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RESEARCH REGARDING THE INFLUENCE OF THE REINFORCEMENT DEGREE UPON THE TENSILE STRENGTH OF SOME COMPOSITE MATERIALS

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Abstract: *In this paper there is presented a study on the mechanical characteristics of some polymeric composite structures with different degrees of reinforcement. The composite structures were produced by Resin Transfer Moulding process (RTM). Based on the results of the tensile tests, comparative studies were made in order to determine the influence of reinforcement degree upon the tensile strength.*
Keywords: *composite materials, Resin Transfer Moulding, tensile strength.*

1. INTRODUCTION

Composite materials are not an entirely new concept. Examples are found in nature, such as wood, which is made of cellulose fibers linked to lignin or bone, comprising the periphery of compact tissue. Another example is the inside bone marrow, the whole being embedded in a fibro-elastic membrane, [IAN 03].
As a general definition, composite materials are a mixture of two or more different components whose properties complement each other, and the result is a material with superior properties to those specific to each component, [ŞOM 00].
Composite’s manufacturing technologies are numerous and the basic concept of each one is different from the others. The choice of the proper technology depends on the following factors: the geometrical shape of the part or product, the structure of the material, part’s dimensions, dimensional accuracy and quality of the parts, production batch, mechanical stresses, part’s destination, and so on [IAN 03].
To highlight the influence of the reinforcement degree upon the tensile strength, composite plates were made by RTM procedure. This is a process characterized by low pressure in a closed mold where a mixed resin and catalyst are injected. The mold is usually containing a fiber pack or a fiber preform. After the resin is cured, the mold can be opened and the finished component removed.
A wide range of resin systems can be used including: polyester, vinylester, epoxy, phenolic and methyl methacrylates, combined with pigments and fillers including aluminum trihydrates and calcium carbonates, if required. The fiber pack can be glass, carbon, aramid, or a combination of these.
Figure 1 shows an RTM installation.

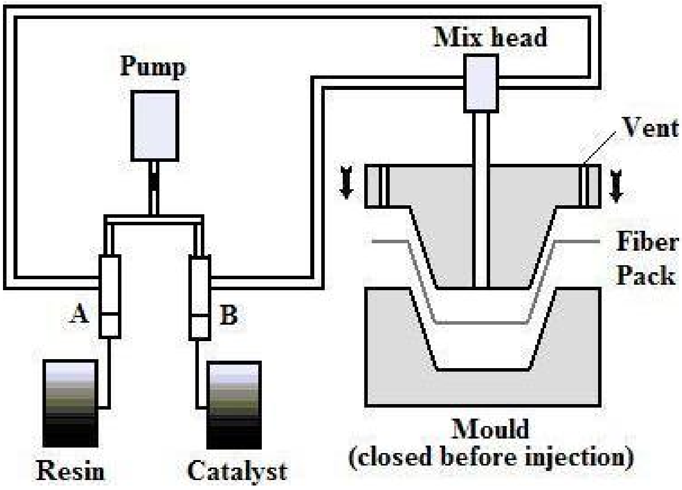

Figure 1. Resin Transfer Moulding installation [FLO 11a]

2. EQUIPMENT FOR COMPOSITE PLATES MANUFACTURING

2.1. RTM installation

For the manufacture of composite structures, fiberglass mat, *Unifilo U 813 300 g/m²*, made of continuous fibers without binder to facilitate the flow, was used as a reinforcement material. It was impregnated with a special polyester resin for RTM process, *Norsodyne I 20282 I.*
Composite plates were made using an experimental installation (fig. 2), located in *The Research Laboratory of Materials and Competitive Manufacturing Parts* from Technical University of Cluj-Napoca.

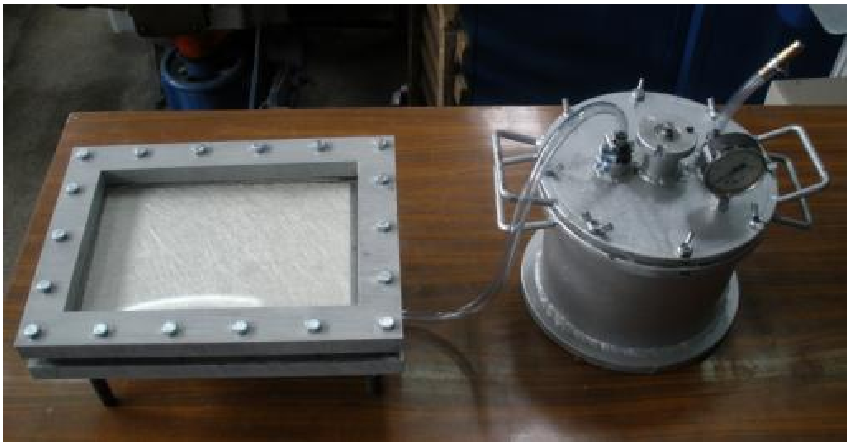
Figure 2. Experimental installation of RTM

2.2. Specimens

For tests were made 7 composite structures with different reinforcement degree. They were coded according to Table 1. The specimens cut from these plates were labeled with the same code as the plate.

