Assessment of Agricultural Waste for Production of Break Pads

Olumodeji, *J.O
*Department of Mechanical Engineering
Federal Polytechnic Ado-Ekiti, Nigeria.

Abstract

The following operating properties, these are mechanical properties, wear and frictional values for the three types of brake pads tested namely: coconut brake pads, palm kernel brake pads and imported brake pads were investigated and presented. The comparisons of the results of the palm kernel pads and coconut pads with the imported pads suggest that palm kernel pads can be used as a possible alternative to the imported pads.

Keywords: Wear, friction, brake pad, hardness, compression loads.

1.0 INTRODUCTION

A braking system is a system which transforms the total kinetic energy of a vehicle into generated heat energy as result of friction interface in a rapid controlled manner, thereby slowing it under a variety of loads, speed and climatic conditions. Friction materials are the key elements in vehicle foundation's brakes Newcomb et al (1969) and normally takes the form of pads or linings, which operated against a rotor, which may be a drum or disc. These friction materials East (1988) range over a wide variety of organics with mineral fibres, resin bonded metallic, sintered metallic and combinations of metallic with ceramics in form of asbestos. Automotive friction materials must satisfy requirements Malelland (1988) of good wear resistance for prolonged wear life; and stable braking friction force over a wide range of operating speeds, pressures, temperatures etc, high durability, easy of manufacture and inexpensive.

There are five main constituents in the compositions of friction materials namely: fibres, abrasives, lubricants, fillers and organic materials. Lonely (1988). Each constituent has a primary role to play in the performance characteristics of the friction materials, but each also has secondary effects or may perform a dual role. The fractional volumes of each constituent's composition can be varied from formulation to formulation, giving each its own particular performance characteristics. Various proportions of each constituent's compositions can result into families of friction materials with different particular performance and frictional characteristics.

The aim of the present research work is to produce brake pads from waste agricultural materials such as palm kernel and coconut shells, as the basic main materials plus other locally available materials. Experimental tests such as wear, compression, hardness, static and dynamic co-efficient of friction tests are conducted and presented on the developed brake pads with palm kernel and coconut shells pads and imported brake pads. The results of these developed brake pads are then compared with those of imported brake pads.

2.0 METHODOLOGY

2.1 Materials Used and Pads Production

2.1.1 Materials Used: The materials used for the production of the developed brake pads are: grounded palm kernel shell powder, grounded coconut shell powder, as an abrasive basic main materials and fillers, latex rubber as a solvent, and binder, cement, as a binder to improve thermal stability, with carbon black powder, as colouring agent and lubricant. Palm kernel and coconut shells were crushed, using a hammer mill and later grounded to powder. The grounded palm kernel and coconut powders were later sieved to finer particles by using a 500µm sieve before use. Natural rubber (latex) used are obtained from tree plants in the South West Nigeria.

The physical properties of the two major agricultural wastes used, as the main production materials are given in Table 1. Ibeto disc brake pads TT504 Ref

4427.50 Union Brand containing asbestos were made in France by Ibeto brake pads were used as standard pad in the present investigations:

Table 1: Physical properties of Palm Kernel and Coconut shells

Material	**Colour**	**Shape**	**Grounded Powder (Density) (kg/m^3)**	**Ungrounded Shell (Density) (kg/m^3)**	**%max. particle retained/sieve no.**
Palm kernel	Dark Brown	Hollow, irregularly small curved shape	0.707	1.56	45.93(150µm)
Coconut shell	Brown	Irregular large curved shape	0.514	1.74	46.9 (75µm)

2.1.2 Brake Pads Production Method: These materials, namely palm kernel shell powder, cement, latex rubber and carbon black powder were thoroughly mixed properly together to obtain a uniform mix, which was later heated in an electric oven to a temperature of 130^{0}C with intermittent mixing. The ratios of the palm kernel shell powder to cement to latex rubber to carbon black powder by mass were 10:10:10:1 were found to give the best trial mixing results and therefore used throughout this investigation. After heating and soaking at 130^{o}C, the heated mixed product materials were put inside the steel mould with the brake pad backing plate in position. A compressive force of 30KN was applied through the punch by a hydraulic press for a period of about 8 minutes, so as to fully compact it to its final shape and strength. After the brake pad had been removed from the pad steel mould, it was later re-heated or cured in an electric oven at a lower temperature of

80^0C for one hour to achieve the best quality and strength of the brake pad. Similar procedures were carried out by using coconut shell powder in place of palm kernel shell powder to produce other brake pads tested for.

