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Theoretical and Experimental Studies Based on Composite Materials Reinforced with E-Glass Fiber Made of Nylon or Silicone

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Abstract

This paper aims at a comparison between the two composite materials based on a sandwich structure consisting of the glass fiber fabric made with epoxy resin reinforced with nylon fiber or silicone with their characteristics and their properties are also presented in several advantages and disadvantages.

Important case that we pursue is to strengthen the structure by adding variable thickness of glass fiber reinforced composite layers forming and optimizing the concentration of material reinforcement layer of silicone and nylon fibers.

The important parameters like material, thickness and bending are studied for analysis toughness of fiber reinforced epoxy composites.

The analysis paper describes the differences between 6 E-glass layer with a density 280g/m^2 reinforced with silicone and 6 E-glass layer reinforced with nylon fibers and the results will be compared between them by using bending tests. Composites materials are one of the principal areas of research in the fields of mechanics for the last decades.

Key words: *composite, nylon fibers, silicone.*

Introduction

Contains

The paper follows a detailed description of each material used in this study such as fiberglass epoxy resin, silicone and nylon. By mixing these two structures were obtained composite as follows: six layers of epoxy resin with glass fiber fabric, the first structure being reinforced with silicon and the second fiber reinforced with nylon fabric. The two structures were compared with each composite after bending test machine as the bending results were processed in Matlab, obtaining program that resulted in two charts which of the two structures is more resistant.

These materials are used in many industries and the industry in which a potential approach would be the road vehicles, more specifically the passive safety.

Glass fibers

Low cost components contained in glass making procedures simple enough, the glass fiber gives an excellent performance and price. Reinforcement materials are most often used in composites that do not require high performance, high tensile strength due to compression or shock and low-cost price. These fibers have a very good dimensional stability and high resistance to corrosion. The main disadvantage of these fibers consists of a limited application of these fibers because of fatigue life and relatively low stiffness. Liquid Glass products obtained by mixing career (sand, kaolin, limestone) at 15600C. The fluid is passed through special filters and simultaneously cooled to produce glass fiber yarn diameters between 5 and 24 mm. The threads are spun into a strand (fiber) or a cloth woven and dyed yarns and cohesion to ensure their protection.

Features

After composition, can get different types of glass. Next, briefly describe the types of fiberglass structural plates are produced.

Table.1. Features glass fiber used

Characteristic	E Glass
Density [kg/m3]	2520-2550
Softening temperature [0C]	846
Tensile strength [MPa]	3500-3520
Modulus, E [GPa]	73-79
Filament diameter, d [μm]	10-11,25

E-glass fibers (E-glass, electric type): good insulators, good mechanical properties, low cost, are the current composites are obtained by 'high diffusion'. These fibers have a low content of alkali, but are stronger than type A. Glass fibers have good tensile strength and stiffness and compression and also have good electrical properties. They have a relatively low cost but low impact resistance. Depending on the type of glass fiber, the price ranges between 2-4 USD / kg. E-glass is the most common form of fiber reinforcement used in composites with polymer matrix.

Table.2. Physico-mechanical characteristics of type E glass fibers

Characteristic	**U.M.**	**Value**
Density	kg/m^3	2540
Tensile strengh	MPa	3515
The longitudinal modulus at 22 ℃	*MPa*	73815
Specific elongation at 22 ℃	%	4,8
Softening point of the glass mass	℃	846

They are produced in various forms:

- Fire (swimming). Rarely is marketed as such;

- Fiber (yarn). It is obtained by spinning the fibers;

- Stranded (roving). It is obtained by spinning the fibers. Rovingurile often have a smaller diameter than the fibers. Have better mechanical properties and water-repellent and oil, and it is transparent.

Table.3. Features types of resins

Material	Resistance [MPa]	Elasticity Moe. [GPa]	Weight structure with an area of 1 m2 and a thickness of 1mm [kg]
Polyester resin	769	56	1,92
Epoxy resin	1009	56	1,83
Phenolic resin	769	56	1,81

In Table.3. Summarizes the characteristics of several types of resins and the one that was chosen for the next studio due to its resistance to breaking epoxy much higher.

Nylon

Nylon was discovered in 1935 by Wallace Carothers at the DuPont Company and is derived from synthetic polymers and polyamides call. Nylon has many uses and is a good substitute for natural fibersIn the auto industry is processed by extrusion, molding and injection molding. Nylon can be used as matrix material in composite materials, reinforcing fiber such as glass, and has a high density than pure nylon. Thermoplastic composite (45 % glass fiber) are often used in car components replacing metal components.

