

Researches Regarding the Compression of the Films Polymers in Composite System

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Abstract. *This paper presents experimental research results obtained from testing the compression of polymer matrix composites. The four types are analyzed by thin layers of polymer composite material of various thicknesses were subjected to the test of mechanical compression. The analyzed samples were obtained by reinforcing the siloxane rubber with FeSi powder and stretching the mixture on the metallic mesh (PM), as well as stretching the simple siloxane rubber, without reinforcing agent on the metallic mesh. The mathematical modeling of the experimental results obtained on the LFM 30kN compression tester, Walter & Sai AG was performed using the Excel program. Establishment of material was based on regression analysis performed later. The modulus of elasticity of the samples was determined according to the deformation range $0.1 \div 0.3\%$, corresponding to the maximum correlation coefficient resulting from the regression of the experimental data. Following the compression analyzes it was found that in the case of simple siloxane rubber (S) without filling, the average modulus of elasticity decreases from 80 MPa to 39 MPa for the siloxane rubber laying on the metallic mesh. For the composite material (siloxane rubber with FeSi powder addition) noted SF, the value of the module is 81, and in the case of the laying composite (siloxane rubber reinforced with silicon iron powder filler on the metallic mesh, noted PMSF), the value of the module decreases to 31 MPa. We conclude that the addition of silicon iron powder leads to an increase in the elasticity of the siloxane rubber, and its reinforcement with the metallic mesh leads to a decrease in the elasticity modulus of the siloxane rubber, as well as of the siloxane rubber reinforced with the iron powder.*

Keywords : *polymeric films, rubber siloxane, silicon iron powder, Young's modulus, compression*

1.Introduction

The development of new materials, with superior performances, remains an ongoing concern for specialists working in the field of materials science and engineering. Such an objective can be achieved only on the basis of a thorough knowledge of material properties. Explaining them correctly is key to understanding the behavior of materials during the manufacturing processes of the equipment and devices, and especially during their operation. Only on the basis of an understanding of the behavior of materials can be chosen or propose solutions to correct various problems in their operation. [1-4]

Due to the fact that composite materials have a low strength-to-weight ratio, a good resistance to wear and corrosion they have started to replace more and more traditional materials. The structural integrity of the composite material ensures high performance.

Mechanical tests of the compressive strength of the material make it possible to follow the behavior of the material and the dependence of the characteristic parameters by analyzing the tension applied to the corresponding linear strain specific. [5-8] The modulus of elasticity of the composite increases with the addition of filler. There are other factors that can change the mechanical behavior of elastomers with fillers, namely: particle size and their distribution (the smaller the particles the more

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the module grows, probably due to a larger total interaction surface or due to modification the value of the packing fraction). [6-18] Another cause would be the strong interaction between the particles, taking place an increase of the effort for a certain deformation, so an increase of the modulus. The increase of the modulus of elasticity can also be determined by the asymmetry of the particles. [10-18]

In the case of an elastomer with fillers, an elastomer that is capable of dispersing efforts, tensile strength increases with increasing concentration of the filler. The metallic mesh is subjected to compression loads while the core is resistant to compression forces. [18-24,26,27] The thin layers obtained have: light weight, good corrosion resistance [21-24,28-31], thermal resistance and excellent absorption of electromagnetic radiation [25]. Polymeric materials are increasingly used in various fields of activity and study their properties is a topic of great interest in materials used in insulation systems.

2. Materials and methods

Under the action of compression, plastic composite begins to deform. Breaking compression is controlled by shearing of matrix and not the particle, therefore, the behavior of compression depends on the nature and properties of the matrix.[6, 24,25, 32]

Determination of characteristics mechanical testing of materials is doing after trying on special machines corresponding aiming at the behavior of the samples before tear and the manners of fracture appearance.

Mechanical testing of compressive strength of materials enable tracking the behavior of the material and the characteristic parameters by analyzing the dependence between the applied voltage and the corresponding linear specific deformation.

The components necessary to make the composite materials according to the recipe are dosed, namely: the empty capsule is weighed, and the required amount of siloxane rubber and the curing agent are added thereto; mix the two components with a wand until homogenized, for 30-60 s, after which the silicon iron powder is added.

It is mixed again and the mixture obtained is spread with a spatula, a layer of the mixture obtained on both sides of the metal mesh. The films are left in an open atmosphere without special storage conditions at 22-25⁰ C for 24 h. After that, samples can be made for compression testing.