2.2 WEAR TEST AND PAD MOULD RIGS:

2.2.1 Wear Test Rig

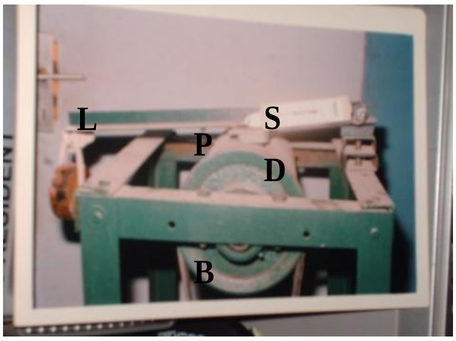

Figure 1: Top parts of the Wear Test Apparatus.

Figure 1. shows the top view of the wear test rig with the following component parts, namely: a pulley/belt drive B, connected to a 0.746KW single phase electric motor, a highly polished steel surface of a rotating drum D, a brake pad, P, pressed against the rotating drum by a compression lever, L, with hanging weight, W and a sensitive spring balance, S, for measuring the dynamic friction forces.

A special soft-ware package [5] written in Visual Basic called "Elements" was used to design for the dimensions of the shaft connected to the rotating drum, D, pulley/belt drive, B, and bearings and keys used to support and to fasten respectively the rotating shaft to the pulley. Abioye (2001).

2.3 EXPERIMENTAL METHODS:

2.3.1 Wear Test:

A brake pad of say mass, m_o, was carefully positioned on a suitable space on the compression lever and later placed on surface of the rotating drum (see figure 1). A known mass was suspended from the end of the compression lever to produce a typical applied pressing force of 54.6N. At the end of any on the brake pad and the rotating drum surfaces. The test wear rig was operated with the brake pad making contact with the surface of the rotating drum at a constant speed of 500rev/min under a pressing force 54.6N. At the end of any pressing time, t, minutes, the current mass, m, of the brake pad was measured, using a digital top loading mass balance of maximum capacity of 500gm and sensitivity of 0.01gm. The difference (m_o-m) gave the wear after a given pressing time, t, minutes. The % wear after a pressing time, t, say 60 minutes under a pressing force of 54.6N can be evaluated as

$$\frac{m_0 - m}{m_o} \times 100.$$

The recorded values of the wear and %wear were based on the average values of three readings. The above procedures were used to obtain the wear and % wear for the palm kernel shell brake pads, the coconut shell brake pads and the imported brake pads.

2.3.2 Compression Test

The brake pads were suitably arranged on the platen of a hydraulic compression testing machine. The hydraulic compression machine was operated to come in contact with the pads and a dial gauge indicator on a magnetic base carefully positioned to contact the ram of the hydraulic testing machine.

During the brake pad compression test, the applied compressive forces were recorded with corresponding displacements of the dial gauge indicator readings. The compression tests were carried on until the pads failed or fractured and the maximum forces were determined from the compressive forces versus compressive displacement curve for each type of brake pads tested.

2.3.3 Hardness Test

The brake pad was placed on the adjustable table, of the Brinell hardness testing machine and adjusted until the pad made contact with the impression ball of the Brinell hardness testing machine. Hardness tests were conducted on each type of brake pad on the Brinell hardness testing machine, under a force of 100Kgf with a 0.5mm steel ball indenter. The recorded hardness number was based on the average of readings of five impressions made on each type of brake pads investigated.

