# Effect of Different Solutions on the Handmade Composite Materials

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*The paper presents the technology for obtaining the composite materials experimental samples – based on a resin reinforced with fiberglass, obtained manually and tested in terms of strength, corrosion behaviour and water absorption. In conducted experiments, these materials are recommended in order to produce finally: containers, tanks, hulls for boats, etc. It was also determined the effect of those solutions on the specimen's surface. The experimental researches conducted and presented here are not studying and there are not made statements about the compatibility and the biological interaction between the composite material and solutions studied (distilled water, saline solution and acetic acid).*

*Keywords: composite materials, behaviour, corrosion, absorbtion conditions*

The studies of composite materials presents a particular interest due to their relative low weight per volume unit compared to a conventional material, high wearing and corrosion resistance, high mechanical characteristics reported to the wall thickness [1-3].

The properties: physical, chemical, magnetically, electrical and mechanical are influenced by the compatibility between the base material (resin) with the reinforcing filler and the arrangement of components [4-6].

The composite material based on resin type reinforced with fiberglass (Stratimat and Tissue) with different specific weights, obtained manually, is suitable for manufacturing of goods and usual objects or with special destinations as: the hulls of boats, vessels for storing various solutions, etc.

From the wide range of resins and existing inserts to obtain composite materials only a small amount of them have been investigated and studied.

Nowadays there is a tendency to reduce consumption of classical materials, to improve technologies, to simplify and reduce the production time. The new material types like resin reinforced with fibreglass are the future trend in industry and manufacturing products [7].

## Experimental part

*Materials and methods for obtaining the composites*

In the study of this research, the authors have used for experiments, the following materials:

Resins:

- Nestrapol 96

Cobalt accelerator 6507

Methyl - ethyl - cetone peroxide 50%

Hardener: D 605

Fibre glass:

·Stratimat with specific weight 300, 450 and 600 g / m$^2$;

·Tissue with specific weight 300 and 500 g / m$^2$

The notations when using reinforcement materials are: tissue **(NT1, NT2 ... etc.),** stratimat **(NS1, NS2 ... etc.)** and for mixtures of tissue and stratimat **(NTS1, NTS2 ... etc.);**

These materials have been used to manufacture plates. The process of obtaining these composite plates was as follows:

- preparing the patterns (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 patterns 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 following types of plates were produced: (table 1)

The technological process for obtaining these composite materials is influenced by the following factors:

-The temperature at which the composite is obtained. A lower temperature slows down and even stops the resin polymerization when it has a high temperature (as well as direct exposure to sunlight) may lead to release toxic gases and it is possible even an auto-ignition phenomenon;

-The amount of hardener. A small amount of hardener (less than it is recommended by the manufacturer of the resin) results in a delay to cure the resin and thus in a greater working time, when a larger amount of hardener leads to shortening of polymerization and an exothermic reaction followed by the appearance of cracks in the resin mass (when the amount of hardener is too high).

-Being a handmade process for obtaining those composite materials the operator's skills and experience influences directly the average of the resin consumption, the final quality of the composite and the curring time.

-The quality of materials used. The consumption of resin at each fiber layer is approximately (70-75)g / layer when using Tissue and (90-95)g / layer when using Stratimat. These resin consumption values are valid for glass fibers with a specific weight of 300g / m$^2$, 450g / m$^2$, 500g / m$^2$ respectively 600g / m$^2$ and are variable, depending on the worker.

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**Table 1**
THE COMPOSITION OF OBTAINED COMPOSITE MATERIALS

