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Development of Brake Pad for Automobile Using Organic Wastes as Reinforcement Material

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Abstract. In this work, locally sourced organic wastes were used to produce brake pad using Taguchi experimental design. Organic wastes selected for production include seashell and snot apple fiber while graphite, ceramic wastes and araldite were used as friction modifier, abrasive and binder respectively. Nine samples were produced using Taguchi design technique by varying percentage composition and adopting constant process parameters. Sample characterization was carried out by investigating the tribological properties (wear rate and friction coefficient). The experimental findings revealed that optimal wear rate of the developed brake pad can be obtained using seashell (105.5g), snot apple fiber (4.5g), araldite (50g), ceramic (24g) and graphite (22g) while the optimal friction coefficient can be obtained using seashell (96g), snot apple fiber (4g), araldite (40g), ceramic (20g) and graphite (22g). Based on the results obtained, it can concluded that the selected organic wastes can effectively serve as reinforcement materials in the production of brake pads.

Keywords. Reinforcement, binder, friction, abrasive, brake pad

1. Introduction

Brake pads are heterogeneous material composed of different elements with each constituent element having its own functions which include improvement of frictional properties at low and high temperature reduce noise prolong life, increase strength and rigidity as well as reduce porosity [1]. Dagwa and Ibhadode [2] have revealed that changes in the weight percentage or types of elements in the brake pads formulation may result to the alternation of the chemical, mechanical and physical properties of the brake pad materials developed. Over the years asbestos have been used as reinforcement materials in the development of brake pads for automobile. However, due to the carcinogenic nature of the material, it has lost favour. Hence, there is need to find a possible replacement for asbestos. Several materials have been used as substitute

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for asbestos in the development of brake pad using non-hazardous reinforcement materials [3].

In addition, Ole–Von et al. [4] have revealed that the use of antimony as friction modifier in commercial brake pads posed a human cancer risk due to considerable concentrations of Sb in the material. As a result, there is also need to find new friction modifier such as graphite in the development of brake pad material with commercially viability and environmental acceptability.

Garcia et al. [5] have utilized rice husks as reinforcement material and revealed that the agricultural product can be utilised as filler in brake pad production. Nakagawa et al. (2015) also utilized metal fibres in the production of brake pads so as to counter the environmental pollution caused by asbestos and revealed that it performed effectively. Though, poor resistance to corrosion was recorded which may be attributed to the presence of the metal particles in the composite. In addition, Abutu et al. [3] and Abutu et al. [6] have utilized coconut shells and seashell respectively as reinforcement material and found that the two performed better when compared with a commercially available brake pads. Also, Lawal et al. [7] utilized grinded waste tyre scrap (rubber) as reinforcement materials and found that the formulated optimal sample degraded between 149.9 and 478.4 °C, with a peak degradation at temperature at 394.8 °C. Therefore, in this work, a brake pad will be developed using seashell and snot apple fiber as reinforcement materials and thereafter characterized by investigating the tribological properties.

2. Materials and Methods

This section deals with the experimental methods and details of the materials used for the conduct of the research.

2.1. Materials

In this work, seashells sourced from Lagos bar beach-Nigeria and snot apple fiber obtained from Numan-Adamawa State were used as reinforcement material while graphite obtained used 1.5V dry cells and ceramics gotten from damaged ceramic products were used as friction modifier and abrasive respectively. Also, araldite (VISA: Modified Acrylic Adhesive) was used binder.

2.2. Preparation of Constituent

The seashells and graphite used in this study were prepared by washing, drying for three days, crushing into smaller pieces, grinding into powder using a grinding machine and sieving with a mesh size ≥125 µm. However, the graphite rods were extracted from used 1.5 volts batteries using pliers. In addition, the snot apple fibers were washed using sodium hydroxide (NaOH), dried for a period of three days, and cut into length of 1mm.

