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FORMULATION OF MATERIALS WITH NATURAL FIBER FOR BRAKE SYSTEM COMPONENTS

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ABSTRACT: The aim of this paper is to formulate some recipes of composites materials with natural fiber of coconut for the brake system components emphasizing on the substitution of the cast iron. Two sets of formulations were prepared with binder, structural materials, filler, frictional additives and varying coconut fiber contents from 0, 5, 10, 15%, using powder metallurgy technique. The first set contains titanium oxide and the second one contains aluminum oxide. The properties examined are hardness and density. It is noted that tests carried out with the addition of titanium oxide were less dense than those with the addition of aluminum oxide. Rockwell hardness has the highest values for samples with titanium oxide and addition of 5%, respectively 10% coconut fiber. Natural coconut fiber is a potential candidate for the automotive brake system components.
Keywords: material, fiber, brake, coconut, system, properties

1. INTRODUCTION

In our daily life, the most common way of transportation is automobiles. Every day car manufacturers spend huge amounts of money to find a way to improve their products about performance, safety and comfort. They invent new things or improve the parts that already exist to make their cars better. However, one of the vital themes about the car manufacturing is safety. When we talk about a car's safety, the first thing is braking system. Safety of the cars has the leading role in automotive industry than the performance of the cars, [1].

A moving car has a certain amount of kinetic energy, and the brakes have to remove this energy from the car in order to stop it. The kinetic energy lost by the moving part is usually translated to heat by friction. After heat and friction, another term that is important for the braking systems is the coefficient of friction. This is a dimensionless scalar value, which describes the ratio of the force of friction between two bodies and the force pressing them together. The coefficient of friction depends on the materials used, [2]. The materials used for the brake systems must meet the following criterias: good thermal criteria, resistance to corrosion, lightweight, long durability, low noise, stable friction, low wear rate and acceptable cost versus performance. [3],[5],[6],[9] To attend the required properties, it is often to combine many materials with different shapes and size, [3]. From theoretical point of view, several materials would be able to attend the requirements for a good performance. Nowadays, more than 2000 different materials and their variants are used in commercial brake components. [3],[8]

2. BRAKE MATERIALS AND ADDITIVE FUNCTIONALITY

The design of the brakes affects heat flow, reliability, noise characteristics and ease of maintenance. In order cu achieve the properties required of brakes, most brake materials are not composed of single elements or compounds, but rather are composites of many materials, [3].

Current trend in the research field is industrial or agricultural wastes as a source of raw materials for composite development. [7] This will provide more economical benefit and environmental preservation by utilize the waste of natural fiber. [5]

The history of brake materials shows that some of the simplest fiber plus resin can be effective, but there have been all kinds of commercial additives introduced. The scientific literature says that the same ingredients can be sent to several plants and the resulting brakes can have different friction coefficient. [2]

The exact composition of braking system materials are almost never published in the open literature. A representative sample of compositions are included in paper [3]. Consist this, the composition of commercial and experimental brake system materials in Table 1 are presented.

Table 1. Representative composition of materials for brake system components

Constituent	Range [vol %]	Typical value [vol %]
Phenolic resin	10-45	20-25
Barium sulphate	0-40	20-25
Fibers	5-30	-
Cashew particles	3-30	15-20
Graphite	0-15	5-7
Metal sulphides	0-8	0-5
Abrasives	0-10	2-3
Friction dust	0-20	-

It is difficult to select the material for brake system components, because of the large number of competing parameters, which often must be satisfied simultaneously. Automotive brake discs, pads and shoes usually contain: binder, structural materials, frictional additives and fillers.[4], [9] There is a little ambiguity in this classification. Some of the additives can be placed into more than one category since they fulfill several functions. Consequently, there are some unavoidable overlaps in the tabular listing. To analyze the role of additives in friction and wear control, it is insufficient to know their composition, because their form, distribution and particle size can affect friction and wear behavior. [3]

Binder is a type of thermoresin used to hold all other components together in order to form a thermally stable matrix, [4], [9].

Structural materials are typically fibers of metal, carbon, glass, Kevlar, and/or ceramic fibers. These materials are utilized to provide mechanical strength. [4], [9]

Fillers, such as aluminum silicate, vermiculite, calcium silicate, basalt fiber, polyacrylonitrile, polyester, aramid fibers, chopped glass fiber and barium sulphate are used mainly to reduce cost of brake elements, [4], [9].