| Composite materials obtained | | | | | |
|---|---|---|---|---|---|
| No. Crt | Symbolization | Resin | Fiberglass insertion | Number of insertion layers | Specific weight of the insertion [g / m$^2$] |
| 1. | N1-A | Nestrapol 96 | Without | -------- | ------- |
| 2. | N1-B | | Without | -------- | ------- |
| 3. | NS1 | | Stratimat | 3 | 300 |
| 4. | NS2 | | Stratimat | 5 | 300 |
| 5. | NS3 | | Stratimat | 7 | 300 |
| 6. | NT1 | | Tissue | 3 | 300 |
| 7. | NT2 | | Tissue | 5 | 300 |
| 8. | NT3 | | Tissue | 7 | 300 |
| 9. | NTS1 | | Stratimat + Tissue | 2 + 1 | 300 + 300 |
| 10. | NTS2 | | Stratimat + Tissue | 1 + 2 | 300 + 300 |
| 11. | NTS3 | | Stratimat + Tissue | 3 + 2 | 300 + 300 |
| 12. | NTS4 | | Stratimat + Tissue | 2 + 3 | 300 + 300 |
| 13. | NS4 | | Stratimat | 3 | 450 |
| 14. | NS5 | | Stratimat | 5 | 450 |
| 15. | NS6 | | Stratimat | 7 | 450 |
| 16. | NT4 | | Tissue | 3 | 500 |
| 17. | NT5 | | Tissue | 5 | 500 |
| 18. | NT6 | | Tissue | 7 | 500 |
| 19. | NTS5 | | Stratimat + Tissue | 2 + 1 | 450 + 500 |
| 20. | NTS6 | | Stratimat + Tissue | 1 + 2 | 450 + 500 |
| 21. | NTS7 | | Stratimat + Tissue | 3 + 2 | 450 + 500 |
| 22. | NTS8 | | Stratimat + Tissue | 2 + 3 | 450 + 500 |
| 23. | NS7 | | Stratimat | 3 | 600 |
| 24. | NS8 | | Stratimat | 5 | 600 |
| 25. | NS9 | | Stratimat | 7 | 600 |

*The behaviour of composite materials in different solutions - experimental procedure*

Given the opportunity to use these composite materials for various purposes (getting large pots, water storage basins, barrel to preserve long-term food, construction of hulls for boats, various containers) the specimens cut from the sheets obtained were tested under the following conditions:

-The behaviour in distilled water at 20°C,
-The behaviour in distilled water at 70°C,
-The behaviour in solution of NaCl 4% at 20°C,
-The behaviour in solution of NaCl 4% at 70°C,
-The behaviour in solution of NaCl 8% at 20°C,
-The behaviour in solution of NaCl 8% at 70°C,
-The behaviour in solution of acetic acid at 20°C,
-The behaviour in solution of acetic acid at 70°C,

At first, the edges of the specimens were not isolated against corrosive environment and because of the glass fiber capillarity was recorded an absorbtion of solution in the specimen mass. Subsequently, by repeating the experiment in terms of edge isolation (and thus of glass fiber) was observed a decrease of the solution absorbtion in the mass of specimens.

The edges isolation was made with resin without fiber glass. This extra step requires additional time waiting (drying and curring) of about 7 days.

The mass variation of the samples was determined by the difference between the mass of the sample before the experiment and after experiment.

The corrosion rate and the density can be calculated according to the relations (1) and (2) and are compared with scale of conventional corrosion resistance [1,8].

$$V_c = h\frac{m_c}{\rho}\ ;\ \text{[mm/year]} \quad (1)$$

where:
h = number of working hours in a year;
$m_c$ = sample mass lost [g/m$^2$h];
$\rho$ = material density [kg/m$^3$];

The density of the composite material will be:

$$\rho_c = \rho_M(1 - v_f) + \rho_f v_f\ ; \quad (2)$$

where:
$\rho_M$ = resin density = 1210 [kg/m$^3$];
$\rho_f$ = fiberglass density = 2540 [ kg/m$^3$]
$v_f$ = fiberglass proportion = 0.30

*The behaviour of the composite materials in distilled water at 20°C*

The samples were cut and on the edges it has been applied a layer of resin to avoid the direct contact of fibers with the solutions to avoid due to capillary of the glass fiber to produce an absorbtion of solution in the mass specimens. Each sample was weighted before each experiment and after: 72, 144, 288, 576, 1152 h and respectively at 7 days after the experiment. The experimental results are summarized in the diagram presented in figure 1.

