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ORIGINAL ARTICLE

Mechanical and morphological study of polymer composite plates having different fiber surface treatments with particular response to high velocity projectile impact

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Abstract This study investigates morphological and mechanical behaviors of polymer composite plates reinforced with surface modified glass fiber woven roving with special interest in high velocity impact response. Four types of surface modification were applied to the glass fiber surface, namely: virgin fabric (silane coupling agent removed), silane-treated (as received fabric), corona-treated virgin fabric and silane- plus corona-treated fabric. Hand layup technique was adopted to make composite plates with [0/90, $\pm 45_2$, 0/90] layup using unsaturated polyester resin as matrix. Mechanical testing methods, such as tensile and bending loading as well as low velocity Izod impact and high velocity impact tests in velocities of 88.5, 108.3 and 144 m/s were conducted. The results showed that, although in lower part of high velocity impact rates, i.e., 88.5 m/s, the panels with fiber fabric treatment of silane plus corona revealed significant increase in ballistic resistance, but in general, it was found that the order of optimum performance for E-glass fiber woven roving surface modification methods are: silane, silane plus corona treatment, virgin fabric and sole corona treatment, respectively. The results further revealed that at impact velocities of 108.3 and 144 m/s, the energy absorptions for the samples with silane treatment are 7.9 and 6.6% higher compared to the samples with silane plus corona discharge treatment (S + C) samples, respectively. Damage assessment revealed higher damage extension in the samples with fiber having silane plus corona discharge treatment. Morphological studies on surface roughness were conducted by SEM analysis. The results correlated well with mechanical and impact results in those samples with higher surface roughness showed better mechanical performance and that silane treatment was the dominant factor in performance.

Keyword Polymer composites · Fiber surface modification · High velocity impact · Damage assessment · Energy absorption

Introduction

Polymer matrix/glass fiber composite laminates and structures offer many advantages compared to traditional materials, such as steel, aluminum, and other metals. Nowadays, these materials are widely used in automotive, aerospace, civil, transport, military and marine industries. High specific stiffness and strength, lightweight, high fatigue life, and corrosion resistance characteristics are among their advantages. Such properties make them a good candidate for the protection of aerospace structures against impacts by foreign objects [1]. The behavior of structures subjected to mechanical loading and specially impact loading has been the focus of many studies and recent reviews presented in literature [2–4]. In construction of composites, it is essential for the reinforcement to be made through good interaction with the polymer matrix; therefore, to meet this condition the surface of fiber reinforcement must be modified. Although the chemical modification of the surface is among the most popular method for fiber reinforcement, but other types of modification include: plasma, flame, laser and corona. Variation of parameters such as: fiber wettability, contact angle, and matrix fiber bonding strength in

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