CYCLIC BENDING OF VARIOUS GLASS FIBRES REINFORCED WITH POLYMER COMPOSITE ARCHITECTURES

Lecturer PhD. Eng. Mihai Alin Pop
Prof. PhD. Eng.Virgil Geamqn
Assoc. Prof. PhD. Eng. Dana Luca Motoc
Lecturer PhD. Mat. Vlad Monescu
Prof. PhD. Mat. Irinel Radomir
Transilvania University of Brasov, Romania

Abstract

The paper presents a contribution to the study and characterization of special composite materials based on resins reinforced with glass fiber and wire netting. Several tests were made previously for testing the behavior of the composites with resin reinforced with glass fiber to determine the physical and mechanical properties. There were used the following materials: Nestrapol 96 type resin reinforced with wire net with the specific weight of 400 [g/m^2] and a number of 3, 5 and 7 layers, Stratimat type fiber glass with the specific weight of 300, 450 and 600 [g/m^2] and a number of 3, 5 and 7 layers and a Tissue type fiber glass with the specific weight of 300 and 500 [g/m^2]. The results obtained for those composites were compared with the results obtained for resin Nestrapol 96 without reinforcement. The second aim of this paper, was to make a mathematical modeling and an optimization of the resin type of composite materials reinforced with wire net and two types of fiber glasses. The modeling and optimization of these composites are based on the results obtained previously from the bending test and cyclical bending test.

Keywords: Bending, fiber glass, polymer, architecture, composite materials

1. Introduction

Composite materials are prospective materials replacing classical materials in many fields, for their good properties, characteristics and a short time for manufacturing. Composite materials are used increasingly in industry and have a very wide spread in many areas of activities.

These materials have better physical and mechanical properties reported to the wall thickness compared to conventional materials.

The use of certain light materials having specific properties in engineering, especially in the air force technique, needs a certain development of research in the field of aluminum alloys, which represents the basic raw material for a great number of components.

The estimation and measurement of composite materials effective properties, such as the mechanical (e.g. longitudinal, shear or bulk modules, Poisson ratio, etc), thermal (e.g. thermal conductivity or thermal expansion, etc.) or electrical (e.g. electrical conductivity, etc.) in terms of the phase properties and microstructure, is a lastingly standing issue.

This paper reports a comparative analysis between the behavior of the composite materials – obtained thanks to resins reinforced with different materials - at the bending and cyclic bending.

Nowadays there is a tendency to reduce the consumption of materials, to improve new technologies, to simplify and reduce the production time.
With the present paper the authors are trying to make a contribution to the study and characterization of thin-walled patterns made from composite resins reinforced with glass fibre.

To the best of our knowledge, this is the first time when this type of materials is used for making patterns in foundry.

2. Experimental researches and modeling

For experiments, were used the following materials:

*a). Resin - **Nestrapol 96****

- It is an unsaturated, ortophtalic polyester resin. It is used to make the glass fibre reinforced parts for car bodies and sports and entertainment articles;
- application methods- spraying, brushing, roller;
- jellying time - 6 - 8 minutes at 25°C; 4 - 9 minutes at 82°C;
- use of the articles- after minimum 7 days since complete hardening;

** According to the information provided by the manufacturer of the resin*
(Available from http://www.industrial-coatings.eu/en/nestrapol-96-0. Accessed: Nov.2012).

b). Glass fibre:

- Stratimat with specific weight **300, 450 and 600 [g/m^2];**
- Tissue with specific weight **300 and 500 [g/m^2]**
- Wire netting 0,8 with specific weight **400 [g/m^2]**

c). Cobalt accelerator 6507;

d). Methyl - ethyl - cetone peroxide 50%;

e). Hardener: D 605

Mechanical tests were made with The Universal Testing Machine, WDS-150S type.