Specimens preparation

The compression analyzes were performed in the Laboratory of Material Characterization and Testing and Electrotechnical Products, within the National Research Institute for Electrical Engineering - Advanced Research (INCDIE ICPE-CA) using the mechanical testing machine, model LFM 30kN, Walter & Sai AG Switzerland showed in Figure 1.



Figure 1. Testing machine with the specimen mounted between the compression jaws of the test device

The samples were tested for compressive testing machine described above, provided with a data acquisition board, DION the name of the software with which the data are processed. The data were taken at intervals of about 0.1s in the form of ASCII files.

The specimens shall be inscribed and fixed in the position in which they will be tested. The specimens were fixed, one by one, between the bins of the test machine (which must be flat, hard and smooth), with the best possible centering of them. Then, they were applied slowly, continuously and progressively - compression loads.

Establishment of material was based on regression analysis performed later. Modulus of the test specimens, it determined corresponding deformation range 0.1 ÷ 0.3%, corresponding to the maximum correlation coefficient derived from regression of the experimental data.

Four samples were taken from each type of material for compression testing. Figures 2,3 siloxane rubber specimens are shown lying on the metallic mesh (PMS) and siloxane rubber test pieces (S).



Figure 2. PMS test samples



Figure 3. S test samples

To obtain correct results for determining compressive strength of polymer matrix composite materials, special attention should be given specimen shape and speed work.

In tables 1-6, the values of the dimensions as well as the results of the tests of the samples tested at the static compression test are presented.

Table 1. Geometry of the specimens, samples PMS and S

Samples	Test width [mm]	Thickness of specimen [mm]	Section area [mm ²]	Breaking resistance [MPa]
PMS 1	6.5	6.0	39,00	851.21
PMS 2	6.5	6.0	39,00	852.59
PMS 3	6.5	6.5	42,25	753.69
PMS 4	6.5	6.5	42,25	739.55
S 1	7.2	7.2	51,84	574.07
S 2	7.0	6.8	47,6	588.11
S 3	6.5	7.0	45,50	598.25
S 4	7.5	7.0	52,50	568.25



Figure 4 PMSF test samples



Figure 5 SF test samples

Figures 4 and 5, the specimens of composite material are shown SF metallic mesh stretched and unstretched on the metallic mesh, and the dimensions of the specimens are shown in Table 2.

Table 2. Geometry of the specimens, samples PMSF and SF

Samples	Test width [mm]	Thickness of specimen [mm]	Section area [mm ²]	Breaking resistance [MPa]
PMSF 1	6.02	8.80	52,976	598.74
PMSF 2	6.02	8.80	52,976	627.45
PMSF 3	6.02	8.5	51,17	608.22
PMSF 4	6.2	8.5	51,17	613.97
SF 1	6.0	7.3	43,80	678.02
SF 2	6.0	7.5	45,00	646.21
SF 3	6.0	7.0	42,00	674.77
SF 4	6.5	6.0	39,00	732.87

3. Results and discussions

Compression test was performed on each specimen in part, by the application of compressive force to the destruction of the test pieces, test pieces where the metallic mesh, as shown in Figure 6.



Figure 6 The appearance of specimens after compression testing
 a) composite material without metallized mesh; b) composite material with metallic mesh

From figure 6 (b), it is found that in the case of the composite materials stretched on the metallic mesh, following the compression test of the materials, it is found that the integrity of the materials is destroyed. Both the metallic mesh and the siloxane matrix are destroyed. In the case of composite materials with metallic mesh is noted that the material integrity is maintained, they deform under the action of compressive force, but not to destroy the sample. The specimen takes the form of a compression tank, which is only flattened.

With the help of the data series graphs for relative and absolute deformations could be drawn, as well as the calculation of the modulus of elasticity. The tests were carried out on the samples to which the compressive force was applied in the direction perpendicular to the metallic fabric.

