as reinforcing fibers.[30] Their high strength weight ratio means that they are preferred over metallic fibers, which are much heavier. Not only are they used in brake pads, they are also used to reinforce brake discs as well. In one instance, aluminium brake discs were reinforced by ceramic fibers because the wear rates encountered when using aluminium brake discs against conventional friction materials are unacceptable.

Figures 2.5: Ceramic

Table 2.1: Mechanical Properties of Material (Dagwa, 2005)

Material Combination	Coefficient of Friction		Temp.(max)	Pressure (Max)
	Wet	Dry	Deg.C	MPa
Cast Iron/Cast Iron	0,05	0,15-0.2	300	0,8
Cast Iron/Steel	0,06	0,15-0,2	300	0,8-1,3
Hard Steel/Hard Steel	0,05	0,15-0,2	300	0,7
Wood/Cast Iron-steel	0,16	0,2-0,35	150	0,6
Leather/Cast Iron-steel	0,12-0,15	0,3-0,5	100	0,25
Cork/Cast Iron- Steel	0,15-0,25	0,3-0,5	100	0,1
Felt/Cast Iron- Steel	0,18	0,22	140	0,06
Woven Asbestos/Cast Iron- Steel	0,1-0,2	0,3-0,6	250	0,7
Moulded Asbestos/Cast Iron- Steel	0,08-0,12	0,2-0,5	250	1,0
Impregnated Asbestos/Cast Iron-Steel	0,12	0,32	350	1.0
Carbon-graphite/Cast Iron- Steel	0,05-0,1	0,25	500	2.1
Kelvar/Cast Iron- Steel	0,05-0,1	0,35	325	3,0

2.2.5 Palm Kernell Shell

Palm oil is a versatile product which competes with other oils and fats. Production amounts to over eight million tonnes world-wide, over half of which is produced in Malaysia. As a result of the oil palm fruit, about two million tonnes of kernel shells are produced. Existing uses for the shells are fuel for boilers in extraction mills and as filler in the making of roads. However use of the raw shells as fuel other than in the mills is hampered by factors such as transport costs. There is still a large amount of shells left over and the disposal problems that these often present has prompted enquiries from the Forest Research Institute of Malaysia (FRIM), Sime Darby, Guthrie Harrison and Niger Carbon as to possible uses for them.

Palm Kernel Shell (PKS) is recovered as by-product in palm oil production. Although, PKS must be ground into fine particles to be suitable for inclusion in brake lining, available information in the literature are on the ungrounded shell particles. Coefficients of friction of PKS on metal surfaces were in the range of 0.37-0.52 (Koya et al., 2004). In contrast, friction coefficient in the range of 0.30-0.70 is normally desirable when using brake lining material (Roubicek et al., 2008). It has been found (Teo, 2006) that incorporation of PKS in the production of structural light weight concretes increased the mechanical strength. Thus, PKS appeared suitable for use as base material in friction composites, because they are subjected to hard and variable braking forces. Akporhonor et al. (2007) reported that PKS did not change significantly in physical structure and weight, for appreciable time duration, when exposed to organic solvent. It is also important that the friction materials experience very little or no changes on contacting varying environmental conditions: wet or dry weather, or hydraulic fluid spilling over. These observations therefore, stimulated the interest in considering PKS for use as friction material in brake lining.

Figure 2.6: Palm Kernell Shell