PROPERTIES OF EPOXY LAMINATES MODIFIED WITH MICRO-PARTICLES

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Abstract

This paper presents the results of epoxy laminate composites examinations. Laminates were reinforced with glass fiber STR 026-450-125 and also were modified using metallic powders with different granulations and content. The laminates were made of L-RTM technology using the laboratory test stand. The investigations contained static tension, flammability test and also impact resistance test. The test results allowed for determine the effect of the amount, the type of particle on the achieved values in tests.

Keywords: Composite, epoxy resin, L-RTM technology, mechanical properties

1. INTRODUCTION

Composite - laminate is a material consisting of at least two components which acquires new properties. It consists of a polymer matrix and reinforcement in the form of continuous or discontinuous fibers, and a modifier, eg. micro-particles. Matrix is a kind of binder and transfers the load on the reinforcement, while the modifier increases the mechanical properties [1].

Laminates are more and more used in the aerospace, automotive, renewable energy and construction.
Their properties depend on:

- type and form of reinforcement,
- layout fiber and weave type,
- the type of resin, in particular adhesion properties,
- potential modifier.

Products and compositions of the laminates are objects of research institutions worldwide. This is due to search for new, lighter materials which will replace the currently applied.

2. METHODOLOGY

In order to determine the effect of modifiers as powders for properties of composite were performed the following steps:

1) Production of laminates using L-RTM technology (**Figure 1**) with different configurations of structure (**Table 1**). On the metal mold with a temperature of 30 °C were placed 6 layers of glass fabric with weave 1/1 and linear density 450 g/m^2. Thus prepared reinforcement covered with a top plate equipped with the corresponding inputs/outputs for resin/air. Then, the vacuum pump was turned on to clamp the top plate to the lower plate. The next step was prepare a resin composition and supersaturation reinforcement located in the mold.

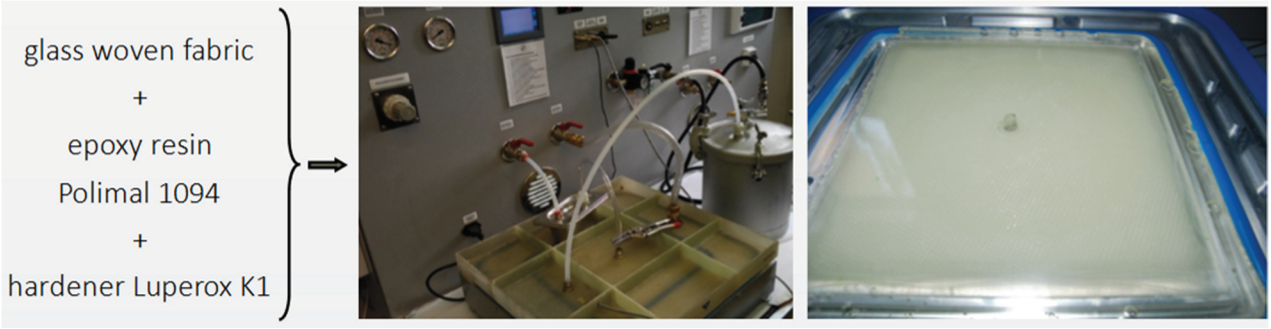


Figure 1 Production of laminates using L-RTM technology

Table 1 The composition and marking laminates

type of powder and	without powder	aluminum			zirconium dioxide			cobalt aluminate		
powder granulation	-	63 µm			63 µm			63 µm		
number of glass fabric layers	6	6			6			6		
type of epoxy resin	Polimal 1094	Polimal 1094			Polimal 1094			Polimal 1094		
powder content (%)	0	3	6	9	3	6	9	3	6	9
sample number	1.0.	1.1.	1.2.	1.3.	2.1.	2.2.	2.3.	3.1.	3.2.	3.3.

2) Preparation of test samples. In this step from composite panels were prepared test samples using water jet cutting. The **Figure 2** shows an example sample for each test.