Observations:

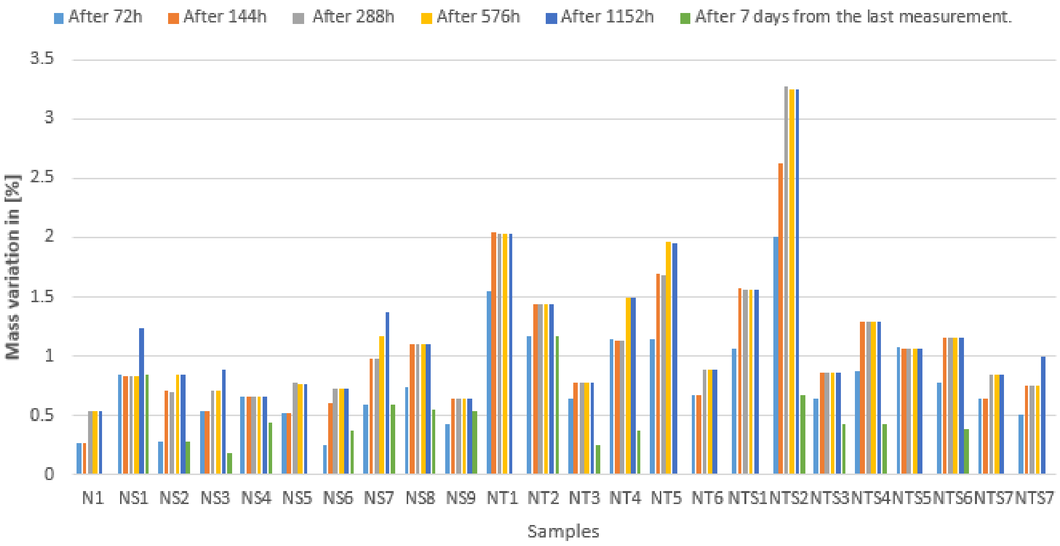


Fig. 1. The variation of mass specimens calculated in [%] in distilled water at 20°C

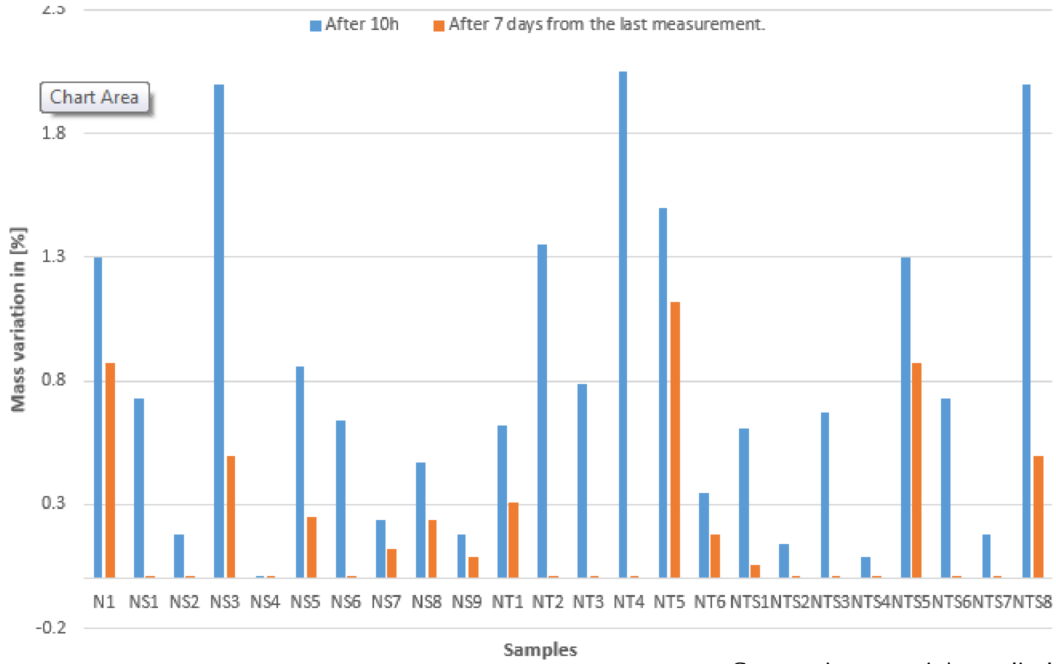


Fig. 2. The variation of mass specimens calculated in [%] in distilled water at 70°C

The samples had a good behavior in the experimental conditions.

Effect of the distilled water is on surfaces (surface tarnishing).