PMS testing (Siloxane rubber laying on metallic mesh)

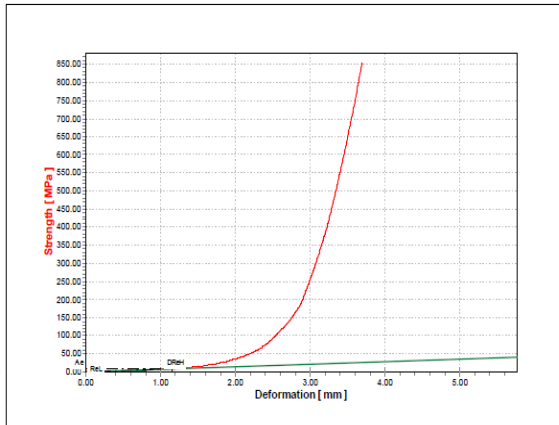


Figure 7 Curve strength - deformation for PMS 1 specimen, curve made by the compression test machine

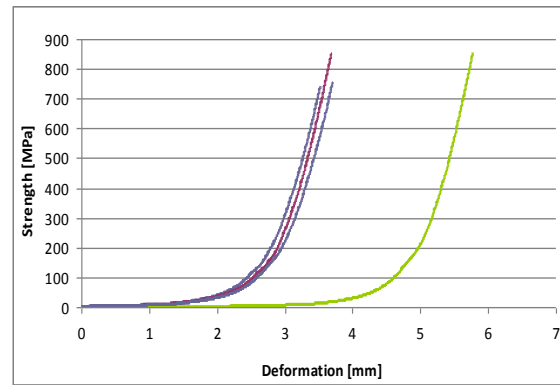


Figure 8. Centralization of strength - deformation for the 4 samples PMS

In Figure 7, we presented only one of the 4 graphs performed on the 4 samples made using the LFM compression machine, Walter & Sai AG, which was the most representative for this type of material. From figure 8 we find that only 3 of the 4 samples, have the same allure of the strength-deformation curve, with that made by the test machine. We notice that the experimental data do not suffer from a very large spread. The 3 samples are very close as values, only for the sample with the number 2 there is a small problem, this coming from the group of the three samples analyzed, according to figure 10.

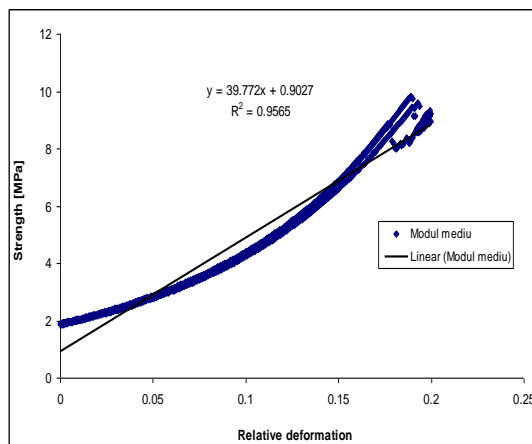


Figure 9. The value of the average module for the PMS material

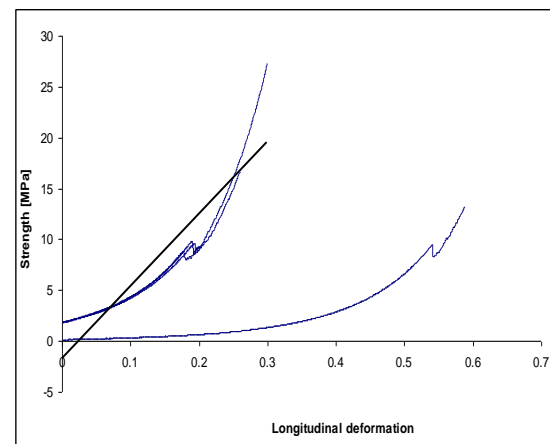


Figure 10. Curves strength-longitudinal deformation of samples PMS

With the data corresponding to the deformation field, the modulus of elasticity for all specimens was determined. In figure 9, the modulus of average elasticity, determined by the regression of the data corresponding to the 4 samples of the PMS material, in the deformation range between 0.1-0.3% is determined. For all determinations, correlation coefficients between 0.954 (for samples number 1 and 4) and 0.760 (for test number 2) are highlighted. The correlation coefficient is very good also when determining the average module, its value being 0.956, according to table 3.

Table 3. Centralized results at determining the modulus of elasticity for PMS material

Samples	PMS 1	PMS 3	PMS 4	Mediate	Estimate (according to figure 9)
Young's module (MPa)	39	38	40	39	39.38
correlation coefficient	0.954	0.964	0.954	0.957	0.957
Error (%) for correlation coefficient	0.31	0.73	0.31		

The calculated errors do not exceed 1%, according to table number 3.

