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INFLUENCE OF MANUFACTURING ERRORS ON THE PROPERTIES OF COMPOSITE MATERIALS

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Abstract: *The aim of this paper is to study how manufacturing errors occur in the production of fiber-reinforced composites, and how they can significantly influence the mechanical properties of materials. In the manufacturing process, the manufacturer obtains dimensional or structural deviations from the values set in the theoretical model, and these do nothing but lead to variations in the mechanical properties of the materials.*
Keywords: *materials, errors, composite materials*

1. INTRODUCTION

During the manufacturing process of the material, while handling, transport from one unit to another or its storage, a multitude of chemical phenomena or mechanical actions occur that will lead to changes in the behavior of the composite or deviations from its theoretical model.
The main idea is that there will always be differences between the theoretical values of perfect models and the values of real models, the theoretical model being impossible to obtain, this being the reason why analyzes are made of factors that can cause deviations from nominal values, and trying to this way obtaining a real model as close as possible to the perfect one.
The use of composite materials can help to achieve a wide variety of applications, which can be purchased at advantageous prices for the intended purpose.
The composite materials, from a constructive point of view, are made of two or more adjacent materials, the aim being to obtain a material with new properties.
To obtain composite materials, various combinations of materials can be used, such as materials of the same type (glass with glass, plastic with plastic, etc.), or materials with different physical and chemical properties (plastic glass, carbon fiber with rubber etc.).
Usually, composite materials are made of the base material, which is also called matrix, this material having weaker properties but with a lower price, reinforced with other materials, different in shape, size and topology with physical, chemical or very good mechanical as opposed to the base material, but the latter having a higher price.
The main advantage of composite materials and their development is due to the fact that it can vary a large number of parameters that will determine the properties of the composite.

2. WORK METHOD

Fiberglass-reinforced composites are some of the most widely used in machine building, as are carbon-fiber-reinforced composites.
During the test, the load borne by the test piece and its displacement were automatically measured and recorded. With the help of the software were determined both the tensile strength and the modulus of elasticity of the composite material. The results of the tensile test were centralized in table 1 and with their help a series of representative graphs were made for 3 tensile test specimens.

Table 1: Mechanical properties of polyester matte fiberglass composite

Characteristics	Sample 1	Sample 2	Sample 3
Force at maximum load (kN)	2.7684	3.0791	2.7923

Fracture load (kN)	2.7498	3.0691	2.7886
Elasticity modulus (MPa)	9384.8	9812.8	9071.2
Tensile strenght (MPa)	83.135	100.332	83.980
Breakage stress(MPa)	82.579	100.005	83.868
Breakage displacement (-)	0.009323	0.012788	0.012064
Deformation of machines at maximum load (mm)	0.56031	0.76733	0.72386

Table 2: Dimensions of the samples tested for traction

Sample	1	2	3
Load speed(mm/min)	1	1	1
Length of the calibrated area (mm)	60	60	60
Sample width (mm)	9	9.3	9.5
Sample thickness (mm)	3.7	3.3	3.5
Area (mm^2)	33.3	30.69	33.25

Regarding the variation of the stiffness of the sample, it can be seen, in table 3, that the minimum value of the stiffness is 5019259.84 N / m related to specimen 2, and the maximum value is 5208595.96 N / m for sample 1, the average of the three samples being 5084946.84 N / mm.