All samples had a solution absorbtion, but at a rate below 3.3% (NTS2 composite).

Composite materials studied it fits in group of *perfectly stable material* and have the stability coefficient 1 and 2.

*The behaviour of the composite materials in distilled water at 70°C*

In this case, each sample was weighted before each experiment, after 10 h and after 7 days after the experiment.

Note. In practical applications of these materials, the high temperature holding time is 2-3 h, and thus, for greater safety the tests were conducted at 10 h.

The experimental results are summarized in the diagram presented in figure 2.

Observations:

The samples had a good behavior in the experimental conditions.

Effect of the distilled water is on surfaces (surface tarnishing).

All samples had a solution absorbtion, but at a rate below 2.1% ( NS3, NT4 and NTS8 composite).

Composite materials studied it fits in group of *perfectly stable material* and have the stability coefficient 1 and 2.

*The behaviour of the composite materials in solution of NaCl 4% at 20°C*

Each sample was weighted before each experiment and after 72, 144, 288, 576, 1152 h and respectively at 7 days after the experiment. The experimental results are summarized in the diagram presented in figure 3.

Observations:

The samples had a good behavior in the experimental conditions.

Effect of the NaCl 4% solution at 20°C on surfaces is an aesthetic one (surface tarnishing and deposit of NaCl on surfaces).

All samples had a solution absorbtion, but at a rate below 2.25% and in the final a deposition of NaCl at a rate of less than 2.25% (NTS2 composite).

In terms of using these composites in salt solution (concentrations up to 4% NaCl) there are no problems.

Composite materials studied it fits in group of *perfectly stable material* and have the stability coefficient 1 and 2.

*The behaviour of the composite materials in solution of NaCl 4% at 70°C*

Each sample was weighed before each experiment and after 10 h and after 7 days from the experiment.

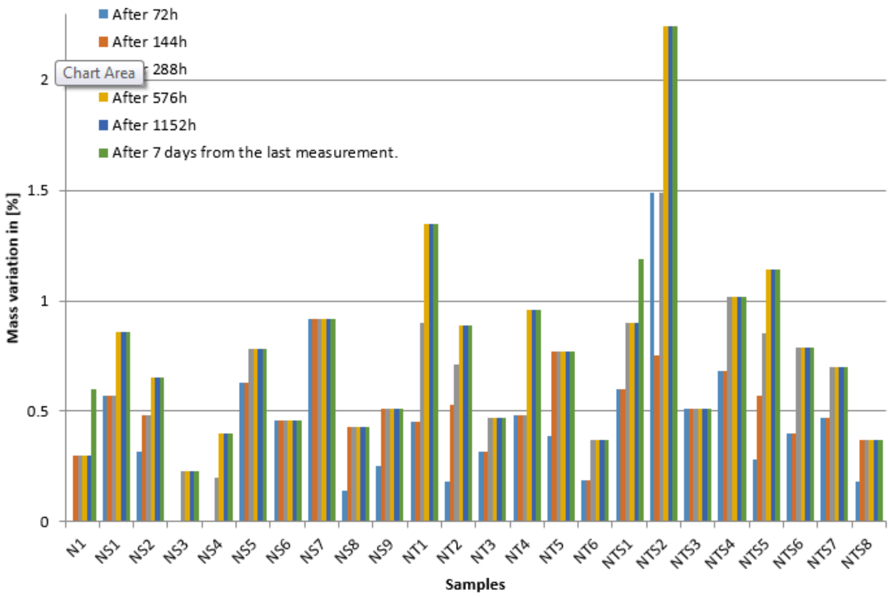


Fig. 3. The variation of mass specimens calculated in [%] in NaCl 4% solution at 20°C

