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MICROSCOPIC ANALYSIS OF COMPOSITE MATERIALS TESTED

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Abstract: *Microscopic analysis can be both an intermediate and a final control method. Its importance is as high as this method is easy and does not require special equipment, a large number of parts being controlled. By this metallographic analysis, information concerning manufacturing technology, the multilayer aspect, type of structure, weft and warp structure can be obtained. Thus, some specimens made of the above presented materials were studied, being able to analyze the layered structure, material damage, distribution of filling materials, non-uniformities that might occur.*
Keyword: *material section, fiberglass, 2D and 3D visualization, detailed analysis*

1. MACROSCOPIC ANALYSIS

The researcheas realized out for different layered composite structure reinforced with fiberglass, focused on the study of fiber orientation effects and positioning of the laminae on the mechanical characteristics of these materials for different combinations of loading. Also, studies have been conducted on the behaviour of polymer composite materials to tensile and bending tests to determine their rigidity, modulus of elasticity, and other mechanical properties of these materials.

Figure 1 Epruveta prinsă în bacurile maşinii de încercat şi extensometrul prins pe epruvetă

Most design procedures whether simple or sophisticated will be based initially on stiffness data and will often for composite applications relate to strain or deflection limit design. Con- sequently, Young's modulus values are nor-mally required for the principal in-plane directions using orthogonal axes. The Young's modulus is important in its own right as it controls the displacement/deflection, and thus the strain in the material. In addition, as many applications of composites are based on thin- walled structures (e.g., pultruded profiles, skins of sandwich structures), the Young's modulus is also important in controlling the ultimate load for the commonly observed, buckling fail- ures.
By macroscopic analysis the faults occurred in different manufacturing technological stages can be highlighted, namely: capacity faults (retouches, porosities, cracks), at the surface or in the depth of the product; these are different in nature (genesis), size, relative distribution (concentrated or dispersed) and may represent products rejection causes.
Acclaim system is a manual video camera with USB plug, 1/4 Inch CCD sensor; automatic exposure control; normal image, non-mirrored; 1,3 megapixels; capacity of magnifying 5 times the studied material.
The microscope meets the requirement of decreasing evaluation time and also improving quality by observing an entire image in real time just by turning the adjustment button while the studied part is observed.
Accurate images can be created within the depth of the observation field, by correcting edge deviations. It adjusts the edges displacement due to the displacement of the focusing position of an optical non-centric lens. A 3D image can be immediately displayed by moving the lens downwards.

Figure 2 VHX microscope during analysis

Figure 3 Video camera

2. ANALYSIS OF THE MATERIAL STRUCTURE

In order to be able to perform the tests for identifying mechanical properties of the new created material we manufactured samples made of several layers of MAT and Roving in various combinations and subjected them to different loads. Then comparisons were made between the theoretical results obtained by finite element method and the experimental results.
In this paper we will present the study of a made of MAT , roving composite material:
The following materials have been used:

- MAT 600 - fibreglass composite (short wires) in the matrix of epoxy resin with specific weight 2x600g / m2, 2-2, 6 mm thick; RT 800 - fibreglass composite (fabric) in the matrix of epoxy resin with specific weight of 4x 800g / m2, thickness 3,2-3,6 mm; MAT 450 - fibreglass composite (short wires) in the matrix of epoxy resin with specific weight 2x450g / m2, 1.6-2mm thick.
- MAT 450 - fibreglass composite (short wires) in the matrix of epoxy resin with specific weight 4x450g / m2, 1.6-2mm thick
- RT 800 - fibreglass composite (fabric) in the matrix of epoxy resin with specific weight of 4x 800g / m2, thickness 3,2-3,6 mm, warp and weft;

Table 1: Properties fiberglass to tensile

Composite material	Extension at Maximum Load, *mm*
MAT-Roving 8 layers composite	0,92118
Roving 4 layers warp	1,28
Roving 4 layers weft	1,10

Table 2: Properties fiberglass to bending

Materiale	Extension at Maximum Extension, *mm*
MAT-Roving 8 layers warp	4,61
MAT-Roving 8 layers weft	2,99
MAT 450 – 4 layers	5,52
Roving 4 layers warp	7,93
Roving 4 layers weft	7,4885

Both for dynamic and static application the appearance of the first damage occurs later tenacious matrix systems than for the brittle matrix .
In order to study the changes occurred in the composite material, 2 efficient devices were used: video camera and VHX microscope. After they were subjected to bending, the specimens were magnified by help of the above presented devices and studied in the breaking area (video camera magnified 5 times the area and the VHX microscope magnified it 500 times).