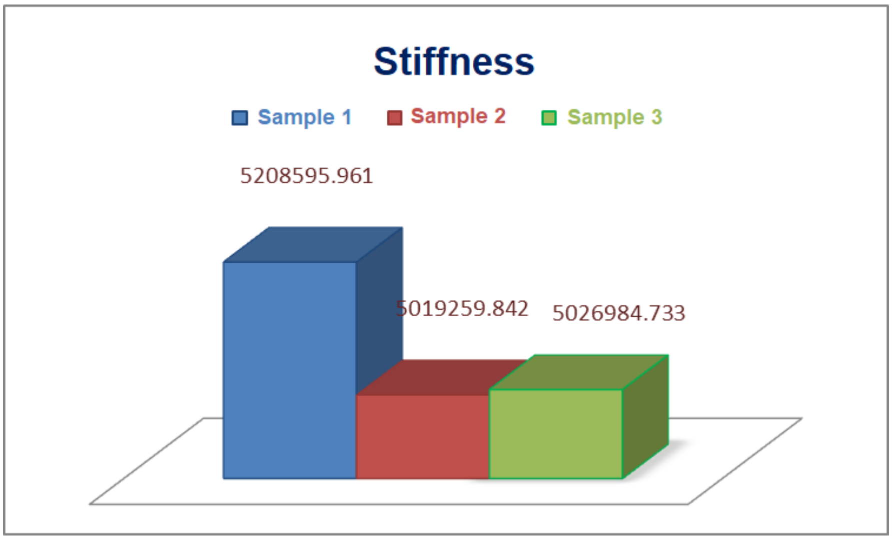

Figure 1: Stiffness variation

Table 3: Mechanical characteristics of mat glass specimens tested for traction

Sample	1	2	3
Stiffness (N/m)	5208595.96	5019259.84	5026984.73
Elasticity modulus (MPa)	9384.85	9812.82	9071.25
Maximum load stress (MPa)	83.1357	100.3321	83.9803
Maximum displacement stress(MPa)	80.7616	90.0159	80.7616
Specific strain at maximum load	0.93237	1.27889	1.20644

Specific displacement at maximum load (mm)	0.55942	0.76733	0.72386
Specific displacement at maximum displacement (mm)	0.66033	1.42074	1.44308
Work at maximum load (Nmm)	746.769	1295.892	1131.783
Work at maximum displacement (Nmm)	1014.789	3201.813	3058.670

Figure 2 shows the values of the modulus of elasticity of the three specimens, noting that the minimum value is 9071.25 MPa for specimen 3 and the maximum value of 9812.82 MPa belonging to specimen 2, the average of the three being 9422.97 MPa.

