Tungsten Carbide Nanopowder Influence Study on Tensile Strength of GRP Specimens Made of Lavesan Glass Fabric and EPR 320 Momentive Epoxy.

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Abstract. This paper presents the test results of fiberglass samples consisting of glass fiber Lavesan (Italy) and a binder - EPR 320 epoxy resin modified with tungsten carbide (WC) nanopowder. The positive effect of nanopowder on the tensile strength and the increase in tensile strength of more than 1.5 ... 2.5 times with the addition of additives in the mass concentration of 1 ... 4% to the mass of the resin are shown.

Keywords: GRP, epoxy, nanopowder, tungsten carbide, strength.

1. Introduction

At present, one of the most popular construction materials in the aerospace industry is composite materials based on carbon glass fiber fillers with polymer matrix [1]. The popularity of these materials is due to their strong physical and mechanical characteristics, small specific weight and low cost [2]. To achieve greater efficiency and expand the range of their application, there is a need to create lighter and stronger materials of this kind.

The most popular reinforcing fillers of composite materials are carbon and glass fabrics of different weaving [3,4]. Thermosetting synthetic resins and thermoplastic polymers are most commonly used as a matrix. In recent decades, there has been an interest in improving the physical and mechanical characteristics of polymer composite materials by introducing nanosize particles into the polymer matrix, such as nanotubes [5], astralenes, fullerenes [6], and mineral and organic nanodisperse powders [7-11]. However, the wide use of nanomodifiers is constrained by their high cost and small production volumes.

To solve this problem, the authors of this paper propose using nanopowders of metals and their compounds obtained by the technology of manufacturing nanopowders of metals, carbides, nitrides and oxides from carbide wastes [12,13]. This method provides mass production of nano-sized powders at a low price, which potentially allows for inexpensive modification of composites.

Previous studies [14] have shown the effectiveness of using nanopowders derived from the technology [13] as an additive to epoxy resin, increasing its strength characteristics.
2. Materials and methods of the study
For this experiment, the glass fabric Lavesan (Italy) was used as a basis for manufacturing fiberglass. Its characteristics are as follows: a density of 162 g/m², weaving twill 2x2, a thickness of 0.16 mm. WC tungsten carbide nanopowder obtained by technology [12] from carbide wastes was used as a modifier of fiberglass plastics. Research of nanoadditives was carried out on the scanning electronic microscope PHENOM proX from Phenom-World B.V. (Netherlands) with an integrated energy dispersion analysis system. An elemental analysis of the studied powders was conducted using Element Identification software by Phenom; ParticleMetric software was used for particle size analysis.
Tungsten carbide powder is a nanoplate with sizes from 40 to 200 nm, larger particles are particle agglomerates (fig.1).

![Figure 1](image1)  
**Figure 1**. Tungsten carbide powder microphotograph (a) at 11,000 times magnification, particle size distribution (b).

The chemical purity used as a modifier of tungsten carbide powder was confirmed by an elemental analysis and the obtained spectra of detected elements (fig. 2).

![Figure 2](image2)

**Figure 2.** Elemental spectra (a) and elemental composition of powder (b) of tungsten carbide.

In order to study the effect of tungsten carbide nanopowder on the tensile strength of fiberglass plastics, samples were produced using lamination technology. The binder was prepared according to the recommendation of the manufacturer and nanopowders were introduced directly into the hardener by mechanical stirring for three minutes. The samples were obtained in the form of plates 150x30x1 mm in size, consisting of three layers of structural glass fabric each with a different content of nanopowder, from 0 to 10% of the mass of epoxy used, with 1% pitch. Thirty-three samples, 3 for
each concentration, were manufactured. Solidification of specimens up to the moment of their testing on the tensile strength was carried out within five days at a temperature of 24°C and relative humidity of 66%. Tensile strength tests were carried out on a universal testing machine TRM – 500 "Tochline" at a loading speed of 20 mm/min until the complete failure of the specimen. The working length of the specimen was 70 mm, the width – 30 mm.

3. Results and analysis

Tensile strength values for all tested GRP specimens were obtained during the tests. The changes in tensile strength (%) compared to the reference sample (without nanopowder) are shown in figure 3.

![Figure 3](image.png)

**Figure 3.** Change in the tensile strength (%) of GRP modified with tungsten carbide nanopowder compared to a reference sample (without nanopowder).

As can be seen from the presented results of the experiment with increasing concentration of nanopowder in fiberglass plastics the change in strength has a wave-like character, which indicates the specificity of the interaction of nanopowder particles and epoxy binder, which requires additional research.

The received results indicate a positive influence of the nanomodifier in the investigated range on the breaking strength alteration of the investigated GRP samples. At the content of nanopowder in epoxy resin of 1%, the tensile strength of fiberglass plastics increases more than 1.5 times. The maximum change of GRP strength in the studied range is achieved more than 2.5 times at the content of nanopowder of 4% of the mass of epoxy resin.

4. Conclusion

The following conclusions can be drawn from the obtained data:
- The use of tungsten carbide nanopowder obtained from carbide waste has a positive effect on the tensile strength of the examined GRP.
- At the concentration of WC tungsten carbide nanopowder from 1 to 4 % of the mass of epoxy resin with hardener, the increase in the tensile strength limit of GRP samples is observed to be more than 1.5 ... 2.5 times in comparison with the control samples.
It should be noted that the production of samples was carried out without using special technological solutions, except for the additional operation of mixing additives in the hardener, which indicates the possibility of using a modifier with minimal changes in the technological process in their production.

This shows the wide potential for these modifiers to be used in the aerospace industry to meet the challenges of increasing strength and facilitating parts.

Since additives significantly increase the strength of the binder, it is planned to further study the possibility of reducing the number of layers of glass fabric while maintaining the strength of samples, or reduce the volume of binder.

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