Frictional additives are solid lubricants, like graphite and metal sulphides and they are utilized to provide stable frictional properties and control wear at high temperatures, [4], [9].

3. FORMULATIONS OF COMPOSITES WITH NATURAL COCONUT FIBER

After studying the scientific literature, were formulated and tested several recipes with natural coconut fiber for brake system components. However, it is find one information on the use of the coconut fiber for the formulation of new brake pad materials. [6] This paper concludes that natural coconut fiber is a potential candidate fiber or filler material for the automotive brake pads. In this direction, we have developed two sets of recipes with similar compositions with addition of coconut fiber in the proportions of 0, 5, 10 and 15%. The difference between the two sets of recipes is that: the first set contains titanium oxide with varying coconut fiber contents and the second one contains aluminum oxide with the same varying coconut fiber contents. Table 2 presents the formulations of materials with coconut fiber for brake system components.

Table 2. Formulation of materials with coconut fiber for brake system components

Pattern composite		Aluminum [%]	Graphite [%]	Zirconia oxide [%]	Silicon carbide [%]	Titanium oxide [%]	Phenolic resin [%]	Coconut fiber [%]
Set1	CT1	25	10	2	10	13	40	0
	CT2	20	10	2	10	13	40	5
	CT3	15	10	2	10	13	40	10
	CT4	10	10	2	10	13	40	15
		Aluminum [%]	Graphite [%]	Zirconia oxide [%]	Silicon carbide [%]	Aluminum oxide [%]	Phenolic resin [%]	Coconut fiber [%]
Set2	CA1	25	10	2	10	13	40	0
	CA2	20	10	2	10	13	40	5
	CA3	15	10	2	10	13	40	10
	CA4	10	10	2	10	13	40	15

For testing the composite materials it was designed and executed a mold for producing composite specimens.[8]

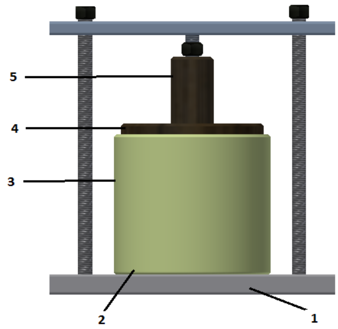

Figure 1. Main components of the mold

Figure 2. The mold for carrying out tests

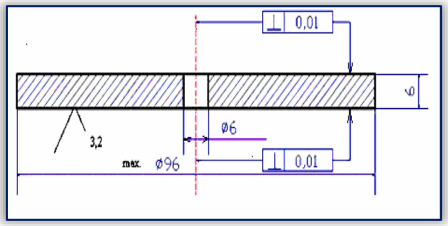

Figure 3. The shape and dimensions of sample

In Figure 1 are presented the main components of the mold: 1 - motherboard; 2 - disc for sample extraction; 3 - body; 4 - disc material pressing of; 5-pin for pressing. Figure 2 presents the mold for carrying out the samples. The sample dimensions of the mold are presented in Figure 3.

In order to achieve samples, all ingredients were prepared using powder metallurgy. It is used a ball mill machine, type PM100, with the size of balls of 8 mm. The raw materials were milled at a speed of 200 rot/min for 5 minutes. After the milling process, the ingredients are mixed and introduced into the mold where are pressed with a force of 10 N. The mold assembly is inserted into an induction furnace existing in the Faculty of Engineering of Hunedoara. The induction furnace model is TLB 180 and it has the following characteristics: maximum heating temperature 1200^{0}C, the voltage 220 V, frequency 60 Hz, intensity of current 15,7 A, the power 3,6KW. The heating temperature of the sample was 200^{0}C. The sample was maintaining in the oven 2.5 hours, after which cooling was carried out in air for 12 hours. To prevent mold sticking test will use aluminum foil and a thin layer of graphite that will settle on the bottom of the mold. The two sets of samples are shown in Figure 4. For the first set of recipes, samples obtained were noted with CT1-CT4, and for the second set with CA1-CA4, in order of increasing coconut fiber.