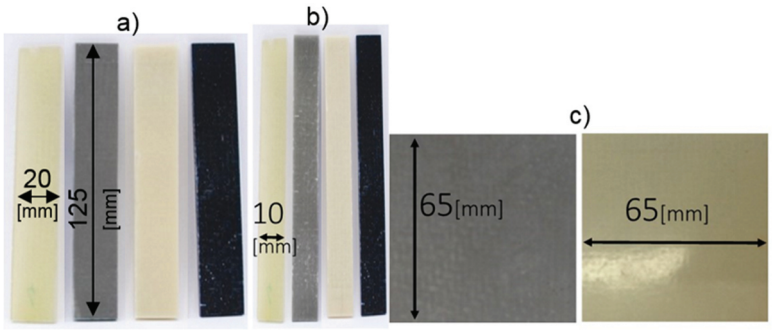


Figure 2 Samples for tests: **a)** Tensile testing, **b)** Flammability test, **c)** Impact tests

3) Tension test was performed on a standard testing machine. In this test was measured the maximum force needed to break of the samples [2].

4) Flammability testing in accordance with UL 94 (**Figure 3a**). The sample was designated in accordance with scheme in **Figure 3b**. Then one end fixed in a special holder to the other end of the sample was applied the flame at a suitable angle. The test was ended after 60 seconds.

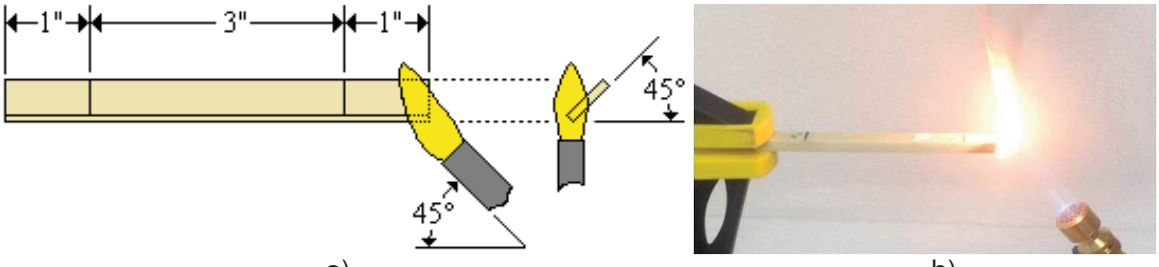


Figure 3 Flammability testing: **a)** testing scheme, **b)** laboratory test stand

5) Impact test (**Figure 4**). Samples of adequate size were placed in the metal sleeve. In the next step, impact hammer was put into the tube placed on the sample. Then were observed the samples surfaces [3].

Figure 4 Impact test: impact hammer and test stand

3. RESULTS

For tests were used 8 of 10 laminate plates. Laminates containing 6 and 9 percent of cobalt aluminate powder were unable to produce, because the resin composition was too dense and it was not able to saturate the reinforcement properly. For each structure configuration were tested 3 samples. The average results are shown in **Figure 5**.