These materials have been used to manufacture plate parts. The process for obtaining this plate composite was as follows:

- Preparing the patterns (the tray with elevated walls) for making the plates; applying the removing wax in order to prevent the resin to stick/adhere to the walls of the pattern; drying and polishing the contact surfaces between the pattern and resin.
- Preparing and cutting the fibre glass to the pattern dimensions.
- Applying resin layers successively by brushing; after applying each layer a tissue fibre glass sheet was placed by brushing. The process was repeated until the desired number of layers was reached.
- The notation when were used reinforcement materials are: tissue **(T1, T2 ... etc.),** stratimat **(S1, S2 ... etc.),** wire netting 0, 8 **(PS1, PS2 ... etc.)** and for mixed tissue and stratimat **(TS1, TS2 ... etc.);**

3. Result

For determining the initial characteristics for polyester resins type Nestrapol 96 were made testing samples for compressive strength, tensile strength, bending, shock resistance and the results are shown in Tables 1 - 3.

Table 1. The initial characteristics obtained for the Nestrapol 96 resin (symbols for the samples N1-A).

Resistance to		**Average value**	**M.U.**
Compression		159,54	N/mm^2
Resilience		0,061	[J/cm^2]
Bending	Deflection of a girder	24,33	mm
	Bending resistance	21,55	N/mm^2
Stress strain		34,87	N/mm^2

Initial characteristics of the fibre glass:

- For tissue with specific weight **300 g / m²** we determined the tensile strength / wire: $\mathbf{R_{t\text{-}wire} = 217,\ 26\ [N/mm^2]}$
- For tissue with specific weight **500 g / m²** we determined the tensile strength / wire: $\mathbf{R_{t\text{-}wire} = 519,\ 91\ [N/mm^2]}$
- For the fibre glass stratimat type samples cannot be made to determine the tensile strength (fibre glass without resin).
- After determining the bending strength of these composite materials resin type reinforced with glass fibre the following were observed'

Table 2. Results obtained to bendings for the composite materials made in comparison with resins without reinforcement.

Type	**Average breaking resistance to bending by type of sample [N/mm²]**
NTS 2	**56.78**
NT 1	**54.85**
NT 4	**39.52**
N1-A	**21.55**

Table 3. Group of composite materials and configuration

Plates	Insertion	No. of Layers	Specific weight [g / m2]	Resin
N1-A	Resin	----	----	Nestrapol 96
NTS2	stratimat + tissue	1 + 2	300 + 300	
NT1	tissue	3	300	
NS4	stratimat	3	450	

4. Disscutions

4.1. Bending tests. From the obtained glass fibre stratimat composites, the maximum resistance to bending is registered at the plate NS1 (30, 23 N/mm^2) and the maximum recorded value of deflection of girder at the plate NS1 (42 mm) as well.

The worst results were recorded for resistance to bending (12.85 N/mm2) at NS6 plate and also the deflection of girder at plate NS6 (8.7 mm). *Bending strength and the value of deflection of girder decreases as the specific weight (for glass fibre) and the number of layers of insertion increases.*

From the obtained glass fibre tissue composites, the maximum resistance to bending is registered at the plate NT1 (54,85 N/mm^2) and the maximum value of deflection of girder at the plate NT6 (41,5 mm). The worst results were recorded for resistance to bending (21, 26 N/mm^2) at NT3 plate and also the deflection of girder at plate NT5 (12,1 mm).

Bending strength and the value of deflection of girder decreases and the specific weight (for glass fibre) increases.

From the composites obtained by combining glass fibre layers (stratimat and tissue), the maximum resistance to bending is registered at the plate NTS2 (56,78 N/mm^2) and the maximum value of deflection of girder at the plate NTS4 (37 mm). The worst results were recorded for resistance to bending (16,26 N/mm^2) at NTS3 plate and also the deflection of girder at plate NTS6 (11,3 mm).

When are using mixed glass fibres, the composite properties are given by the majority of the glass fibre in the mass of the composite;

If composites are obtained from the resins reinforced with wire netting, they are above the average of strength of glass fibre composites obtained from stratimat with specific weight 450 and 600 g / m^2, but lower than the composites made from tissue.