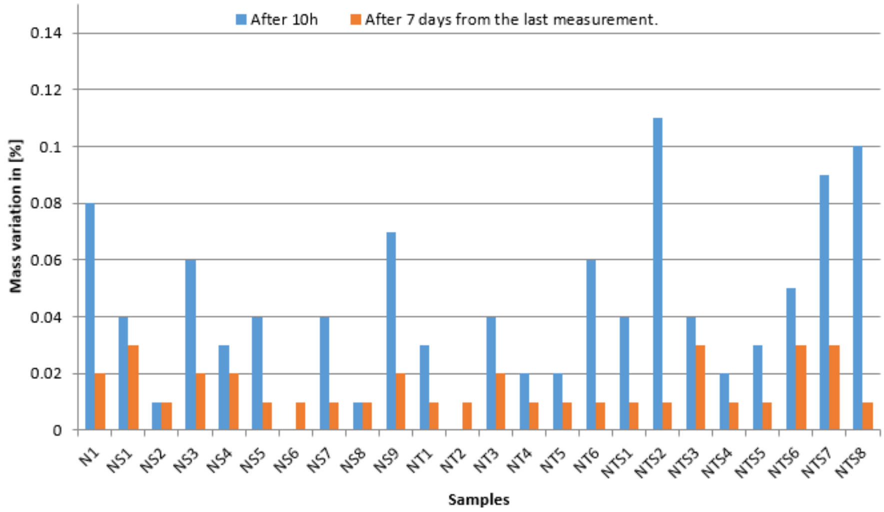


Fig. 4. The variation of mass specimens calculated in [%] in NaCl 4% solution at 70°C

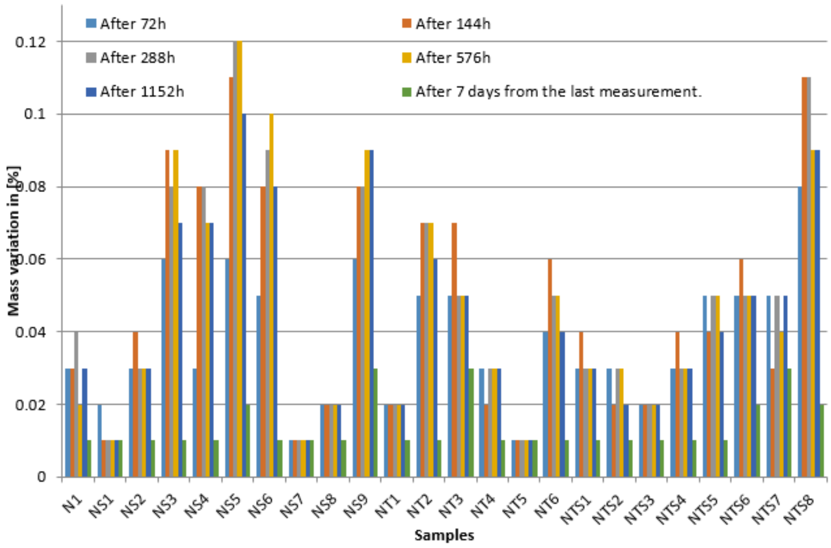


Fig. 5. The variation of mass specimens calculated in [%] in NaCl 8% solution at 20°C

Note. In practical applications of these materials, the high temperature holding time is 2-3 h, and thus, for greater safety the tests were conducted at 10 h.

The experimental results are summarized in the diagram presented in figure 4.

Observations:

The samples had a good behaviour in the experimental conditions.

Effect of the NaCl 4% solution at 70°C on surfaces is an aesthetic one (surface tarnishing and deposit of NaCl on surfaces).

All samples had a solution absorbtion, but at a rate below 0.15% and in the final a deposition of NaCl at a rate of less than 0.03% (NTS2 composite).

In terms of using these composites in salt solution (concentrations up to 4% NaCl at 70°C) there are no problems.

Composite materials studied it fits in group of *perfectly stable material* and have the stability coefficient 2.