2.3. Design of Experiment

In this study, Taguchi ($L_9 3^4$) was utilized for experimental design. The factor levels utilized in this study include reinforcement (100-120g), binder (40-60g), abrasive (20-28g) and friction modifier (10-22g). Also, the experimental design matrix obtained using Minitab 19 software is presented in table 1.

Table 1. Taguchi $L_9 3^4$ Experimental design matrix.

S/No	Reinforcement (g)	Binder (g)	Abrasive (g)	Friction modifier (g)
1	100	40	20	10
2	110	50	24	16
3	120	60	28	22
4	100	50	24	22
5	110	60	28	10
6	120	40	20	10
7	100	60	28	16
8	110	40	20	22
9	120	50	24	10

2.4. Production Process

The production of the brake pad samples was carried using a hydraulic press (VOLTZ Tool, 10000kg) situated at the Hydraulic Laboratory of Mechanical Engineering Department, Taraba State University, Jalingo-Nigeria. Production was done using varying composition as shown in table 1 and a constant process parameter (14 MPa moulding pressure, 160ºC moulding temperature, 12-minute curing time and 1 hour heat treatment time). The moulding procedure involves pouring a weighed portion of the araldite into a container followed by the addition of small amount of hardener. However, the seashell, snot apple fiber, ceramic and graphite were also mixed thoroughly in a separate container. The overall mixture was thereafter mixed thoroughly using a manual blender in order to obtain a homogenous mixture and then transferred into the mould for compression. The produced brake pad samples are shown in figure 1.

Figure 1. Produced brake pad samples.

2.5. Sample Characterization

Brake pads samples were characterized by investigating their tribological properties (wear rate and coefficient of friction). The wear rate was carried out in accordance with ASTM G77 standard using a Bench grinder (MD-3220K; 230V-50Hz-Taiwan) with disc diameter and speed of 2950 rev/min and 250 mm respectively. Also, coefficient of friction of the developed samples was measured in accordance with ASTM D203 standard using an inclined plane

3. Results and Discussion

The experimental results obtained from sample characterization along with signal-to noise ratios are presented in table 2 below. The experimental results showed a wear rate of 1.34±3.5 x10^{-6} mg/m and friction coefficient of 0.483±0.557. These results are in close agreement with the work of Dagwa and Ibhadode [2] who reported coefficient of friction of 0.35±0.44 and wear rate of 0.17±1.70 x10^{-6} mg/m. In addition, the main effect plots which specified the optimal conditions for individual response were thereafter represented as shown in figures 2 and 3. Figure 2 revealed that the optimal conditions for wear rate of the developed brake pad can be obtained using seashell (105.5g), snot apple fiber (4.5g), araldite (50g), ceramic (24g) and graphite (22g) while figure 3 revealed that the optimal conditions for friction coefficient of the developed brake pad can be obtained using seashell (96g), snot apple fiber (4g), araldite (40g), ceramic (20g) and graphite (22g). Zaharudin et al. [8] have revealed that any change from these optimal conditions may affect the performance of the friction material during application.

Table 2. Results of sample characterization.

	Experimental factors					Experimental results		Signal to noise ratios (Db)	
S/N	Seashell (g)	snot apple fiber (g)	Araldite (g)	Ceramic (g)	Graphite (g)	Wear rate (10^{-6} mg/m)	Coefficient of friction	Wear rate	Coefficient of friction
1	96	4	40	20	10	3.5	0.533	-40.6765	-5.4655
2	105.5	4.5	50	24	16	1.44	0.500	-40.6055	-6.0206
3	115	5	60	28	22	1.45	0.516	-39.8784	-5.7470
4	96	4	50	24	22	2.34	0.532	-39.6761	-5.4769
5	105.5	4.5	60	28	10	2.88	0.511	-40.4634	-5.8316
6	115	5	40	20	10	3.07	0.483	-40.1958	-6.3211
7	96	4	60	28	16	3.06	0.523	-40.4700	-5.6300
8	105.5	4.5	40	20	22	1.34	0.557	-40.7891	-5.0829
9	115	5	50	24	10	2.34	0.532	-40.3682	-5.4818

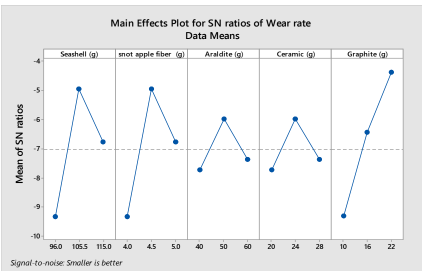

Figure 2. Main effect plots for wear rate.

