Journal of King Saud University – Engineering Sciences (2016) 28, 110–118

King Saud University

Journal of King Saud University – Engineering Sciences

www.ksu.edu.sa
www.sciencedirect.com

ORIGINAL ARTICLE

Evaluation of palm kernel fibers (PKFs) for production of asbestos-free automotive brake pads

K.K. Ikpambese *, D.T. Gundu, L.T. Tuleun

Department of Mechanical Engineering, University of Agriculture, p.m.b. 2373, Makurdi, Nigeria

Received 12 August 2013; accepted 6 February 2014
Available online 18 February 2014

KEYWORDS
Brake pads;
Friction coefficient;
Palm kernel fibres;
Wear rate;
Asbestos

Abstract In this study, asbestos-free automotive brake pads produced from palm kernel fibers with epoxy-resin binder was evaluated. Resins varied in formulations and 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 were investigated. Other basic engineering properties of mechanical overload, thermal deformation fading behaviour shear strength, cracking resistance, over-heat recovery, and effect on rotor disc, caliper pressure, pad grip effect and pad dusting effect were also investigated. The results obtained indicated that the wear rate, coefficient of friction, noise level, temperature, and stopping time of the produced brake pads increased as the speed increases. The results also show that porosity, hardness, moisture content, specific gravity, surface roughness, and oil and water absorption rates remained constant with increase in speed. The result of microstructure examination revealed that worm surfaces were characterized by abrasion wear where the asperities were ploughed thereby exposing the white region of palm kernel fibers, thus increasing the smoothness of the friction materials. Sample S_6 with composition of 40% epoxy-resin, 10% palm wastes, 6% Al_2O_3, 29% graphite, and 15% calcium carbonate gave better properties. The result indicated that palm kernel fibers can be effectively used as a replacement for asbestos in brake pad production.

1. Introduction

Brake pads are used in the braking systems of automobiles and other vehicles and machines to control the speed by converting kinetic energy of the vehicles to heat which is dissipated to the atmosphere. Brake pads are steel backing plate with friction material bound to the surface facing the disc (Idris et al., 2015). The demands on the brake pads are such that they must maintain a sufficiently high friction coefficient with the disc; not decompose or break down in such a way that the friction coefficient with the brake disc is not compromised at high temperatures; exhibit a stable and constant friction coefficient with the brake disc (Efendy et al., 2010).

According to Idris et al. (2015) brake pads generally consist of asbestos embedded in the polymeric matrix along with several other ingredients. That the use of asbestos is being avoided

* Corresponding author. Tel.: +234 7036850364.
E-mail address: kikpambese@yahoo.com (K.K. Ikpambese).
Peer review under responsibility of King Saud University.

ELSEVIER Production and hosting by Elsevier

1018-3639 © 2014 Production and hosting by Elsevier B.V. on behalf of King Saud University.
http://dx.doi.org/10.1016/j.jksues.2014.02.001

due to its carcinogenic and harmful nature new asbestos free materials and brake pads have been developed.

Agricultural residues or wastes are now emerging as new and inexpensive materials in the brake pads' development with commercial viability and environmental acceptability. Idris et al. (2015) produced an eco-friendly asbestos free brake pads using banana peels and the findings concluded that banana peels can be effectively used as to replace. Namessan et al. (2012) developed brake pads from kenaf (*Hibiscus canabinus*) fibres, using different treatments. Koya and Fono (2010) developed automotive brake pad using palm kernel shell following the standard procedures employed by commercial manufacturers and the result obtained showed that the properties of palm kernel shell based brake pad wholly satisfied the recommendation of the Standard Organization of Nigeria (SON).

Also, development of asbestos-free brake pad using bagasse was reported by Aigbodion et al. (2010). Ibhadode and Dagwa (2008), developed asbestos-free friction lining materials from palm kernel shell and when compared with a premium asbestos-based commercial brake pad they were found to perform satisfactorily. Palm slag was also employed by Ruzaidi et al. (2011) for the production of brake pads; results indicated that palm slag can be used effectively as an alternative to in brake pad composites.

This research paper aims to evaluate properties of asbestos – free automotive brake pads produced from palm kernel fibres and to compare it with the commercial brake pad.

2. Materials and methods

2.1. Preparation of the raw materials

Palm kernel fibers (PKFs) were collected and suspended in a solution of caustic soda (sodium hydroxide) for twenty four hours to remove the remnant of red oil left after extraction. The fibers as shown in Fig. 1 were then washed with water to remove the caustic soda and sun dried for one week. The dried PKFs was grounded into powder form using a Hammer mill and was thereafter sieved using sieve size $\leqslant 100\ \mu m$ aperture.

2.2. Characterization of palm kernel fibre

The elemental composition of the PKFs was determined using X-Ray Fluorescence (XRF) machine. The powder sample of PKFs was initially pulverized using Agate/pestle. Pulverization of the sample was necessary to ensure homogenization of the sample. A measured mass of 5 g of pulverized PKFs was formed into pellets in a pelletizer with hydraulic press. Pelletization was done to aid the removal of voids between the particles of the sample and to ensure a better interaction of the sample with the primary X-ray from the x-ray tube which excites the atoms in the sample giving x-rays flouresence/characteristics. The pellets were sealed into the chamber of the XRF (Amptek Inc) and allowed to run for 1000 s at a voltage of 25 kV, and a current of 50 μA and excited by the primary x-ray source from the x-ray tube. The x-ray detector inclined at 90° to the primary x-ray source picks up characteristic x-rays which were amplified and the signal from the amplifier was processed by multichannel analyzer and relayed to the computer where the data was acquired by the appropriate software. The acquired data was then analyzed using Axil customized software for the determination of the elemental composition of the materials.

Figure 1 Fibres of palm kernel.

Figure 2 The produced brake pads.

2.3. Development of the brake pad

The production of brake pad consists of a series of unit operations including mixing, cold and hot pressing, cooling, postcuring and finishing (Koya and Fono, 2010).

The sieve size of 100 μm of PKFs was added in varying percentages to aluminium oxide, calcium carbonate and epoxy resin (Table 1) based on 176 g weight of commercial brake pad. The combinations were separately dry-mixed using a blender in order to achieve a homogeneous state ready for molding.

The mixtures for each of the formulations were separately transferred into a designed mould placed on the backing plate obtained by removing the friction materials on the used commercial brake pad. The mould containing the friction materials

Table 1 Additives used for brake pads production from palm kernel fibre (PKFs).

Brake additives	Samples in percentage weight (% wt)					
	S_1	S_2	S_3	S_4	S_5	S_6
Epoxy resin	15	19	23	25	30	40
Palm kernel fibres (PKFs)	35	6	27	30	40	10
Aluminium oxide	5	0	10	5	5	6
Graphite	5	5	10	5	5	29
Calcium carbonate	40	70	30	35	20	15