Bending strength decreases as the number of layers of insertion increases;

4.1. Cyclic bending tests. From plates previously made with best results to bending (Table 3) we made samples for the cyclic bending tests.

Tests were made by following steps: 5 samples from each material, 3 types of testings (1000 cyclic bending, 2000 cyclic bending, 3000 cyclic bending). In Fig. 1 is presented the Diagram for 1000 cyclic bindings

- The deformation of samples was approx. 2.4 mm for all samples.

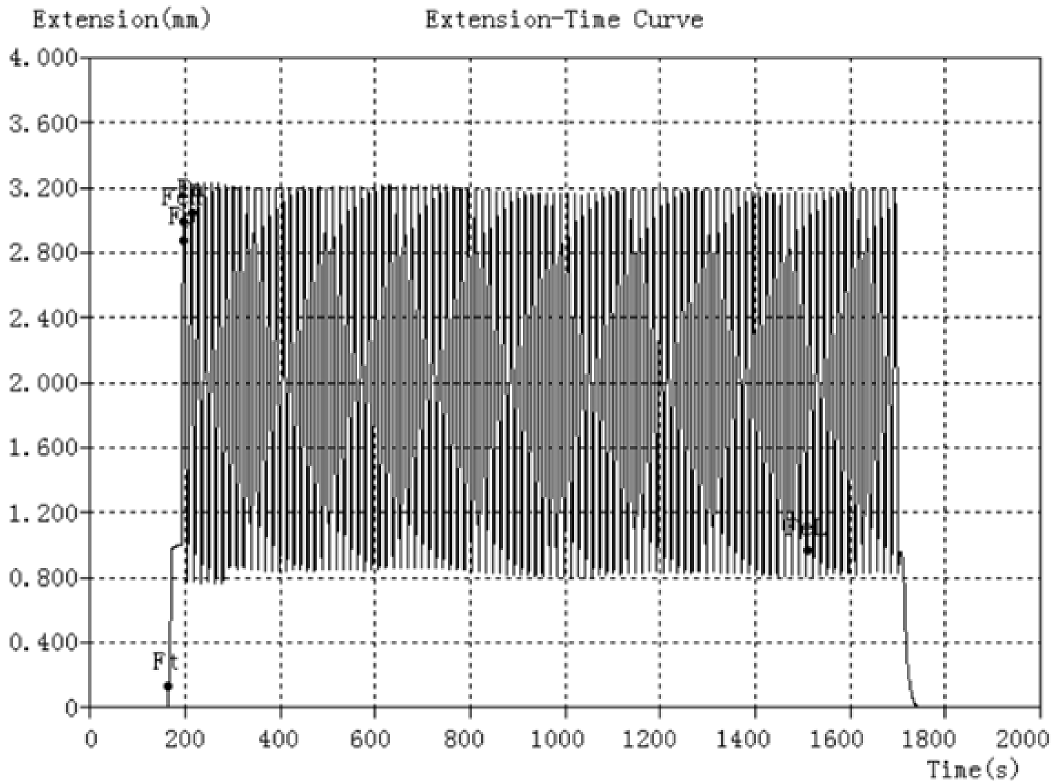

Fig. 1. Diagram for 1000 cyclic bendings.

After each test for all samples were determinate the resistance to bending. In Table 4 are presented the average of results.

Table 4. The average breaking resistance to cyclic bendings

Type	Average breaking resistance to cyclic bending by type of sample [N/mm^2]
1000 cycles	
NTS 2	55.64
NT 1	53.75
NT 4	38.73
N1-A	21.12
2000 cycles	
NTS 2	52.23
NT 1	50.46
NT 4	36.36
N1-A	19.83
3000 cycles	
NTS 2	48.26
NT 1	46.63
NT 4	33.59
N1-A	18.317

After analyzing the obtained results we can conclude:

- The resistance to bending is lower than the initial materials tested to bending without cycling bending, with approx. 1-2% for 1000 cycles, 7-8% for 2000 cycles and 14-15% for 3000 cycles.
- The resistance to bending decreases with increasing the number of bending cycles.