According to figure 10, we notice discontinuities for sample number 1, at approximately 9,043 MPa at 19.5% deformation, for PMS 2, the discontinuity appears at a 54.8% deformation value of the specimen and is 8,671 Mpa. For the PMS 3 sample, the discontinuity appears at a value of 8.156 MPa, and for the last test the discontinuity of the voltage-deformation curve appears at the value of 8.698 MPa. We find, according to figure 10, that the values characteristic of the sample with the number 2, are far removed from the values of the other samples, for which there is a small scattering of the experimental data, these being quite well grouped.

The values of the force for which the discontinuities appear, from figure 10, are appreciated as forces attributed to the metallic fabric breaking, with respect to the direction of application of the compression force, this destroying the integrity of the material.

PMSF testing (SF composite material, siloxane rubber and silicon iron powder, laying on metallic mesh)

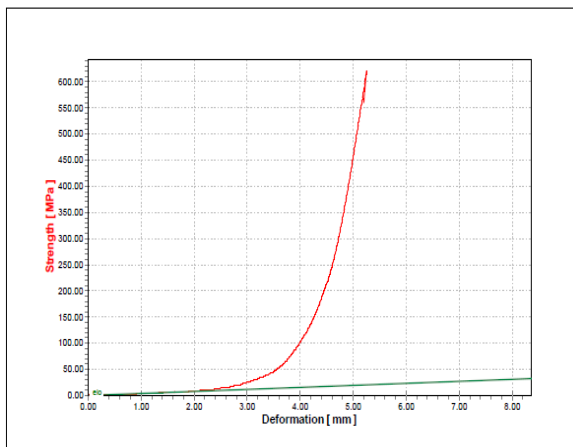


Figure 11. Curve strength - deformation for PMSF 1 specimen, curve made by the compression test machine

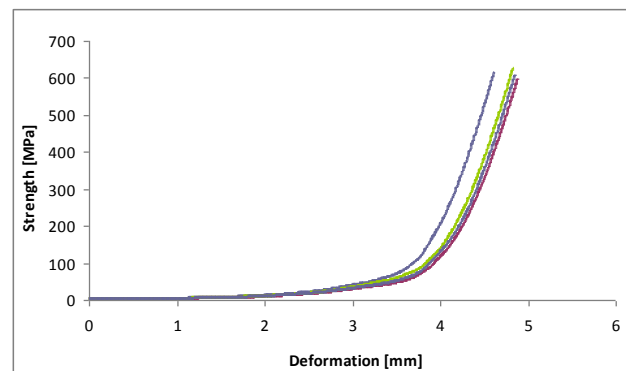


Figure 12. Centralization of strength - deformation for the 4 samples PMSF

According to figure 12, there is a fairly good grouping of results, for all 4 samples analyzed.

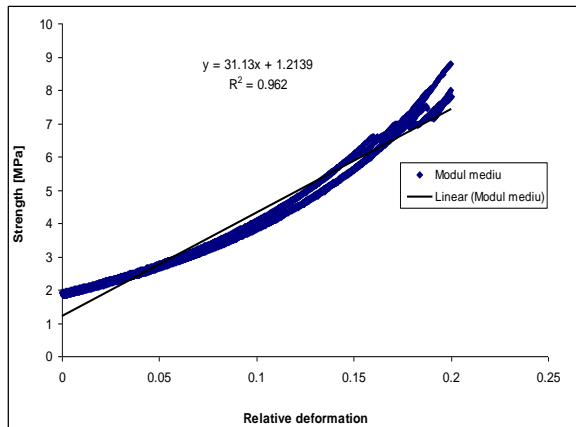


Figure 13. The value of the average module for the PMSF material

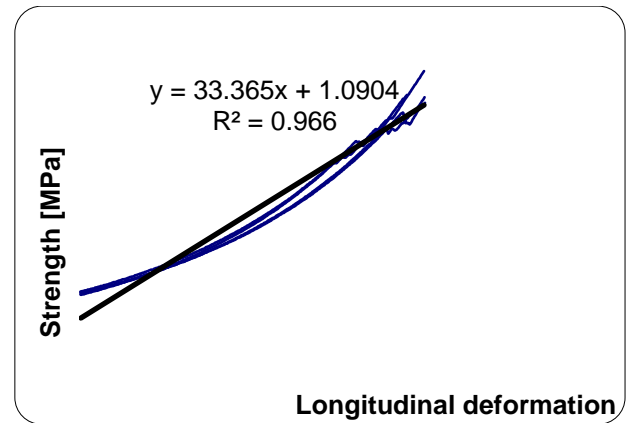


Figure 14. Curves strength-longitudinal deformation of samples PMSF

In figure 13, the average elasticity modulus, determined by the regression of the data corresponding to the 4 samples from the PMSF material, is determined. For all determinations, correlation coefficients between 0.969 (for the PMSF 2 test) and 0.964 (for the PMSF 1 test) are highlighted. The value of the correlation coefficient is very good and in the case of determining the average module it is 0.962, according to table 4.