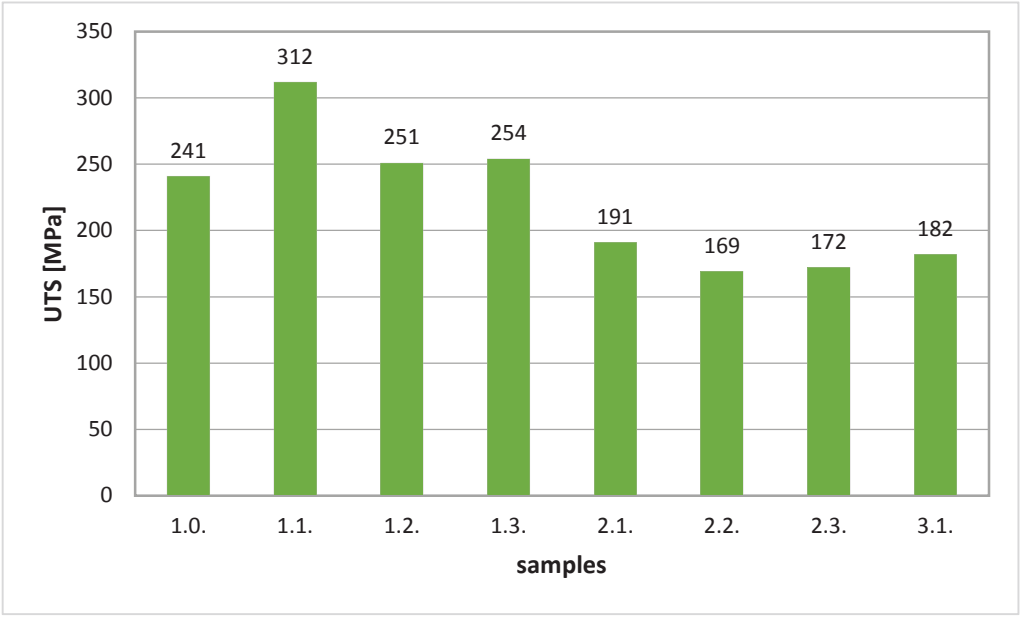


Figure 5 UTS values for samples

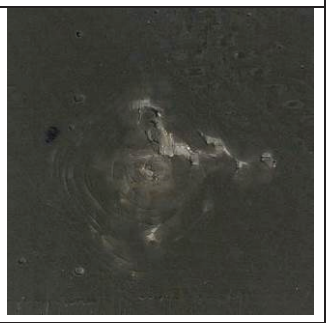
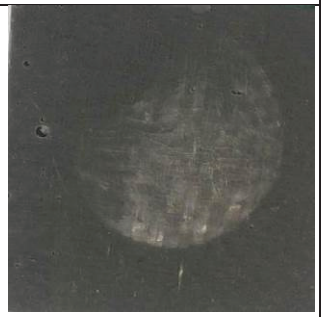
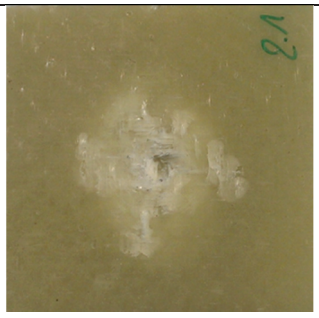
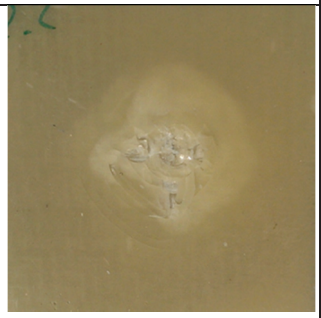
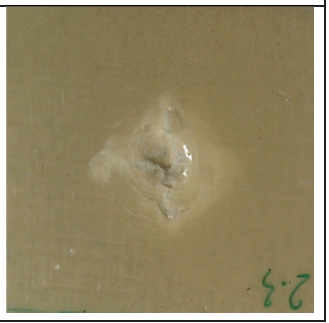
The first test was static tensile test. The tensile strength of the samples without powders was on the level of 241 MPa. Samples 1.1. with 3% aluminum powder have UTS at the level of 312 MPa. This was the highest value among all the tested samples. Application 6 and 9 percent of aluminum powder resulted in a slight increase of UTS value compared to the sample 1.0. Samples with added zirconium dioxide powder were UTS

at the level of 170 - 190 MPa. The 3% of modifier cobalt aluminate (sample 3.1.) also had a negative impact on the value of UTS in comparison to the samples without modifier.

The next test was the flammability test. The sample without the modifier quickly started to burn bright flame. A similar situation was with the samples with added zirconium dioxide and cobalt aluminate. Samples with added aluminum behaved differently. After applying the flame to the sample, was not burned for about 10 seconds. In comparison with others, those are the most resistant to flame. **Figure 6** shows samples after the test.

Figure 6 Samples after flammability test

The last test was the impact test. Pictures of samples after impact test are shown in **Figure 7**.

