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Advanced Heliopol/Stratimat Composite Laminate Material Behavior under Cyclic Bending Loads

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Abstract

Within this paper, the material behavior of an advanced composite laminate subjected to static cyclic bending loads have been experimentally determined on an LR5KPlus Lloyd Instruments materials testing machine. The composite laminate structure is formed of HELIOPOL 9431ATYX_LSE resin reinforced with five layers STRATIMAT300 glass fibers of 300 g/m^2 specific weight. One composite specimen has been subjected to various deflection limits to determine its hysteresis behavior. The results show a maximum hysteresis towards 14 mm upper deflection limit.

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Keywords: Heliopol resin; Stratimat; Composite laminate; Three-point bend test; Cyclic bending load.

1. Introduction

Fibers-reinforced composite laminates are widely used in structures that require high strength to weight ratio. Especially polyester and epoxy resins, as embedding materials for glass and carbon fibers, are common constituents of a composite material [1]. Two-phase composites are encountered in many applications but three-phase as well as multiphase composites require special applications. For instance, three-phase composites, known as prepregs, present beside thermoset/thermoplastic resin, glass/carbon/aramid fibers in various forms, and filler as third phase also.

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Good examples of three-phase composites are Sheet Molding Compounds (SMCs) in which filler plays an important role. To predict the elastic properties of two-phase composites, theoretical approaches can be carried out without any problem using well-known software as ABAQUS, ANSYS, and NASTRAN and so on. For three-phase composites, the prediction of elastic properties can be done using homogenization as well as averaging methods [2].

Static tensile tests are used together with the theoretical approach to fully understand and characterize the mechanical behavior of any composite material. Especially the Young's modulus is for a great importance as a measure of stiffness for any kind of material. Not only static tests are carried out but also cyclic ones. For instance, static cyclic tension-compression tests have been accomplished on three-phase and multi-phase composites varying some important test parameters such as cycling limits, number of cycles, test speed and so on [3].

Simulations regarding the elastic properties of various fiber-reinforced composite laminates subjected to loading systems that differ from the global axes system of a composite material show interesting results. Orthotropic as well as quasiisotropic composite laminates have been subjected to these simulations using the finite element method also. Thin composite laminates present quite low stiffness. To increase the overall stiffness of a composite laminate without using ribs, a spacer between composite layers can be inserted starting from the laminate manufacture. This structure can be seen as a sandwich presenting thin core and dissimilar skins. For this kind of composite sandwich structure a damping analysis combined with a thermo-mechanical experimental approach have been accomplished [4]. Coefficients of linear thermal expansions for the whole structure have been experimentally determined. Not only glass fabrics but also randomly disposed chopped strand mats have been used as reinforcing material in composite laminates. Chopped strand mats of various specific weights in combination with glass fabrics represent a good choice to manufacture a composite structure that can be subjected to bending loads. For instance, such structures have been subjected to three and four-point bend tests to determine their most important mechanical properties. A growing interest has been noticed in using carbon fabrics and especially unidirectional ones to reinforce a wide range of epoxy resins [5], [6]. These structures have been subjected to flexural loads using the three-point bend method. Glass fabric of type RT300 has been used also as reinforcing material in polyester resin based composite structures [7-9]. Various researches have been carried out on different composite structures subjected to various complex loadings. These researches are presented in references [9-12]. Other related researches are in references [13-15]. The study of the mechanical properties of such materials can found in [16-19] and models with experiments are perform by [20-23]. Results concerning the mechanical behavior of such type of composite are presented in [24-30] and [31].

2. Material and Method

A composite laminate plate with main dimensions of 400 x 200 x 6 mm has been manufactured using following compounds:

- Resin: HELIOPOL 9431ATYX_LSE;
- Hardener: BUTANOX M50;
- Glass fibres: STRATIMAT300 with 300 g/m^2 specific weight.

Five plies of Stratimat300 glass fibres have been stacked to form a 6 mm thick composite laminate with ID number 107. From the cured plate, specimens have been cut according to SREN ISO 14125:2000 and subjected to static cyclic three-point bend tests using various deflection limits. First, static three-point bend tests have been accomplished to determine the distributions load-deflection at break. One specimen has been subjected to following upper deflection limits: 2 mm, 4 mm, 6 mm, 8 mm and 14 mm. The lower deflection limit has been maintained allways to zero. One whole cycle three-point bend test is performed by the LR5K materials testing machine from Lloyd Instruments and consists of following cycles:

- One loading cycle;
- One unloading cycle;
- One loading cycle again.