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ORIGINAL RESEARCH

Impact performance of hybrid laminated composites with statistical analysis

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Abstract

The main emphasis of this work is to fabricate a new composite system having high impact performance, light weight, cost-effective and reduced water absorption. Glass (G)–polypropylene (P) fibers reinforced epoxy composite laminates were fabricated using the hand lay-up technique. The impact response and water absorption capabilities of G–P fibers reinforced epoxy composites were investigated to know their suitability and adaptability for different industrial applications. Morphological studies of the fractured surfaces were performed using scanning electron microscopy (SEM). Two-parameter Weibull distribution function was used to obtain the scatter in the results and to construct the reliability graphs. These reliability graphs are important tools for helping the designers to understand and choose the suitable material for the required application. The proposed G–P/epoxy hybrid composites showed an improvement in the impact performance and reduction in water absorption capability compared to the host composites. The hybrid composite with G-fiber at the periphery and P-fiber at the core has lower void content and lower water uptake. The plies stacking sequence has almost no effect on edge-wise impact strength values, whilst it has a noticeable effect on flat-wise impact strength values. When P-layers are at the impacted face, the composite exhibits higher impact strength. Both edge-wise and flat-wise impact strengths increase when P/G fiber ratio increases.

Keyword Hybrid composites · Polypropylene and glass fibers · Impact resistance · Voids · Water absorption

Introduction

Composites have found numerous applications in aerospace, automotive, and construction industries owing to their light weight, high specific strength, high specific stiffness, and other performance benefits [1]. Composite structures are prone to impact loadings during service life, which significantly can cause inner damages, such as matrix cracking, interfacial debonding and delamination [2]. Impact behavior of composite materials is controlled by many factors such as the nature of the matrix, the nature, content, length and orientation of the reinforcement, the fiber–matrix interface and hybrid design [3, 4]. To improve the impact energy-absorbing ability of composites, high strain-to-failure fibers can be added to the host composite, realizing hybrid composites [5].

Hybrid composites are materials fabricated by incorporating two or more different reinforcements in a common matrix to obtain a synergistic improvement in the mechanical and physical properties. The hybrid reinforcements achieve a performance that cannot be obtained using a single reinforcement type. Hybrid composite approach aims to reduce the production cost by the proper selection of reinforcing materials. A compromise between the performance and cost could be achieved [6]. Hybridization process has proved to be an effective method to design materials suited for various requirements [7].

Various studies have been reported on the impact performance of hybrid composites. Pothan et al. [8, 9] studied the impact properties of banana-glass/polyester hybrid composites with different layering patterns. It was concluded that the composite with five layers, where glass forms both the core and the skin is giving the highest impact properties. Pincheira et al. [10] evaluated the influence of the reinforcing aramid fibers in carbon/epoxy composites. The presence of aramid phase in the hybrid carbon/aramid composite induced a significant enhancement in the impact (37.9% in

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