	1.1.	1.2.	1.3.
top surface			
bottom surface			
	2.1.	2.2.	2.3.
top surface			

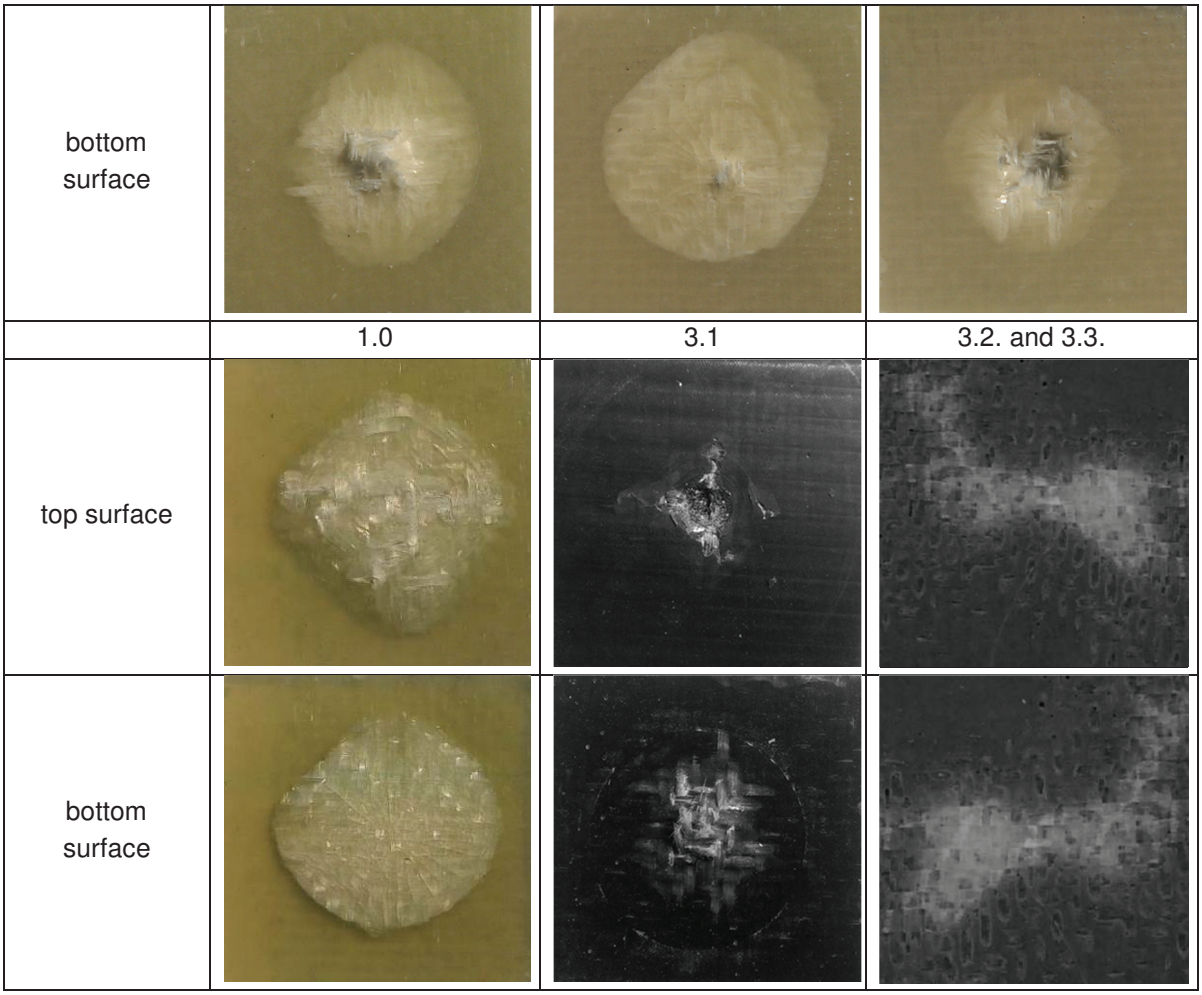


Figure 7 Top and bottom surface samples

The sample with no addition of modifier has a significant amount of damage to both sides. However, the hammer does not break through the sample. For sample 1.1. with addition of 3% aluminum powder have similar defects as the sample 1.0., but on the top surface of sample the resin was less chipping. Samples 1.2. and 1.3. had slight damage. The samples with addition zirconium dioxide and cobalt aluminate were too brittle and impact hammer pierced them.

4. CONCLUSION

1) The resin with 6 and 9 percent of cobalt aluminate powder was too dense and not saturated the fiber.
2) Aluminum powder increases the tensile strength of the laminates.
3) Samples with aluminum powder show a lower flammability.
4) Aluminum powder increases the impact resistance of the laminate.

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