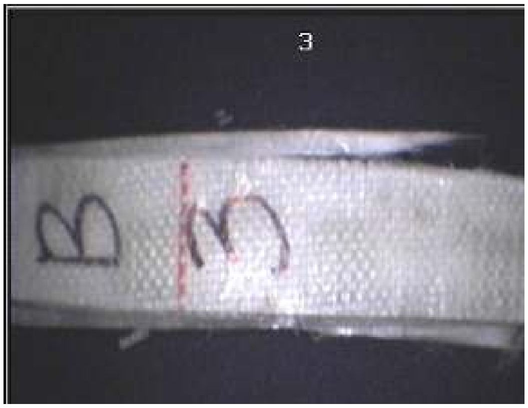

Figure 4 Specimen 3b Roving on weft magnified 5 times by video camera

Figure 5 Specimen 3b Roving on weft magnified 500 times by 2D microscope

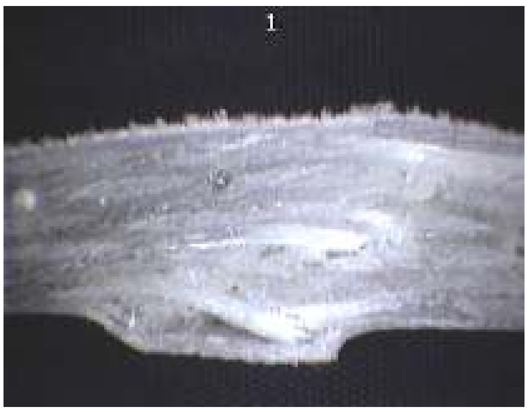

Figure 6 Specimen b4 Roving on weft magnified 5 times by video camera

Figure 7 Specimen b4 Roving on weft magnified 500 times by 2D microscope

If there are internal stresses in the composite materials reinforced with fibres, with higher values than those admissible, then during their use even a low load may damage irreversible the composite. Following the researches performed by now, it comes out how important are the precautions for diminishing the cracks creation risk. A representative method is the multilayer composite pre-tensioning namely introducing internal stress in composite, in order to increase its cracking limits.

Figure 8 Specimen u3 Roving on warp magnified 5 times by video camera

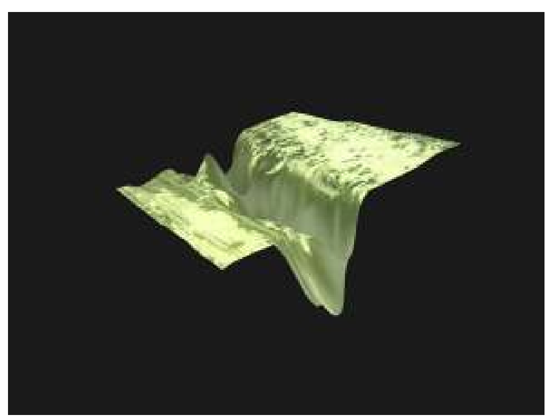

Figure 9 Specimen u3 Roving on warp increased 500 times by 2D microscope

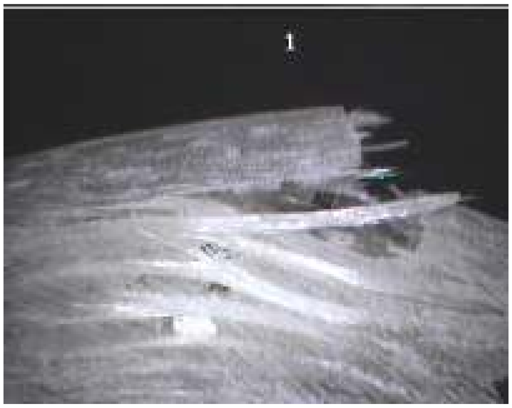

Figure 10 Specimen 5 MAT-Roving magnified 5 times by video camera

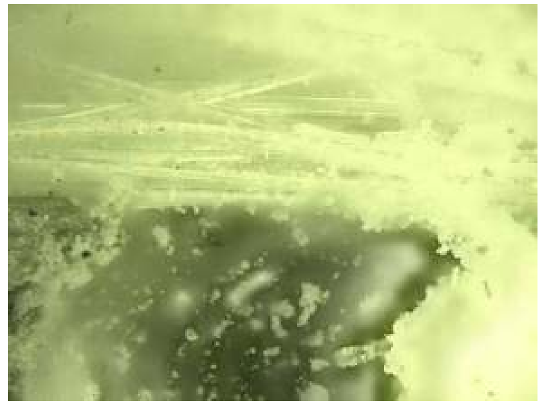

Figure 11 Specimen 5 MAT-Roving increased 500 times by 2D microscope

Figure 12 Specimen 8 MAT-Roving magnified 5 times by video camera

Figure 13 Specimen 5 MAT-Roving increased 500 times by 2D microscope

3. CONCLUSIONS

Performing microscopic researches lead to a detailed analysis of the material, its faults, breakage as follow of different loads, specifically thrust and bending, which usually produce damages both at fibre level and at matrix level.
We cannot match a composite material with a regular one, it is much more resistant, elastic, easier to manufacture, cheaper, lighter and keeps its properties in time.
The extreme complexity of some products, continuous appearance of new models and scientific theories that change the approach of the technologic act itself, makes anything to require a high concentration of material and conceptual forces
Thus, some specimens made of the above presented materials were studied, being able to analyze the layered structure, material damage, distribution of filling materials, non-uniformities that might occur.

REFERENCES

[1] Daniel, I.M. & Ishai, O. (2005). Engineering of Composite Materials, 2nd ed., Oxford University Press, ISBN: 978-0195150971.

[2] Davies, J.M. (2001). Lightweight Sandwich Construction, Wiley-Blackwell, ISBN: 978-0632040278.

[3] Noakes, K. (2008). Successful Composite Techniques: A practical introduction to the use of modern composite materials, Crowood, 4th ed., ISBN: 978-1855328860.

[4] A.E. Stanciu, D. Cotoros, M. Baritz, Microscopic analysis following bending of mat and roving type composite material, The 4th International Conference Advanced Composite Materials Engineering COMAT 2012 18- 20 October 2012, Brasov, Romania, 638-641.