Figure 4. The presentation of two sets of samples with variable addition of coconut fiber

In Figure 4, the first set contain four samples, which are made with titanium oxide with varying content of coconut fiber. The second set of samples are made with aluminum oxide and the same addition of coconut fiber. Sample obtained are completely circular and shows no tendency dismantling areas in structure. They have a proper homogeneity and a good consistency.

During the preparation of samples have encountered the following difficulties:

- inability correct mixing of the components of the recipe;
- correlating the ratio of the powdered material/phenolic resin;
- frequent samples sticking to the walls of the mold and destruction to debate it.

These weaknesses were resolved as follows: use of a mini mixer to obtain a homogeneous mixture; increasing the amount of the phenolic resin to achieve wetting of the powder; graphite foil combination solves the problem of sticking of the sample mold. During the mixing of ingredients, it was observed that the factors, which affect a homogenous mixture, are the speed of mixing and the amount of the phenolic resin. Obtaining a compact sample influenced by the heating-cooling.

4. RESULTS AND CONCLUSIONS

Specific gravity measures density depends upon the ingredient of the brake material formulation, [5]. The true density of the samples was determined by weighing the samples on a digital weighing machine and calculated their volume with the relation:

$$V = 2\pi \cdot R \cdot h$$

In this relation: „R” represents the radius of the sample and “h” represent the thickness of the sample, both expressed in millimeters.
The specific gravity formula is:

$$\rho = \frac{m}{V}$$

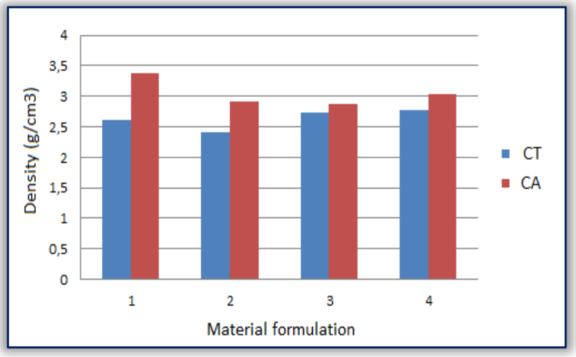

Figure 5. Specific density of samples

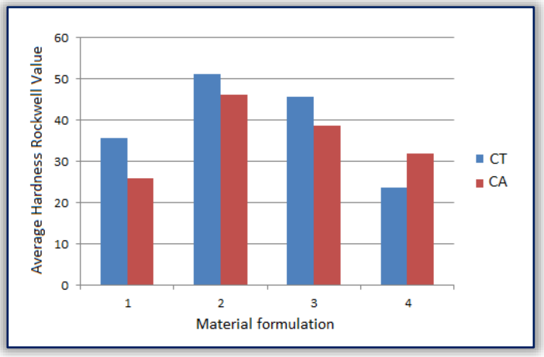

Figure 6. Hardness of samples

Figure 5 shown that samples of the first set, carried out with the addition of titanium oxide have a less density than the second set. The lowest sample density has CT2, which is 2.41g / cm.^{3}
The hardness testing was conducted on a Rockwell unit PH -C -01 /02 in accordance with EN ISO 6508-1 standard: 2002. These measurements were conducted under test load of 980.6 N, the steel ball diameter is 1.58 mm, using scale B as stipulated in the standard. The measurements were performed at a distance of 13 mm. Drive speed of the load is 0.8 m/s and the holding time is 10s. The hardness of the sample is the arithmetic mean of the readings five indentations.
Figure 6 shows the hardness values of the materials obtained. It can be seen that the hardness value of CT2 with 5% coconut fiber is the highest of all and the hardness value of CT4 with 15% coconut fiber show lower hardness value. The lowest hardness values were obtained for samples CA1 and CT4. The same conclusions are obtained in paper [5]. Varying content of aluminum and coconut fiber will exhibit different hardness value of the material. The highest hardness was obtained for samples with titanium oxide and containing 5% and 10% coconut fiber. The samples CT2 and CT3 samples meet the best qualities of density and hardness.
Next we will examine other properties such as: friction coefficient, porosity, hardness, microstructural analysis, wear resistance, compressive strength, thermal conductivity, but the study of this mechanical properties are the subject of other papers.
Selection and formulation of the material for brake system components is not an easy task rather a complex process.

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