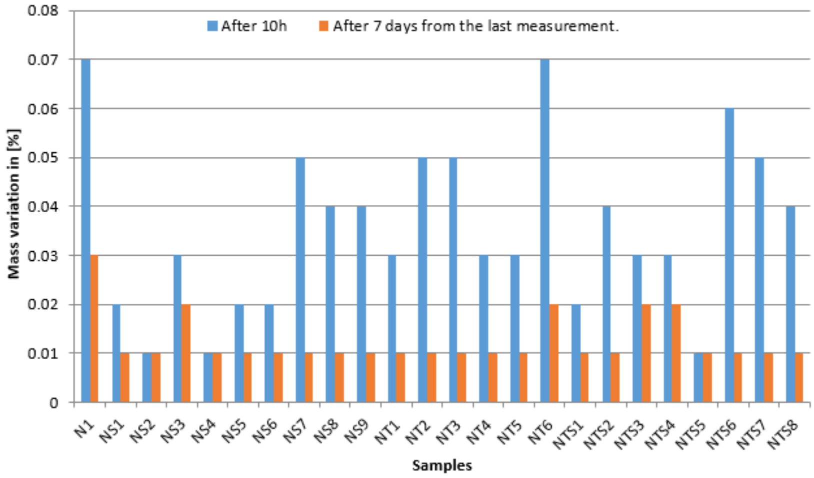


Fig. 6. The variation of mass specimens calculated in [%] in NaCl 8% solution at 70°C

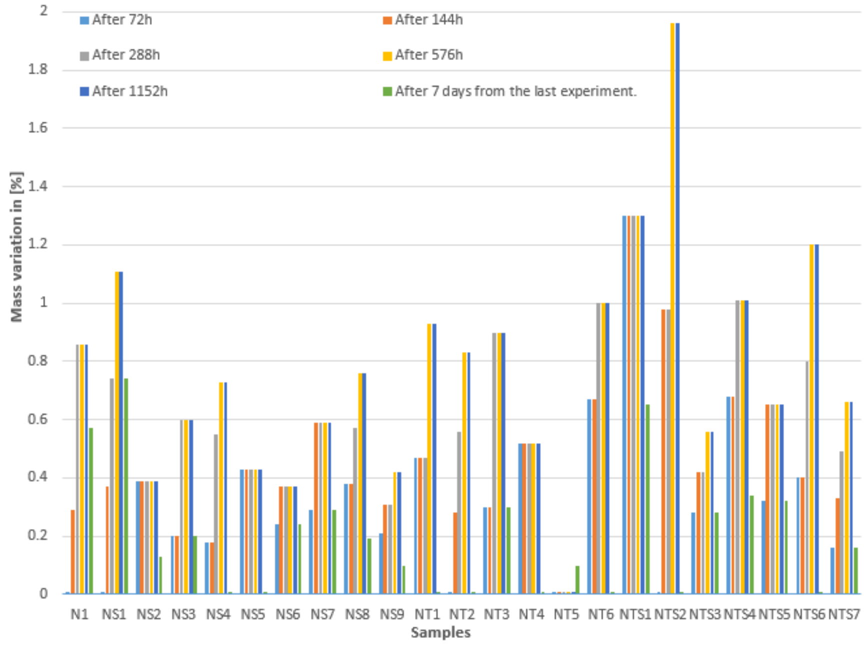


Fig. 7. The variation of mass specimens calculated in [%] in solution of acetic acid at 20°C

*The behaviour of the composite materials in solution of NaCl 8% at 20°C,*

Each sample was weighed before each experiment and after 72, 144, 288, 576, 1152 h and respectively at 7 days after the experiment. The experimental results are summarized in the diagram presented in figure 5.

Observations:

The samples had a good behavior in the experimental conditions.

Effect of the NaCl 8% solution at 20°C on surfaces is an aesthetic one (surface tarnishing and deposit of NaCl on surfaces).

All samples had a solution absorbtion, but at a rate below 0.15% and in the final a deposition of NaCl at a rate of less than 0.05% (NS5 composite).

In terms of using these composites in salt solution (concentrations up to 8% NaCl at 20°C) there are no problems.

Composite materials studied it fits in group of *perfectly stable material* and have the stability coefficient 1 and 2.

*The behaviour of the composite materials in solution of NaCl 8 at 70°C*

Each sample was weighed before each experiment and after 10 h and after 7 days from the experiment.

Note. In practical applications of these materials, the high temperature holding time is 2-3 h, and thus, for greater safety the tests were conducted at 10 h.

The experimental results are summarized in the diagram presented in figure 6.

Observations:

The samples had a good behavior in the experimental conditions.

Effect of the NaCl 8% solution at 70°C on surfaces is an aesthetic one (surface tarnishing and deposit of NaCl on surfaces).

All samples had a solution absorbtion, but at a rate below 0.1% and in the final a deposition of NaCl at a rate of less than 0.03% (NT6 composite).