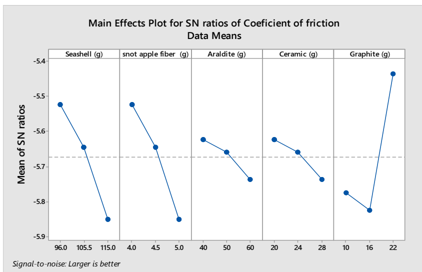

Figure 3. Main effect plots for Coefficient of friction.

In addition, the contour plots presented in figures 4 and 5 deduce the effect of changes in two independent variables (seashell and araldite) when the other variables are kept constant. Figure 4 indicates that the wear rate increases as the seashell increases with increasing araldite. Careful observations showed that the wear rate of less than 1.5 x10^{-6} mg/m can be achieved using seashell of 105.5g and araldite of 45g and vice versa. Also, figure 5 shows that friction coefficient of the developed brake pad increases as the seashell increases with decreasing araldite. Careful observations showed that the friction coefficient of greater than 0.55 can be achieved using seashell of 103g and araldite of 41g and vice versa.

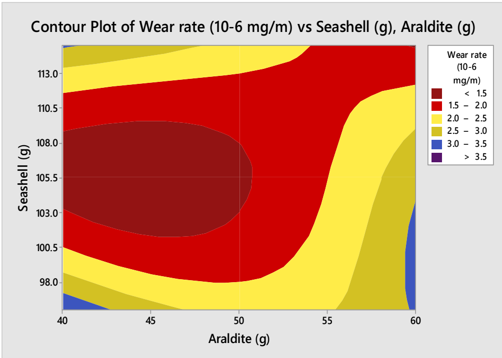

Figure 4. Contour plots for wear rate.

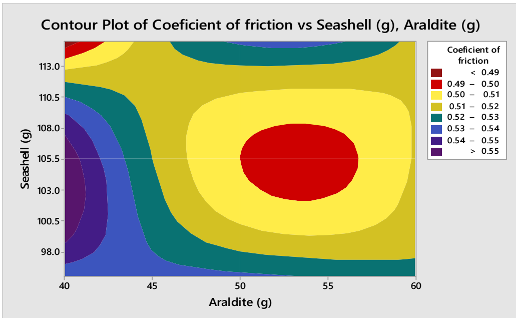

Figure 5. Contour plots for friction coefficient.

4. Conclusion

In this study, seashell and snot apple fiber were used as non-hazardous reinforcement material to produce brake pads. The newly developed friction material was investigated by determining its tribological properties. From the result obtained, the following conclusion can be drawn.

a) Variation in the brake pad constituents affects the properties of friction materials as the brake pad samples possesses a wear rate of 1.34±3.5 x10^{-6} mg/m and friction coefficient of 0.483±0.557
b) The optimal conditions for wear rate of the developed brake pad can be obtained using seashell (105.5g), snot apple fiber (4.5g), araldite (50g), ceramic (24g) and graphite (22g) while the optimal conditions for friction coefficient of the

developed brake pad can be obtained using seashell (96g), snot apple fiber (4g), araldite (40g), ceramic (20g) and graphite (22g)

c) In the development of brake pad for automobile application, it is recommended that graphite (friction modifier) of 22grams be used and any alteration in the value of the constituent materials from the optimal values may lead to a poor bonding between the resin and its constituent fillers.

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