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MECHANICAL TESTING OF COMPOSITE MATERIALS WITH ORGANIC FIBRES FOR AUTOMOTIVE BRAKE PADS

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Abstract: Society is directed to use composite materials reinforced with natural fibers due to ecological catastrophes and the exhaustion of natural resources. Natural fibers have low mechanical properties, but these have some advantages such as:low density, low price of raw material and biodegradability. Thanks to these advantages, organic composite materials are appreciated in areas where material weight plays an important role, such as automotive. The weight of the materials used in the construction of automotive influences the amount of CO_2 emitted in the atmosphere with adverse effects on the environment. The paper presents some experimental research results from mechanical testing of new organic composite materials for automotive brake pads without any harmful effect. In this sense, four different laboratory formulations were prepared with varying percentage of coconut fiber, friction modifiers, abrasive material and solid lubricant using powder metallurgy technique. The results obtained provide useful information's about the behavior of these materials in operations.
Keywords: mechanical, organic, composites, pads, test, sample

INTRODUCTION

The environment holds a very important place in society. On the one hand, ecological catastrophes and on the other hand, the exhaustion of natural resources, have led to population awareness regarding to the impact of products and services on the environment. [1] So, it is aimed at designing products with low impact on the environment, but with maintaining a level of performance and similar functionality. For these problems, society is directed to use composite materials reinforced with natural fibers. Although natural fibers have low mechanical properties, these have some advantages such as: low density, low price of raw material and biodegradability. Thanks to these advantages, composites materials reinforced with natural fiber are appreciated in areas where material weight plays an important role, such as automotives. The weight of materials used in the construction of automotives influences the amount of CO_2 emitted in the atmosphere with adverse effects on the environment. [2]

In this regard, has been designed and built a family of organic composite materials. For these materials will be studied the behavior by determining the physico-mechanical and tribological characteristics. In the paper are presented four recipes of organic composite materials and the sequence of operations in manufacturing technology intended for making brake pads for small and medium vehicles.

The main objective of the paper is to present the results obtained from the mechanical tests (tensile, bending and compression) of new organic materials reinforced with coconut fiber. These results are necessary for the complete characterization of composite materials designed.

COMPOSITION OF MATERIALS AND MANUFACTURING TECHNOLOGY

New composite materials proposed and achieved have the chemical composition shown in Table 1. [3,4,5]

Table 1. Chemical composition of the developed composite materials

Samples / Components	C 1	C 2	C 3	C 4
Aluminium (%)	25	20	15	10
Graphite (%)	10	10	10	10
Zirconium oxide (%)	2	2	2	2
Silicon carbide (%)	10	10	10	10
Titanium oxide (%)	13	13	13	13
Phenolic resin (%)	40	40	40	40
Coconut fibre (%)	0	5	10	15

In establish the recipes it was considered the study realized in paper [6] referring to automotive brake pads formulations. All materials were prepared in powder form. The method used in fabrication of new developed composites was powder metallurgy technique. The prime reason for using the powder metallurgy is the possibility of obtaining uniform parts and reducing tedious and expensive machining processes. [7, 8]

Parameters of manufacturing technology used in obtaining the samples were: heating temperature 200^{0}C, heating time 15 min, retention time 45 min, pressing force at cold (before the samples are placed in the oven) 5 KN, pressing force at hot 5 KN, cooling medium: air, cooling time 10 hour.

The sequence of operations in the manufacturing technology of the samples was:

≡ the phenolic resin is put into the mixing tank;
≡ homogenize the constituents with a mechanical mixer;
≡ constituents homogenized are introduced in the phenolic resin; the composition is homogenized with a mixer;
≡ place a layer of aluminium foil on the base of the mold and on the active surface of the piston;
≡ place a layer of graphite on the based mold;
≡ the mixture is introducing into the mold; the piston of the mold is take up;
≡ performing a cold pressing force on a hydraulic press;
≡ the assembly sample-mold is insert in the oven.

Fifthineen minutes after the introduction into the oven, the mold assembly is removed from the oven and is performed a hot pressing force. After that, the sample is return in the oven and maintained for 30 minutes. At the end the samples are cooled in air for 10 hours after which they are extracted from the mold (Figure 1).

Figure 1. Specimen of composite material using for mechanical tests

In order to characterize the new composites materials, were achieved tests to determine mechanical properties. The samples for each test were carried out by cutting in concordance with actual standards, [2].

TESTING METHODS

Mechanical test methods for composite materials must be appropriate to the type of composite analyzed as well as the structure of the product to be achieved. [9], [10]

For composite materials is considered to be necessary a minimum of testing on the basis of which the material can be characterized satisfactorily. Characteristics of materials, especially of composites, must also be determined experimentally. Samples may be subject to various requests: tensile, compression, bending, etc. The type of request is chosen depending on the role of the piece in the assembly. [1]

In this case, the purpose of composites materials is to make brakes pads for small and medium vehicles. The main request to which they are subject is compression. Fora complete characterization of the newly created composite materials, tensile and bending tests will also be performed. These results are necessary in the simulation using mathematical modeling.

