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New Plain 200 Epoxy Based Carbon Prepregs

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Abstract

This paper presents the most important mechanical properties of three new developed prepregs based on 1050 epoxy resin and PLAIN 200 carbon fabric with 200 g/m^2 specific weight used as skins in ultra-lightweight sandwich composite panels with applications in the aerospace industry. Three types of prepregs using one ply, two respective three plies carbon fabric have been developed and then cured in an autoclave with controlled pressure and temperature. From cured plates with 0.2, 0.4 and 0.6 mm thickness, eight specimens from each plate have been cut using a special diamond tool and subjected to tensile tests until break. Various distributions have been experimentally recorded including stress-strain, Young's moduli, load at break-machine extension at break, tensile strengths as well as mean values distributions in case of these three prepregs. Young's modulus, stress and percentage strain at maximum load, force at break, stiffness and tensile strength present an increased tendency with the increase of plies number unlike strain at maximum extension, which presents a decreased distribution with the increase of plies number.

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*Keywords:*Prepreg; Carbon fibers; PLAIN 200 fabric; Composite skin; Mechanical behavior.

1. Introduction

Plain weave carbon fabrics are extensively used both for medium size composite structures and large size ones due to their high ratio between tensile strength and specific weight. These fabrics present good drape ability, a feature that allows them to be placed on complex shapes. Other carbon fabrics widely used as skins, especially in sandwich structures applications, are so-called twill weave fabrics.

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The main feature of this kind of weave is that the warp and weft threads are crossed in a programmed order and frequency, to obtain a flat appearance with a specific diagonal line [1], [2]. A twill weave fabric needs at least three threads and presents excellent drape ability. More threads can be used for fabrics with high specific weight depending on their complexity. After plain weave, the twill is the second most common weave. It is often denoted as a fraction, in which two or three threads are raised and one or two is lowered when a weft thread is inserted [3], [4], [5]. For instance, plain weave presents the fraction 1/1. For composite materials that include resin, reinforcement materials and fillers, to compute their elastic properties it is suitable to use homogenization methods and/or averaging procedures [6], [7], [8],[9]. For a three-phase polymer matrix composite, it is usual to compute upper and lower limits of these elastic properties. A better understanding of a composite structure behavior is obtained by subjected it to dynamic or even static cyclic loads. Some experimental results have been determined on three-phase polymer matrix composites, which means unsaturated polyester resin, glass fibers chopped strand mat as reinforcement and ceramic particles as filler. Interesting approaches regarding the determination of elastic properties of various glass, carbon and Kevlar49 composite laminates with different plies sequences subjected to off-axis loading systems are presented in references [10], [11], [12]. Other related researches are in references [12], [13], [14], [15]. The study of the mechanical properties of such materials can found in [16], [17], [18], [19] and models with experiments are performed by [20], [21], [22], [23]. Results concerning the mechanical behavior of such type of composite are presented in [24], [25] and [26].

2. PLAIN Epoxy Based Carbon Prepregs

Three types of prepregs have been manufactured using following compounds:

- Epoxy resin of type 1050, Hardener: 1059, PLAIN 200 carbon fabric with 200 g/m^2 specific weight and 0.2 mm thickness;
- Epoxy resin of type 1050, Hardener: 1059, PLAIN 200 carbon fabric with 200 g/m^2 specific weight and 0.4 mm thickness;
- Epoxy resin of type 1050, Hardener: 1059, PLAIN 200 carbon fabric with 200 g/m^2 specific weight and 0.6 mm thickness.

The PLAIN 200 carbon fabric has been impregnated with 1050 epoxy resin/1059 hardener in the hand lay-up process. The 1050 epoxy resin/1059 hardener presents following characteristics given in table 1.

Table 1.Material's features for 1050 epoxy resin/1059 hardener

	Young's modulus [MPa]	Maximum stress [MPa]	Stress at break [MPa]	Strain at break [%]
Tensile	3321	77.5	74.5	3.7
Bending	3390	125.1	116.9	6.3
Compression	2147	86	-	-

These prepregs have been placed in an autoclave and cured at a certain temperature and pressure (Fig.1..a). From cured plates, eight specimens from each plate have been cut at 25 mm width (150 mm gauge length) using a diamond powder tool and subjected to tensile loads until break occurs (Fig. 1.b). The tensile tests have been carried out on an LS100Plus universal materials testing machine produced by Lloyd Instruments, UK using a 1mm/min test speed. Each specimen has been placed into grips and a 21 mm/min preload/stress speed has been used to stiff the specimen in order to attach an axial extensometer of type 3542 from Epsilon Technology Corp. This extensometer according to ISO 5893 is able to determine the relative variation of specimen's reference length in every moment of the test. It is connected to a computer and using the Nexygen Plus software, the data are recorded during tests.

The extensometer must be free of any influence due to the inertia at the prescribed test speed and must be able to measure the length of reference with the accuracy of 1%, or higher, for the measured value. A detail regarding the attachment of the extensometer is presented in Fig. 1.c.