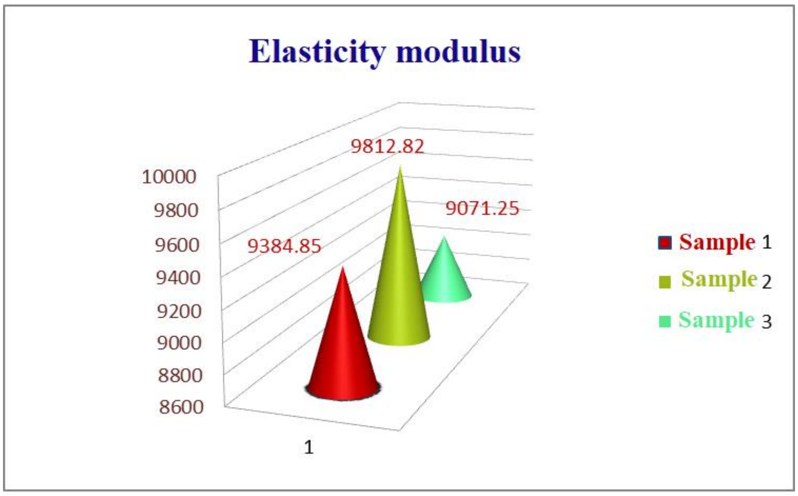

Figure 2: Variation of the elasticity modulus

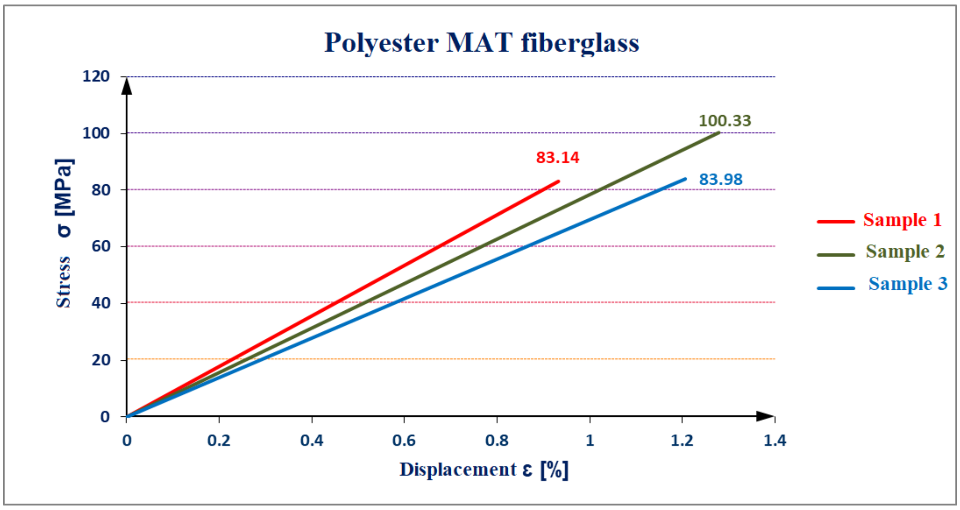

Figure 3: Specific stress-strain variation

As can be seen in Figure 3, the specimen with the largest specific deformation is specimen 2, the value of the deformation being 1.27889 [%].