The mechanical tests will be carried out in the Materials Resistance Laboratory of the Department of Mechanics and Resistance of Materials in Timisoara, on a Zwick / Roell Z005 equipment. The technical characteristics of the equipment are: maximum test force 5 KN, maximum test speed 3000 mm/min, test temperature: 0-250^{0}C, maximal pressure in the contact area: 300 N/mm^2. [11]

The test equipment works with the testXpert II software, which uses a programming language specific to physical-mechanical testing ZIMT (Zwick Interpreter for Materials Testing). This program offers maximum power and flexibility to operator, it provides a unique data export interface to the most popular systems or programs. These include Word, Excel, Adobe, Access, Oracle, SAP, MySQL and others. The software is designed in a modular system and can be used for several Zwick / Roell test tools. [11]

RESULTS

Figure 2 shows the assembly of the equipment Zwick / Roell Z005 for mechanical tests. Before performing each test, were measured the dimensions of the cross-section of each sample. The dimensions being entered as input in the computer connected to the test equipment. After making the measurements the samples were mounted in series on the equipment assembly. Both the tensile test, as well as bending and compression were performed on a number of ten samples. In the paper are presented the average values of the results obtained.

Figure 2. Assembly of Zwick / Roell Z005 equipment prepared for mechanical tests

At the tensile test the samples were elongated along its main axis with a constant speed, until break or until the load or deformation has reached a preset value. Figure 3 shows a sample made of one of the composite material mounted in the equipment in order to perform the tensile test. Table 2 shows the values of the samples parameters subjected to the tensile test.

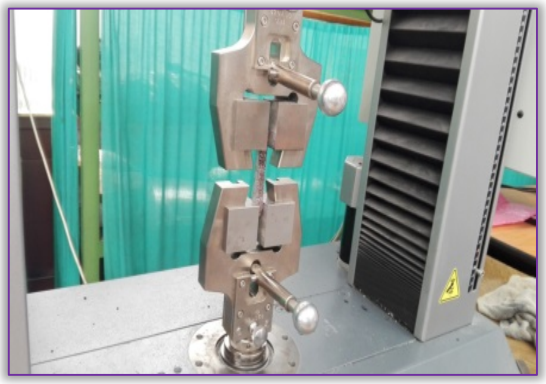

Figure 3. Sample mounted in the equipment to perform the tensile test

Figure 4. Sample broken after tensile test

Table 2. Values of the samples parameters subjected to the tensile test

Parameters	C1	C2	C3	C4
Length of the calibrated portion[mm]	60	60	60	60
Width [mm]	10	10.1	10	10.2
Thickness [mm]	6	5.9	6	5.8
Area of cross section [mm^2]	60	59.59	60	59.16
Loading speed [mm/min]	20	20	20	20

When fitting C1 and C4 samples, in the testing equipment, they crumbled due to a large porosity. These did not allow for mechanical tensile tests. Samples C2 and C3 did not raised problems when they are fitting in the equipment. Table 3 shows the mean values of mechanical tensile test.

Table 3. Average values of tensile tests

Characteristics	C1	C2	C3	C4
Breaking force [N]	Sample broken when the jets crash	3000	2430	Sample broken when the jets crash
Breaking voltage [MPa]		5.0344	4.0500	
Elongation		0.0123	0.0211	

Figure 4 shows the sample made of composite C2 at the end of the mechanical tensile test. Due to the breakage of the samples made of C1 and C4 composites comparative assessments cannot be made for the tensile behavior of the composites materials designed.

The samples subjected to the bending test were taken from disk samples presented in Figure 1. The thickness of disks were between 6 and 10 mm. Table 4 shows the average values of sample subjected to the bending test.

Table 4. Average values of sample parameters subjected to the bending test

Parameters	C1	C2	C3	C4
Length[mm]	100.01	100.02	100	100.01
Width [mm]	15	15	14.99	15
Thickness [mm]	7.2	7.5	7.4	7.5
Area of cross section [mm^2]	108	112.5	110.926	112.5

Figure 5 shows a sample mounted in the Zwick/Roell Z005 equipment for bending test. The distance between the supports of equipment is 48 mm, the loading speed was 20 mm/min and the temperature was constant, T=28°C. Bending test results are shown in Table 5.