5. Final Conclusions

- From these materials it is recommended to obtain small and medium foundry patterns and the allowed pressure in the mixture is approx. 1 MPa.
- Because the resistance to bending decreases with increasing the number of bending cycles, the foundry patterns are recommended to be used of unique, small and medium production.

References:

Pop M. A., Constantinescu A.: Comparative study between the behaviour of composite resin reinforced with glass fibre. Mechanical properties, Proceedings of ModTech 2011. New Face of T.M.C.R., ISSN 2069 – 6736, pag. 889-893. Vadul lui Voda, Republica Moldova.

Milosan I.: Theoretical aspects regarding of some metallurgical's processes optimization; Metalurgia International, Volume: 15; Issue: 8; ISSN: 1582-2214,2010, pag. 55 - 58

Allaire G.: Numerical Analysis and Optimization. An introduction to mathematical modelling and numerical simulation, Oxford University Press, 2007

Maxfield B.: Essential Mathcad For Engineering, Science, and Math, Elsevier, 2009.

Mihai Alin POP, Alexandru CONSTANTINESCU: Manufacturing process for shell-type patterns utilised for moulds manufacturing. Metalurgia (60) no. 7 – 2008, ISSN 0461-9579.

Mihai Alin POP, Alexandru CONSTANTINESCU: Utilisation of composites for shell-type patterns manufacturing. Metalurgia International vol. XIII (2008) – no.9, ISSN 1582-2214.

Diana Elena APOSTU, Mihai Alin POP, Alexandru CONSTANTINESCU: Static loading of moulding thin-walled cave patterns manufactured of composite materials. Metalurgia International vol. XIV (2009) – Special Issue no. 10, ISSN 1582-2214.

Mihai Alin POP, Alexandru CONSTANTINESCU : Determination of material properties for thin-walled composite resin reinforced with glass fiber. Metalurgia (62) no. 8– 2010, ISSN 0461-9579.

Motoc Luca D., Pop P. A., Bejinaru, Gh.: A perspective in sizing the main influencing factors on the thermal properties of different metal/non-metal powders, Metalurgia International, vol. 4 (2011), p. 97, ISSN: 1582-2214, 2011.

Gheorghe SIMIONESCU, Constantin CERNAT, M. PANA: Engineering of moulding process, Elvarom Publishing House, Bucuresti, 2000.

Florin STEFANESCU, s.a: Composite Materials, Didactical and Pedagogical Publishing House, Bucuresti, 1996.

Aurel IACOBESCU: Modern Materials and technologies for resistance structure construction of solid fuel rocketmotors, http://www.actrus.ro.

Ioan MILOSAN: Some aspects about the processing of ceramic matrix composites (CMC) applied in automotive industry; Metalurgia, Volume: 62; Issue: 8; ISSN 0461-9579, 2010, pag. 29 – 31.

Motoc Luca D., Novac Gh., Bejinaru Gh.: Measuring and characterizing CTE variations for multiphase polymeric composites subjected to extreme environmental conditions, Metalurgia International, vol. 1 (2011), Issue. 1, ISSN: 1582-2214, 2011.

Virgil GEAMĂN, Mihai Alin POP: Microstructures of ATSi5Cu1 aluminum alloy processed by accumulative roll – bonding, Metalurgia, Volume: 64; Issue: 4; ISSN 0461-9579, 2012, pag. 9 – 13.

Mihai Alin POP: Determining the optimum number of layers using mathematical modeling for composite materials depending on the resistance to bending, Metalurgia International, Volume: 17 (2012); Issue: 9; ISSN: 1582-2214,2012, pag. 42 – 45.

Mihai Alin POP, Dana LUCA MOTOC, Alexandru CONSTANTINESCU, Virgil GEAMĂN, Rudolf Alexandru DERCZENI: CTE assessment of various glass fibre reinforced polymer composite architectures, Metalurgia International vol. XVIII (2013) – Special Issue no. 5, pag. 131-134, ISSN 1582-2214.