Tabelul 1. Coding the composite plates

Nr. crt.	Specimen code	Number of layers	Reinforcement degree [%]
1	P1	5	37
2	P2	6	42
3	P3	7	47
4	P4	8	52
5	P5	9	56
6	P6	10	61

The reinforcement degree M_f of composite plates was calculated using the formula:

$$M_f = \frac{m_f}{m_c} \times 100 \quad [\%] \tag{1}$$

where: m_f - fiber weight;

m_c - total weight of the composite material.

3. EXPERIMENTS AND RESULTS

Determination of tensile strength through tensile testing is the most general and important resistance test. The method consists in applying a load along the main axis of the specimen, with a constant speed until failure or until the elongation reaches a predetermined value. For the tensile tests, 7 specimens were taken from each plate. They were cut from the composite plates to the desired dimensions on *Water Jet Cutting Machine* OMAX Jet Machining Center 2626 (fig 3), located in *Unconventional Technologies Research Laboratory and Competitive Manufacturing* from the Technical University of Cluj-Napoca.

Figure 3. Waterjet Cutting Machine OMAX Jet Machining Center 2626

Specimens dimensions and test data are in accordance with ISO 527-4 3 [ISO 97]. Specimens dimensions shown in figure 4 are: L = 250 mm, h = 25 mm, b = 2 – 3,2 mm.

To prevent the crushing or the breaking of the specimen because of the pressing from the machine jaws, end tabs were glued using a slow curing adhesive, Bison Epoxy Universal.

End tabs were made from a laminate composed of fiber reinforced epoxy resin.

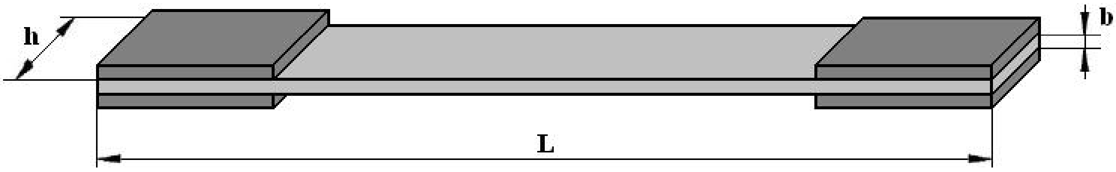

Figure 4. Tensile test specimen

For the tensile test was used an universal testing machine type Zwick/Roell Z150 (fig. 5), located in *The Research Centre on Sheet Metal Forming Technology CERTETA* from the Technical University of Cluj-Napoca.

Figure 5. Tensile test machine Zwick/Roell Z150

The tensile test machine is equipped with a computer control system with the ability to draw the diagrams of the variation of the force during traction and to calculate, based on section area specimens, the breaking strength, the elasticity modulus and the maximum strength. For fixing, longitudinal axis of specimens must be aligned to the test machine columns.
Speed test was 2 mm/min., and the tensile strength (σ_r) was calculated using the relationship:

$$\sigma_r = \frac{F_{\max}}{A}[MPa] \tag{2}$$

where: F_{max} - the maximum force required to break the specimens, [N];
A - initial cross-sectional area, [mm^2].
Tensile test were made at a temperature of 20 -22 ° C.
The tensile test results, the maximum breaking strength and the elasticity modulus for composite structures made by RTM process are presented in table 2. The specimens, subjected to tensile strength, are shown in Figure 6.

Figure 6. Specimens subjected to tensile strength

Table 2. Mechanical characteristics obtained after tensile test

Nr. Crt.	Specimen code		Specimens size		Section area [mm^2]	Longitudinal modulus E [MPa]	Maximum force [N]	Tensile strength [MPa]	Average tensile strength [MPa]
			Width [mm]	Thickness [mm]					
1	P1	P11	25.4	2.4	60.9	4259	4530	74.3	72.3
2		P12	25.3	2.4	60.7	4078	4310	71	
3		P13	25.3	2.4	60.7	4217	4360	71.8	
4	P2	P21	25.3	2.5	63.2	4897	5770	91.2	85.9
5		P22	25.3	2.6	65.7	4235	5200	79.1	

6		P23	25.3	2.6	65.7	4684	5750	87.5	
7	P3	P31	25.3	2.9	73.3	4007	6780	92.4	95.1
8		P32	25.4	3.1	78.7	4079	7450	94.6	
9		P33	25.3	2.9	73.3	4202	7220	98.4	
10	P4	P41	25.3	2.8	70.8	4489	7930	112	107.1
11		P42	25.3	3	75.9	3479	7960	104.8	
12		P43	25.4	3.4	86.3	3510	9030	104.6	
13	P5	P51	25.4	3.5	88.9	2947	9570	107.6	106.8
14		P52	25.4	3.4	86.3	2260	9090	105.3	
15		P53	25.4	3.8	96.5	3365	10400	107.7	
16	P6	P61	25.4	3.6	91.4	1968	9880	108.1	106.1
17		P62	25.4	4.2	106.6	2294	10830	101.6	
18		P63	25.4	4.2	106.6	2635	11600	108.8	

Variation of the tensile strength according to the reinforcement degree is shown in Figure 7.