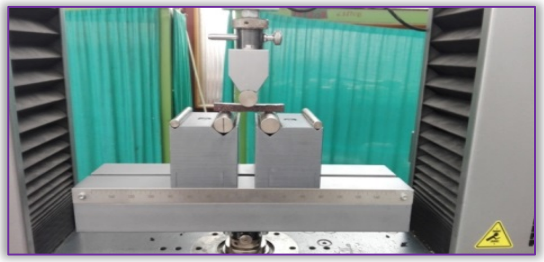

Figure 5. Sample mounted in the equipment to perform the bending test

Table 5. Average values of bending tests

Caracteristics	C1	C2	C3	C4
Breaking force [kN]	0.023	0.0842	0.0362	0.0723
Breaking voltage [MPa]	2.148	7.185	3.1752	6.1696
Elongation	0.1221	0.2114	0.1143	0.2345

The minimum breaking force was recorded for the C1 sample which does not contain coconut fiber and the maximum value of this force was obtained for sample C2 with 5% coconut. If in material exist internal stresses higher than admissible values during their use, even at a reduced load, there is the possibility of irreversible damage of composite material. [12] This shows the importance of reducing the risk of cracks in manufacturing technology.

Table 6. Average values of the parameters of the samples subjected to the compression test

Characteristics	C1	C2	C3	C4
Length [mm]	27.05	30.20	30.26	28.96
Width [mm]	26.49	30.16	31.33	31.43
Height [mm]	8.48	11.8	9.76	9.72
Loading speed [mm/min]	20	20	20	20
Area of cross section [mm^2]	716.55	910.83	948.04	910.21

The samples subjected to the compression test are parallelepiped and were taken from disk samples presented in Figure 1. Table 6 presents the values of the parameters of the samples subjected to the compression test, and the test results are shown in Table 7. Figure 6 shows the sample made of C2 composite with 5% coconut fiber at the time of compression.

Figure 6. Sample mounted in the equipment
to perform the compression test

Table 7. Average values of bending tests

Characteristics	P7	P8	P9	P10
Breaking force[N]	2270	1620	3200	899
Breaking voltage [MPa]	3.1679	1.7785	3.3756	0.9876
Elongation	0.03	0.02	0.11	0.1

The values of the forces at which compression is produced for the test samples are between 899 N and 3200 N. At compression tests, the C3 composition with 10% coconut fiber has the best behavior. The evolution of compressive behavior of C2 and C4 composites was similar.

The mechanical behavior of the composite materials tested is satisfactory. To improve these will be followed: optimizing the proportion of raw materials and adding new constituents. One of them would be hexametayltetramine which has the role of transforming thermoplastics into thermosets. This will result in higher values of mechanical characteristics resulting in better mechanical behavior of the composites designed.

CONCLUSIONS

The study shows the results obtained from the mechanical tests which provide useful information in behavior of this composites materials intended for making brake pads for small and medium vehicles.

The results obtained allow to change the proportion of constituents in order to improve operating behavior.

The conclusions obtained from the experimental determinations are:

≡ C3 composition with 10% coconut fiber have the best behavior followed by C2 and C4 which has a similar evolution;

≡ the composite materials analyzed have a satisfactory behavior and have increased potential for their use in the manufacture of brake pads;

≡ the study offers possibilities to improve the mechanical properties by adding new constituents to the recipe and optimizing the proportion of materials for given operating conditions.

References

[1] O.I. Nicolae, Impact of composite materials used in construction on the environment, Doctoral Thesis, 2013

[2] O. M. Terciu, I. Curtu, C. Cerbu, M. D. Stanciu, Traction testing of lignocellulosic composites with applications in the automotive industry, Buletinul AGIR nr. 1/2012

[3] A.L. Crăciun, C. Pinca-Bretotean, Advanced materials with natural fibred reinforced aluminium composite for automotive brake disc, Solid State Phenomena, 254, pp.91-96, 2016

[4] A.L. Crăciun, T. Heput, C. Pinca-Bretotean, Formulation of materials with natural fiber for brake system components, International Journal of Engineering, XIV (3), 2016

[5] A. L. Crăciun, C. Pinca-Bretotean, D.Uțu, A. Josan, Tribological properties of nonasbestos brake pad material by using coconut fiber, Materials Science and Engineering, 163 012-014, 2017

[6] M.A. Maleque, A. Atiqah, R.J. Talib H. Zahurin, New natural fibre reinforced aluminium composite for automotive brake pad, International Journal of Mechanical and Materials Engineering (IJMME), Vol.7(2012), No.2, 166-170.

[7] T. Kato, A. Magario, 1964, Wear of aramid fiber reinforced brake pads: the role of aramid fibers, Tribology Transactions 37(3) 559–565

[8] Y. Sasaki, Development Philosophy of Friction Materials for Automobile Disc Brakes, The 8th International Pacific Conference on Automobile Engineering. Society of Automobile Engineers of Japan, pp 407- 412, 1995

[9] C. Dumitraș, C. Opran, Processing of composite, ceramic and mineral materials, Editura Tehnică, București, 1994.

[10] I. Curtu, A.E. Stanciu, Determination of mechanical characteristics of specimens made of Mat-Roving composite material, Buletin AGIR 1/2011

[11] https://www.dcu.ie/sites/default/files/mechanical_engineering/images/Zwick_universal_tester_chap_1&_2_&_%20intro.pdf

[12] L.V Pascu, Research on improving the quality of brake shoes intended for rolling stock, Doctoral Thesis, 2014

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