Features

Table.4. Physico-mechanical properties of sandwich structures: glass fiber reinforced nylon fiber fabric

Laminated construction	**Pure resin**	**Layers random fiber reinforced nylon**			**Nylon fiber fabric**	**Unit measure**
Glass fiber content	-	25-30	30 -35	35-40	45 - 50	% weight
Tensile strengh	50	75	95	120	200	MPa
Tensile elasticity modulus	4600	7700	8700	9500	14500	MPa
Tensile Elongation	1.6	2.4	2.3	2.3	2.3	%
Flexural strength	90	145	165	190	260	MPa
Flexural modulus	4000	6700	7400	8200	10500	MPa
Impact strength	5,0 – 6,0	80	90	100	125	mJ / mm^2
Inflection temperature	62	-	-	-	-	°C

Silicone

Silicone was discovered in 1901 by Frederick Kipping. Silicone is used where high performance and durability required in most of heavy components, such as in space (rocket technology). The operating temperatures is required (-65 to 300 ° C). Silicones also have the advantage of increased less exothermic heat during curing, low toxicity, good electrical properties and high purity. The use of silicones in electronics is not without problems, however. Silicones are relatively expensive and can be easily attacked by acids and base migrates as a liquid or vapor or other components.

Features

Injection of liquid silicone rubber is a process to produce sustainable high-volume folding parts. Liquid silicone rubber is a high purity platinum cured silicone with low compression set, high stability and ability to withstand extreme heat and cold temperatures ideal for the production of components, where high quality is a must. Due to the nature of thermosetting material, injection molding liquid silicon requires special treatment, such as intensive mixing distribution, while maintaining the material at low temperature before being pushed into the cavity heated and cured. Chemically, silicone rubber is a family thermo set elastomers have a backbone of alternating silicone and oxygen atoms and the methyl or vinyl groups. Silicone rubbers retain their mechanical properties over a wide temperature range and the presence of methyl groups in the silicone rubber material is extremely hydrophobic. Typical applications are liquid silicone rubber products requiring high precision such as seals, sealing membranes, electrical connectors, where products are desired smooth surfaces such as medical applications and kitchen goods such as baking pans. Often, silicone rubber is over molded on other parts of different plastics.

Results and conclusions

Comparative general characterization of fibers needs comparative analysis of all types of fibers show some reaction to various practical applications.

Tabelul.5. Properties

Properties	E-glass	Silicone	Nylon
High tensile strength	B	B	A
High tensile modulus	C	B	A
High compressive strength	B	C	A
High compression modulus	C	B	A
High flexural strength	B	C	A
Large bending mode	C	B	A
High impact resistance	B	A	C
Higher inter laminar shear strength	A	B	A
Higher shear strength in plane	A	B	A
Low density	C	A	B
High fatigue resistance	C	B	A
High Fire Resistance	A	A	C
Good thermal insulation	B	A	C
Good electrical insulation	A	B	C
Low thermal expansion	A	A	A
Low cost	A	C	C

In Table.5. are shown the most important characteristics of different types of fibers. It means good quality properties, and C is weak properties, showing that the fibers are not suitable for those qualities.

Table.6. Advantages for nylon and silicone

The advantages of nylon	The advantages of silicone
Durability	Excellent resistance to UV light
High elongation	Thermal Stability
Excellent abrasion resistance	High gas permeability

In Table.6. are shown some of the advantages for nylon and for silicone and in opposite we will have Table.7.which it contains the disadvantages for both of the materials.

Table.7. Disadvantages for nylon and silicone

Disadvantages of nylon	**Disadvantages of silicone**
High notch sensitivity	high in cost
Requires UV stabilization	sensitive to substances like sulfur clay
High shrinkage in molded sections	expensive and hard process to develop
Attacked by strong acids and oxiding agents	

Experimental studies

Currently there is a high degree of empiricism in addressing the physical properties of materials with filler agents. In a first approximation, you can use the law of mixtures (1) written in general form:

$$P_c = \sum P_i w_i \tag{1}$$

Where:
P_c= Composite material property;
P_i= property component *i*;
w_i= volume fraction of component *i.*
Sometimes the relationship is also used (2):

$$\frac{1}{P_c} = \sum \frac{w_i}{P_i} . \tag{2}$$

If mechanical properties in these equations must take into account the parameters included particle size filler agent, particle size distribution, orientation, packing geometry, specific interactions between the matrix and filler agent and effects along the interface. For these reasons, physical and chemical properties of the composites can be described by a single equation. Type epoxy resin with a hardener will pour six layers of fiberglass fabric. After drying, fiber glass and silicone joins the reinforcement layer in a sandwich structure.
In the figures below can be seen specimens obtained:

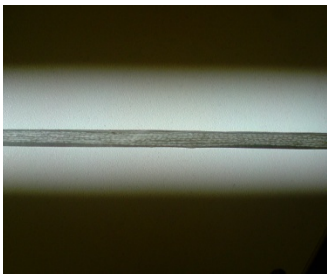


Fig.1. 6 E-glass layers

Fig.2. Core test-piece silicone

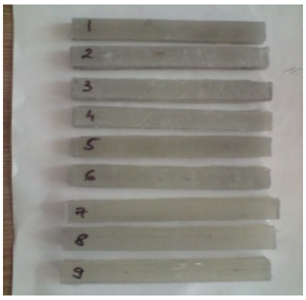


Fig.3. Specimens reinforced with silicone

Similar to the above process repeats for nylon fibers. In the figures below can be seen specimens obtained:

Fig.4. Specimens reinforced with nylon fiber

Fig.5. Specimens reinforced with nylon

Charpy bending tests:

Fig.6. Charpy bending tests

These samples were subjected to bending tests:

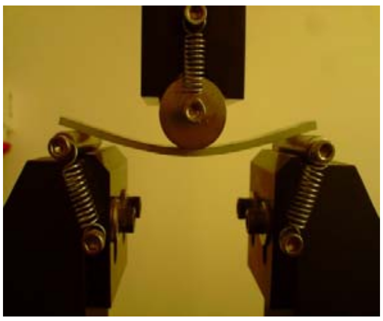


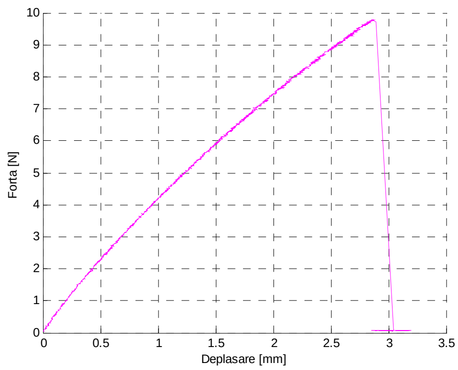
Fig.7. Specimens reinforced with nylon fiber

Fig.8. Specimens reinforced with nylon

After the bending test is finish, the results for both tubes with 6E-glass epoxy reinforced silicone and with nylon:

Fig.9. After bending test

Based on testing data were obtained that have been processed using Matlab program that emerged from these graphs:



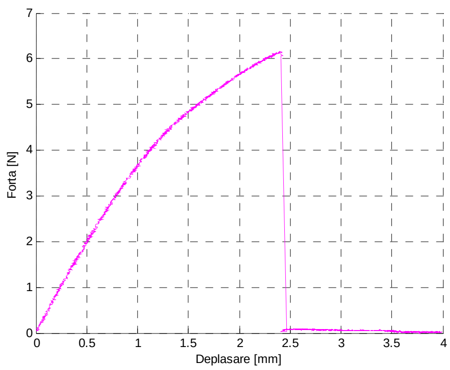


Fig.10. The result for nylon obtained in bending test

Fig.11. The result for silicone obtained in bending test

Conclusions

Comparison of two composite materials has resulted in favorable fabric fiberglass reinforced nylon given very good results obtained in bending.

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Studii teoretice si experimentale asupra materialelor compozite pe bază de fibră de sticlă armată cu țesătură din fibră de nailon sau silicon.

Rezumat

Această lucrare propune o comparație între cele două materiale compozite bazate pe o structură de tip sandwich compusa din rasina epoxidica cu fibră de sticlă armata cu fibra de nailon sau silicon, cu caracteristicile şi proprietățile acestora. De asemenea sunt prezentate mai multe avantaje şi dezavantaje.

Cazul important pe care il urmărim este de a consolida structura prin adăugarea unei grosimi variabile de straturi compozite din fibra de sticla ce formeaza şi optimizeaza concentraţia din stratul de armare al materialului din silicon sau din fibre de nailon.

Parametri importanţi cum ar fi materialul, grosimea şi îndoirea sunt studiati pentru analiza duritatii compozitelor epoxidice armate cu nylon sau silicon.

Analiza lucrarii descrie diferenţele între 6 straturi de rasina epoxidica cu fibra de sticlă cu o densitate 280g/m2 armate cu silicon şi 6 straturi de rasina epoxidica cu fibra de sticlă cu o densitate 280g/m2 armate cu nylon, iar rezultatele vor fi comparate între ele cu ajutorul testelor de îndoire. Materiale compozite sunt una dintre principalele domenii de cercetare în domeniul mecanicii pentru ultimele decenii.