PREDICTING THE FLEXSURAL STRENGHT OF TEXTILE COMPOSITES BASED ON GLASS FABRICS

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Abstract

Properties of textile reinforced composites arise as a function of its constituent materials, their distribution, and the interaction among them and as a result of it an unusual combination of material properties can be obtained. This paper examines the effect of type of textile fabric and applied pressure on flexural properties of laminated composite materials. For this purpose prepregs were made from two types of E- glass fabric (with different weave structure) and epoxy resin, which were further processed into composite plates using compression molding technology. The flexural properties of manufactured samples were determined with help of three-point-bending test according to the standard EN ISO 14125. In order to obtain the maximum number of data with a minimum number of experiments and to obtain the appropriate properties of the laminated composite samples, factorial design of experiment 2^2 was used. Obtained results shown that the main contribution to the flexural strength is given by the type of textile fabric used for manufacture the samples. Laminated composite samples reinforcement with glass fabric with twill weave pattern shown maximal flexural strength of 546, 934 MPa. On the other hand, applied pressure has a negligible positive effect on the response.

SPECIMEN PREPARATION

In this study are used pre-impregnated composite materials, which were produced by using the hand lay-up technique. For the production of prepreg materials two different types of two- dimensional E - glass fabric were used. In these experimental test as a matrix, a two-component thermosetting system of epoxy resin (DER 3821) and a hardener ((Polypox H 766) was used. For production of composite laminates ten piles of manufactured E glass fabric/ epoxy resin prepreg with dimensions 250 mm x 200 mm were used. The plies were stacked in press machine where final curing of the preforms was performed at compressive pressure of 30 and 40 bar and temperature of 70-80° C. Flexural properties of manufactured samples were determined with help of three-point bending test in accordance with the procedure described in the standard EN ISO 14125. For that purpose computer controlled universal testing machine (UTM) Hydraulic press, SCHENCK- Hidrauls PSB with maximal load of 250 kN, constant crosshead speed of 5 mm/min and span-to-depth ratio of 16:1 was used (Figure 1). With help of machine five rectangular forms (15 x 60 mm) in a machine direction MD and five rectangular forms in CD direction (contrary to the direction of the machine) were cut from finished composite laminates. Load and displacement were recorded by an automatic data acquisition system for each sample. Minimum five reproducible tests were conducted for each sample at room temperature. Samples ready for testing are presented on Fig. 1, whereas three-point-bending test is given on Fig. 2.