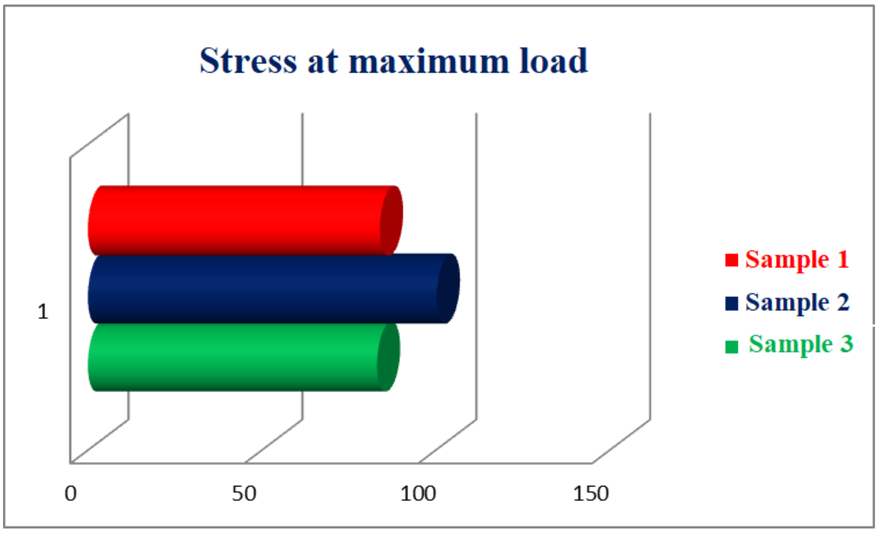

Figure 4: Stress at maximum load

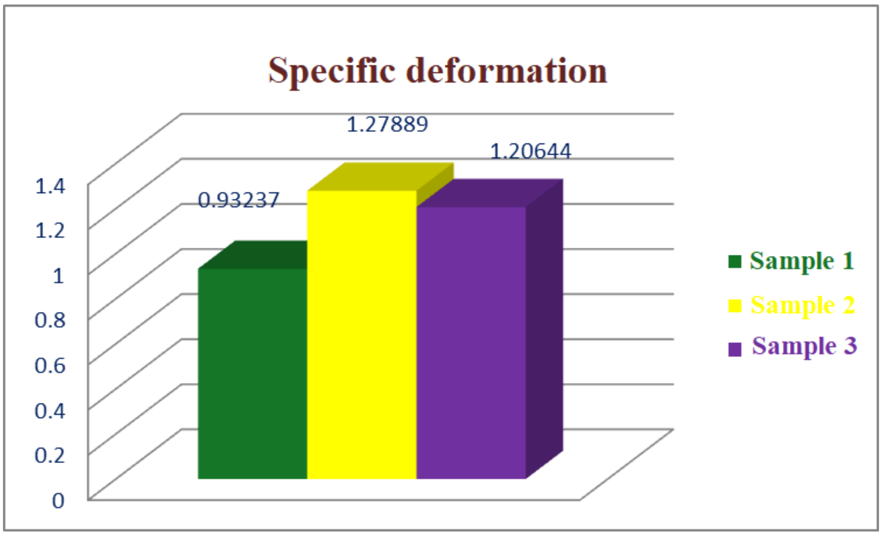

Figure 5: Specific deformation at maximum load

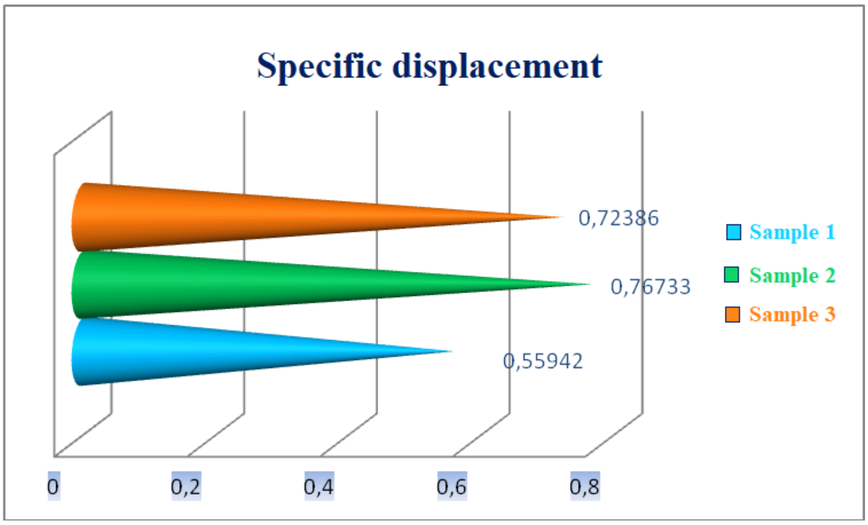

Figure 6: Specific displacement at maximum load

The specimen with the largest specific deformation is the specimen 2, which is also the specimen with the smallest initial thickness 3.3 mm, the specific displacement of which is 0.76733 mm, as can be seen in Figures 5 and 6.

It can be seen that the fibers influence the mechanical properties of the composite material by increasing the mechanical strength and delaying the cracking process.
The use of fibers in a composite increases the maximum tensile strength, but the volume ratio between the epoxy matrix used and the additive, the volume ratio between the matrix and the fiber, their nature and their arrangement in the composite must also be taken into account.
For polymeric composites with epoxy matrix and fabric-reinforced, the matrix shall not exceed 0.01 mm in fabric thickness.
The geometry of the threads depends directly on the thickness of the fiber; the larger the cross section of the fiber, the more the thickness of the yarn is directly proportional to the thickness of the fibers;
The number of fibers contained in the yarn depends directly on the geometry of the fabric, the fiber and the yarn, so the fabrics have a direct influence on the area of the yarn sections; the more spaced the wires, the longer the wavelength of the wire and the smaller the angle of passage.
An important element in the mechanical study of fiber-reinforced composites is the maximum tensile stress of the material. The maximum stress is calculated as the ratio of the maximum force applied to the composite to the area of the initial cross-sections of the tensile test specimen.

3. CONCLUSIONS

In the examples presented above it can be easily observed that, both during the manufacturing processes and during the use of composite materials, a series of manufacturing imperfections and chemical diffusion phenomena can appear which will generate a considerable difference between the real composite material and the theoretical model.
Examples of deviations between theoretical models and real models:
- Differences between the size of the theoretical mechanical characteristics of the matrix and the reinforcing material and their real values.
- Dimensional differences of reinforcement materials.
- Differences in the geometric arrangement of reinforcing materials.
The deviations mentioned above will influence the results obtained on the theoretical models and an analysis is needed to determine which of the formulas obtained over time are the most appropriate to analyze a certain type of composite material.

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