In terms of using these composites in salt solution (concentrations up to 8% NaCl at 70°C) there are no problems.

Composite materials studied it fits in group of *perfectly stable material* and have the stability coefficient 1 and 2.

*The behaviour of the composite materials in solution of acetic acid at 20°C*

Each sample was weighed before each experiment and after 72, 144, 288, 576, 1152 h and respectively at 7 days after the experiment. The experimental results are summarized in the diagram presented in figure 7.

Observations:

The samples had a good behavior in the experimental conditions.

The effect of the acetic acid solution at 20°C on surfaces is an aesthetic one (surface tarnishing).

All samples had a solution absorbtion, but at a rate below 2% and in the final a deposition at a rate of less than 0.75%

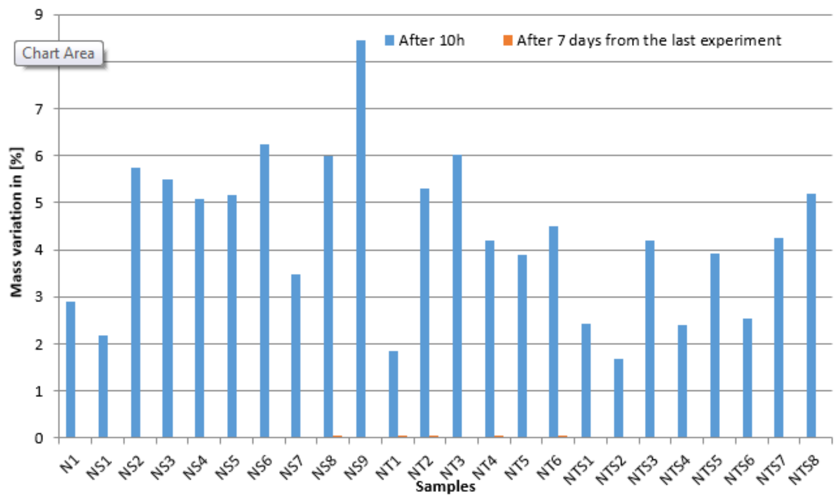


Fig. 8. The variation of mass specimens calculated in [%] in solution of acetic acid at 70°C

(NTS2 composite).

In terms of using these composites in acetic acid solution at 20°C, there are no problems.

Composite materials studied it fits in group of *perfectly stable material* and have the stability coefficient 1 and 2.

*The behaviour of the composite materials in solution of acetic acid at 70°C*

Each sample was weighed before each experiment and after 10 hours and after 7 days from the experiment.

Note. In practical applications of these materials, the high temperature holding time is 2-3 h, and thus, for greater safety the tests were conducted at 10 h.

The experimental results are summarized in the diagram presented in figure 8.

Observations:

The samples had a good behaviour in the experimental conditions.

The effect of the acetic acid solution at 70°C on surfaces is an aesthetic one (surface tarnishing).

All samples had a solution absorbtion, but at a rate below 8.5% and in the final a deposition at a rate of less than 0.05% (NS9 composite).

In terms of using these composites in acetic acid solution at 70°C, there are no problems.

Composite materials studied it fits in group of *perfectly stable material* and have the stability coefficient 2.

## Conclusions

All composite materials obtained and tested is suitable to manufacture of containers, tanks for collecting / storing water for ambient temperature and for temperatures up to 70°C.

All composite materials obtained and tested is suitable to manufacture containers, tanks for storage and / or manufacturing boat hulls that come into contact with solutions with salt concentrations of up to 8% and temperatures less than 70°C.

All composite materials obtained and tested is suitable to manufacture containers, tanks for collecting / storing acetic acid solution for ambient temperature and for temperatures up to 70°C.

*Acknowledgements: This paper is supported by the Sectoral Operational Programme Human Resources Development (SOP HRD), financed from the European Social Fund and by the Romanian Government under the project number POSDRU/89/1.5/S/59323" and we hereby aknowledge the structural founds project PRO-DD (POS-CCE, O.2.2.1., ID 123, SMIS 2637, ctr. No 11/2009) for providing the infrastructure used in this work.*

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Manuscript received: 23.11.2016