Table 4. Centralized results at determining the modulus of elasticity for PMSF material

Samples	PMSF 1	PMSF 2	PMSF 3	PMSF 4	Media	Estimate (according to figure 13)
Young's module (MPa)	29	31	30	33	30	31.13
correlation coefficient	0.9644	0.969	0.969	0.966	0.967	0.962
Error (%) for correlation coefficient	0.2	0.2	0.2	0.1		

The calculated errors slightly exceed the value of 0.2%, according to table 4.

According to figure 13, we notice discontinuities for the sample PMSF 1, at about 7.202 MPa at a 19% deformation, for PMSF 2, the discontinuity appears at a deformation value of 17% of the specimen and is 7.053 MPa. For the PMSF 3 sample, the discontinuity appears at a value of 6,970 MPa, and for the last test the discontinuity of the strength-deformation curve appears at the value of 6,557 MPa.

S testing (siloxane rubber)

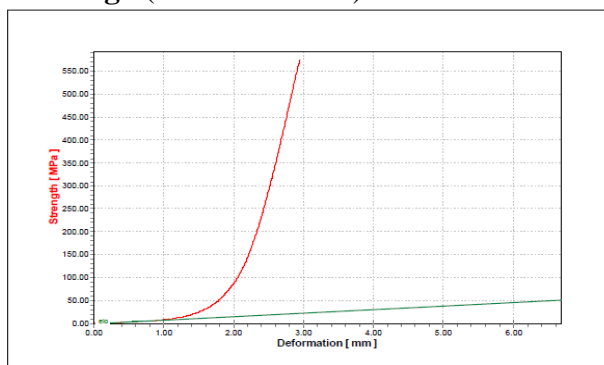


Figure 15. Curve strength - deformation for S 1 specimen, curve made by the compression test machine compresiuene

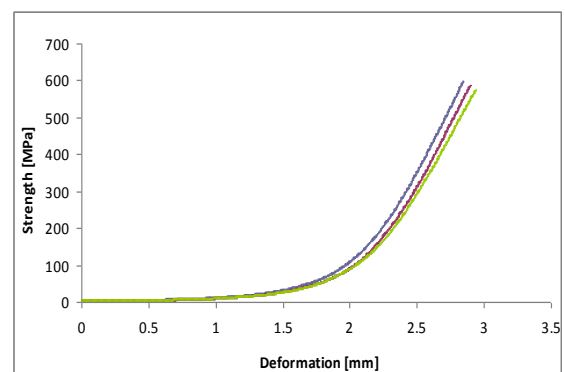


Figure 16. Centralization of strength - deformation for the 4 samples S

According to figure 16, there is a very good grouping of results, for all 4 samples analyzed.

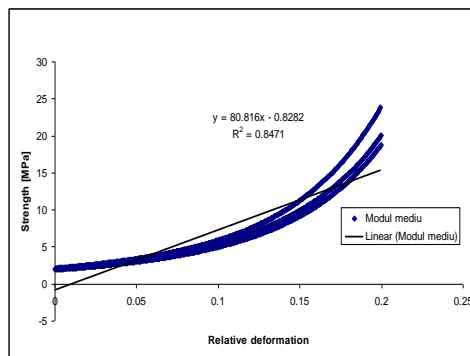


Figure 17. The value of the average module for the S material

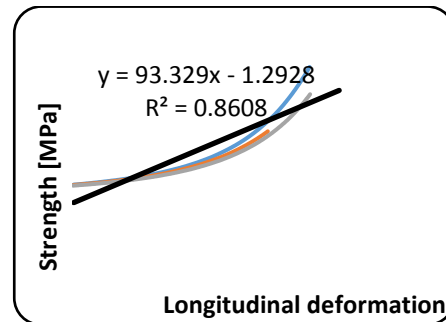


Figure 18. Curves strength-longitudinal deformation of samples S

Table 5. Centralized results at determining the modulus of elasticity for S material