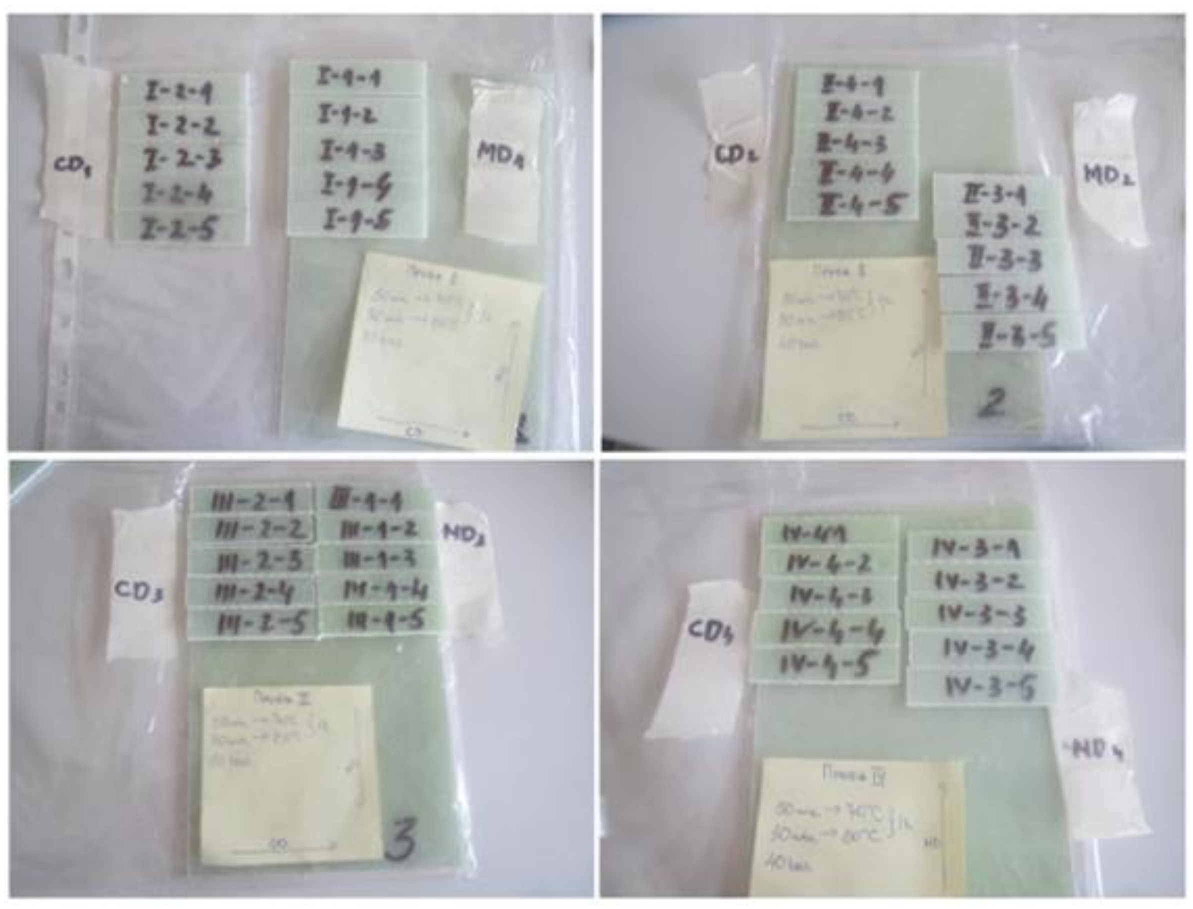

Figure 1. Prepared composite samples for testing

Figure 2. Flexural strength test using a three-point flexural method

DESIGN OF EXPERIMENT (DOE)

To optimize the production process of laminated composite samples and quantitatively to determine the influence of production parameter: applied pressure (X_1), type of weave structure (X_2), design of experiment (DOE) has been followed. DOE has been well known for its efficiency and allow gaining a maximum of information from a minimum amount of experiments. Used technological parameters in two different levels with number of permutations 2^2 are presented in Table 1, whereas Table 2 represents manufacturing parameters of each laminated sample.

Table 1. Level of used parameters

Parameters	**Symbol**	***Parameter level***	
		1	**2**
Pressure (bar)	(X_1)	14	18
Type of weave structure	(X_2)	Twill (T)	Plain (P)

Table 2. Design of experiment (2^2) for laminated samples

N°	$\mathbf{X_1}$	$\mathbf{X_2}$	$\mathbf{X_1}$ **(bar)**	$\mathbf{X_2}$ **(type)**
1	1	1	18	T
2	-1	1	14	T
3	1	-1	18	P
4	-1	-1	14	P

RESULTS AND DISSCUSSION

The results for flexural strength, dispersion and minimal value of parameter's final coefficients for factorial design 2^2 in this research are shown in Table 3.

Table 3. Results from design of experiment (DOE)

N°	Y_{exp}	Y_{cal}	S_y^2	S_y^2 **sum**	S_y^2**mid**	**Sβ**	**Sβt**
1	546,9342	544,65	67,4116	2366,70	591,67425	5,439	11,53
2	492,8126	495,09	1404,4564				
3	436,7326	434,45	561,6971				
4	481,7312	484,01	333,1320				

According to table 3, minimal calculated value of parameter's final coefficients is 11,53. Parameter's function and their interaction with 5% mistake are represented with following equation:

$$\mathbf{y = 489{,}5511 + 30{,}321x_2 + 24{,}7811x_1x_2}$$

From design 2^2 were calculated Cochran criteria (Gcal) with value 0,593 and Fisher criteria (Fcal) with value 0,176, which fulfill the rule Gcal < Gtab and Fcal < Ftab. According to this, the hypothesis for model 2^2 is acceptable with 5% mistake. Obtained results shown that the main contribution to the flexural strength is given by the type of textile fabric used for manufacture the samples.