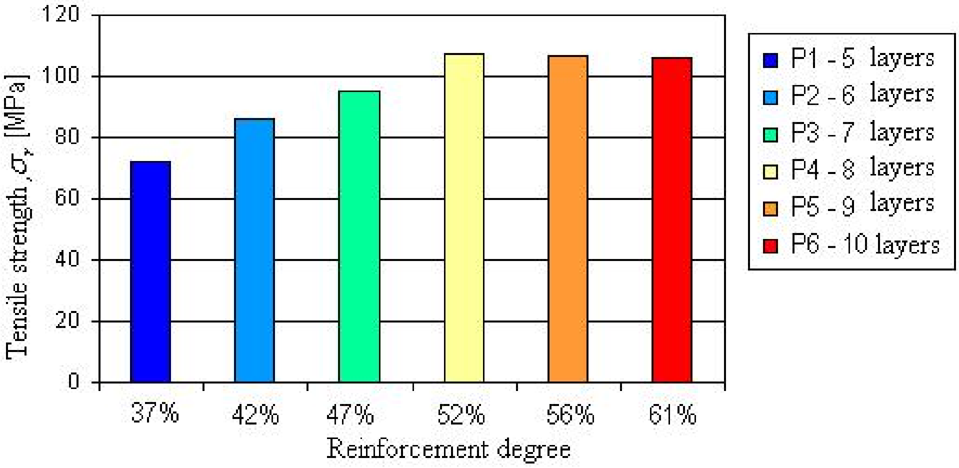

Figure 7. Variation of the tensile strength according to the reinforcement degree

4. CONCLUSIONS

Considering the results of the tensile test it is obvious that increasing the reinforcement degree, it also increases the tensile strength of the composite material. It appears to be an optimum on a degree of reinforcement for the composites studied by us, at 52%, corresponding to a composite with 8 layers.

It is noted that if exceed this degree of reinforcement, the tensile strength e begins to decrease. The explanation comes from the fact that the manufacturing process using RTM procedure takes place in a closed mold. That's why if the reinforcement degree is increased by increasing the number of layers, the quantity of the resin from the mold becomes insufficient to transmit filaments efforts. In this way they are not bound by the matrix, thus producing composite depreciation.

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REFERENCES

[1]. [BAR 87]Barrau, J.J., Laroze, S., *Calcul des structures en materiaux composites*, Tome 4, Ecole nationale superieure de l'aeronautique et de l'espace, Toulouse, 1987;

[2]. [BER 99] Berthelot, J.M., *Matériaux composites. Comportement mécanique et analyse des structures.*, 3^{e} édition, Editions TEC & DOC, Paris, 1999, ISBN 2-7430-0349-9;

[3]. [DEC 00] Decolon, C., *Structures composites: calcul des plaques et des poutres multicouches*, Hermès Science Publications, Paris, 2000, ISBN 2-74620-114-3;
[4]. [FLO 10a] Florea C., Iancău, H., Popescu A., Simon, M., and Bere, P., *Consideration regarding the manufacturing of the composite structures using the RTM process,* 3rd International Conference "Advanced Composite Materials Engineering " COMAT, ISSN 1844 – 9336, pag. 92 – 97, Brasov, 27- 29 October, 2010;
[5]. [FLO 11b] Florea C., Iancău, H., *Consideration regarding the influence of manufacturing process of the composite structures on their mechanical behaviour,*The 10th International Conference "Modern Tehnologies in Manufacturing" Cluj-Napoca, Romania, 6-8 Octombrie, 2011.
[6]. [HAD 02] Hadăr, A., *Structuri din compozite stratificate. Metode, algoritmi şi programe de calcul*, Ed. Academiei Române: AGIR, Bucureşti, 2002, ISBN 973-8466-25-3;
[7]. [IAN 03] Iancău, H.,Nemes, O., Materiale compozite. ConcepŃie si fabricaŃie., Ed. Mediamira, Cluj- Napoca, 2003, ISBN 973-9357-24-5;
[8]. [MAN 06] Manolea, Gh.: *Bazele cercetării creative,* Editura AGIR, Bucureşti, 2006.
[9]. [ŞOM 00] Şomotecan M., Compozite. Calcul de rezistenţă., Ed. U.T. Pres, Cluj-Napoca, 2000, ISBN 973-9471-28-5;
[10]. [TER 05] Tero, M. Materiale compozite realizate prin procedeul RTM. Cluj-Napoca, Editura Napoca Star,2005.