Samples	S 1	S 2	S 3	Media	Estimate (according to figure 17)
Young's module (MPa)	92	77	71	80	80.81
correlation coefficient	0.861	0.876	0.870	0.869	0.847
Error (%) for correlation coefficient	0.92	0.8	0.15		

The calculated errors do not exceed the value of 1%, according to table 5

SF testing (SF composite material, siloxane rubber and silicon iron powder)

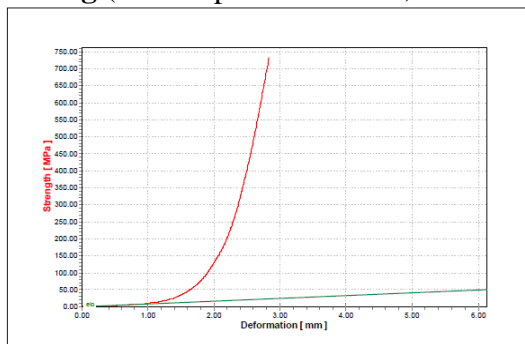


Figure 19. Curve strength - deformation for SF 1 specimen, curve made by the compression test machine

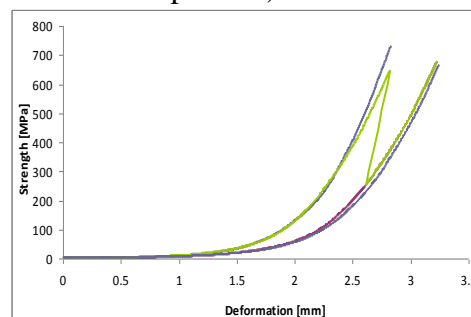


Figure 20. Centralization of strength - deformation for the 4 samples SF

According to figure 20, there is a good grouping of results, for all 4 samples analyzed.

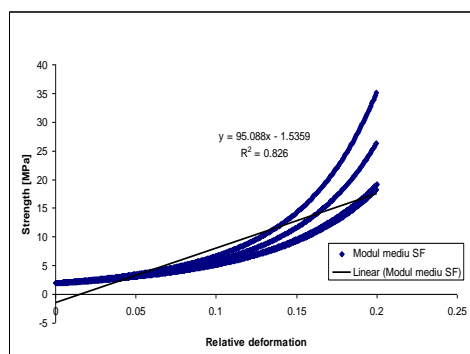


Figure 21. The value of the average module for the SF material

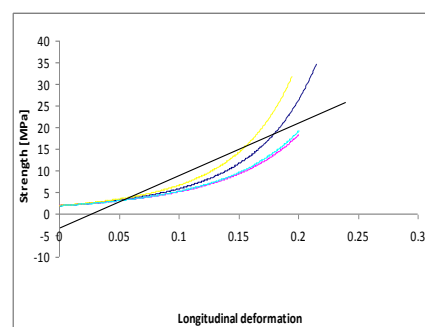


Figure 22. Curves strength-longitudinal deformation of samples SF

Table 6. Centralized results at determining the modulus of elasticity for SF material

Samples	SF 1	SF 3	SF 4	Media	Estimate (according to figure 21)
Young's module (MPa)	70	74	101	81	81.79
correlation coefficient	0.883	0.881	0.846	0.87	0.826
Error (%) for correlation coefficient	1.49	1.26	2.75		

As shown in table 6, the calculated error does not exceed 3%.

4. Conclusions

According to the results processed in order to obtain the average elasticity mode, we find that, in all samples, the value of the module decreases when the composite material is laying on the metallic mesh.

In the case of S, ie simple siloxane rubber without filling, the average modulus of elasticity decreases from 80 MPa to 39 MPa for siloxane rubber laying on the metallic mesh. For SF composite material, the value of the module is 81, and in the case of the composite material laying on the metallic mesh, PMSF, the value of the module decreases to 31 MPa.

Starting from the simple siloxane rubber, ie without reinforcing or filling additions, following the compression analysis we find that the reinforcing agent, the silica iron powder dispersed in the siloxane rubber, leads to an increase in the modulus value slightly above the value of the matrix, from 80 to 81 MPa.

The measured errors, for the correlation coefficients are small, exceeding only for the SF material value of 3%, instead of the rest of the analyzed materials, we find a maximum of 1%, which indicates that the results of the compression measurements are valid.

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