2.3.4 Dynamic Co-efficient of Friction Determination

A spring balance, S, graduated in Newtons was attached to the wear test pad specimen, P, to give the readings of the kinetic frictional forces, F_k, under varying applied normal pressing forces, to a maximum of 54.6N (see Figure 1). The average kinetic frictional forces, F_K, over a given period of time was recorded for any given normal pressing force, N. By varying the hanging weight, W, suspended at the end of the compression lever, the applied normal pressing forces N, with the corresponding kinetic frictional forces, F_K, were recorded. The dynamic co-efficient of friction was determined from the slope of graph of kinetic frictional forces, F_K, versus applied normal pressing force. N.

2.3.5 Static Co-efficient of friction

The static coefficient of friction was determined experimentally by using the brake pad fixed under a hollow wooden box of known mass on a cast iron plate. The limiting friction force, F, to just move the pad and wooden box (normal reaction, R) was determined through a string and pulley/scale pan arrangements. By adding known masses to the inside of the hollow wooden box, the normal reactions, R, were varied and their corresponding limiting friction forces, F were determined by adding suitable masses to the scale pan. From a plot of limiting friction forces, F, versus the normal reactions, R, the slope of the graph gave the static coefficient of friction between the cast iron and brake pad.

3.0 RESULTS AND DISCUSSION

Table 2: Operating properties of Coconut pad, Palm kernel pad and Imported pad.

Types	Average Hardness (Hv)	Maximum Compressive Load (KN)	Wear (after 1hr) (gm)	Static Co-efficient of Friction μ	Dynamic Co-efficient of Friction μK
Palm Kernel Pad	17	160	1.17	0.385	0.275
Coconut Pad	15	140	2.0	0.370	0.275
Imported Pad	23	180	0.5	0.310	0.240

Table 2 gives the operating properties of the coconut pads, palm kernel pad and imported pads. From the compression tests, the maximum compression loads before failure for coconut pad, palm kernel pad and imported pads are respectively 140KN, 160KN and 180KN. The average hardness values for coconut pad, palm kernel pad and imported pad are respectively 15, 17 and 23HV. It can be seen that the higher the hardness value of the pad, the greater the maximum compression loads (see Table 2).

Figure 3, shows the histogram showing the % wears for coconut pad, palm kernel pad and imported pad under an applied pressing force of 54.6N over a period of 1 hour at an operating speed of 500rev/min. From Table 2 and Figure 3, it can be observed that the % wear or wear of the three types of brake pads tested under a pressing force of 54.6N over an operating time of 60 minutes indicated coconut pads to have the highest % wear (1.1%) followed by palm kernel pads (0.62%), while the imported pads have the least % wear of 0.23%. The % wears for the three types of pads tested are also found to depend or correspond to the hardness value of each type i.e. the higher the hardness value of the pad, the lower the % wear of the pad over the operating time of one hour investigated.

