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Effect of equi-biaxially fabric prestressing on the tensile performance of woven E-glass/polyester reinforced composites

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Abstract

The tensile properties of prestressed fabric-reinforced composites have been investigated. A method of applying an equi-biaxially fabric prestressing prior to and during the curing process of a plain-weave fabric composite was performed. A novel fibre prestressing equipment was built to apply and measure the tension load in the principal yarn directions of a fabric. The equi-biaxial fabric prestressing level, ranged from zero to 100 MPa, was used. Tensile tests were performed for the batches with different fabric prestressing levels to estimate the optimum level that gives the maximum tensile performance. The samples were also tested at different orientation angles, precisely from warp to bias direction. Prestressing the fabric enhanced the tensile performance such as elastic modulus and critical stress to first fracture of the composite by 10–20%. Most tensile properties, for instance tensile modulus and critical stress, reached their ultimate values at 50 MPa of prestressing level; however, the tensile-limited toughness was maximum at a level of fabric prestressing of ~75 MPa.

Keywords

Polymer-matrix composites, fibre pretension, biaxial fabric prestressing, plain-weave fabric, tensile properties, residual stress

Introduction

Polymer-matrix composites (PMCs) are widely used, especially in aerostructures, automotive, and marine industries, due to their relatively higher strength and stiffness-to-weight ratios.[1–3] Recently, the fabrication of woven fabric composites has been used more widely than unidirectional reinforcements due to the relatively lower cost and better mechanical performance.[4–6] In addition, woven fabric composites have better resistance to crack propagation due to the presence of interlacing tows.[7]

In the last few decades, the developments in the manufacturing process of PMCs have been increasing to keep up with the rising requirements of modern structures.[8] As it is well-known, improving composite material performance is usually accompanied with increasing its production cost. Because the constituent materials and their fabrication share the total production cost of composites,[9] focusing on improving the manufacturing method is still reasonable and effective. One important factor that is responsible for the decline in the structural properties of PMCs, immediately after they have been cured, is the formation of residual stresses during the manufacturing process.[10,11] Several techniques have been used to reduce the formation and development of these stresses such as optimisation of dwell temperature cycle,[12–14] performing electron beam

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