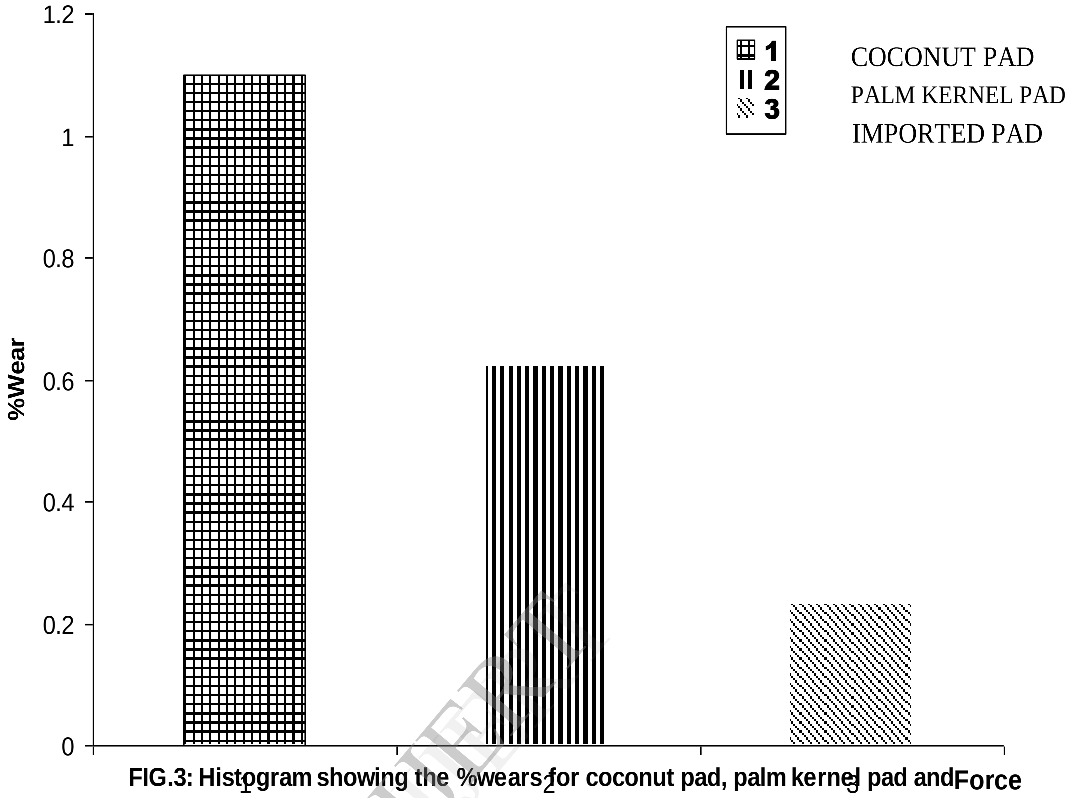

FIG.3: Histogram showing the %wears for coconut pad, palm kernel pad and imported pad under the applied pressing force of 54.6N over a period of 1hr at a speed of 500rev/min

From Table 2, the values of the static coefficient of friction between the tested pads and cast iron are highest for palm kernel pads (0.385), followed by coconut pad (0.37) and least for imported pads (0.31). The values of the static coefficient of friction are influenced by the degree of surface finish of the various tested pads of which imported pads are of better surface finish. From Table 2, the values of the dynamic coefficient of friction for coconut and palm kernel pads are the same (0.275) with imported pads still giving a least value of 0.240.

4.0 CONCLUSION

(a) From the comparisons of the results of the tested types of pads investigated at the given operating conditions, it can be concluded that the imported pads give better operating properties, as regarded to hardness value, maximum compression loads and % wear, but with frictional properties, coconut and palm kernel pads are better than imported pads.

(b) The comparisons of the results of the palm kernel pads and coconut pads with the imported pads, suggest that palm kernel pads can be used as a possible alternative to the imported pads.

5.0 ACKNOWLEDGEMENT

One of the authors wishes to acknowledge the Department of Mechanical Engineering, Federal Polytechnic, Ado-Ekiti, Nigeria for making facilities/equipment available for the project research investigations.

6.0 REFERENCES

Abioye, A.M (2001) "Design of Engineering Power Transmission Elements using Visual Basic" M. Eng. Research Project Report, Department of Mechanical Engineering, University of Ilorin, Ilorin, Nigeria.

East, R.G. (1988) "Evolution of friction materials for commercial vehicle disc brakes" Proc. of the Institute of Mechanical Engineers. C450/88. p1

Lonely, J.W (1988) "Some compositional effects in the static and dynamic properties of commercial vehicle disc brakes" Proceeding of the Institute of Mechanical Engineers, C453/88 p.32.

Malellan, R.G. (1988) "Requirements of friction materials in commercial brake applications" Mintex Don Limited, Cleckheaton, West Yorkshire, U.K

Newcomb T.P and Spur R.T (1969) "Automotive brakes and braking systems" Chapman and Hall, London, U.K.