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Effect of Silica Nanoparticles on Three-Point Flexural Properties of Isogrid E-Glass Fiber/Epoxy Composite Structures

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Abstract : Increased interest in lightweight and efficient structural components has created the need for selecting materials with improved mechanical properties. To do so, composite materials are being widely used in many applications, due to durability, high strength and modulus, and low weight. Among the various composite structures, grid-stiffened structures are extensively considered in various aerospace and aircraft applications, because of higher specific strength and stiffness, higher impact resistance, superior load-bearing capacity, easy to repair, and excellent energy absorption capability. Although there are a good number of publications on the design aspects and fabrication of grid structures, little systematic work has been reported on their material modification to improve their properties, to our knowledge. Therefore, the aim of this research is to study the reinforcing effect of silica nanoparticles on the flexural properties of epoxy/E-glass isogrid panels under three-point bending test. Samples containing 0, 1, 3, and 5 wt.% of the silica nanoparticles, with 44 and 48 vol.% of the glass fibers in the ribs and skin components respectively, were fabricated by using a manual filament winding method. Ultrasonic and mechanical routes were employed to disperse the nanoparticles within the epoxy resin. To fabricate the ribs, the unidirectional fiber rovings were impregnated with the matrix mixture (epoxy + nanoparticles) and then laid up into the grooves of a silicone mold layer-by-layer. At once, four plies of woven fabrics, after impregnating into the same matrix mixture, were layered on the top of the ribs to produce the skin part. In order to conduct the ultimate curing and to achieve the maximum strength, the samples were tested after 7 days of holding at room temperature. According to load-displacement graphs, the bellow trend was observed for all of the samples when loaded from the skin side; following an initial linear region and reaching a load peak, the curve was abruptly dropped and then showed a typical absorbed energy region. It would be worth mentioning that in these structures, a considerable energy absorption was observed after the primary failure related to the load peak. The results showed that the flexural properties of the nanocomposite samples were always higher than those of the nanoparticle-free sample. The maximum enhancement in flexural maximum load and energy absorption was found to be for the incorporation of 3 wt.% of the nanoparticles. Furthermore, the flexural stiffness was continually increased by increasing the silica loading. In conclusion, this study suggested that the addition of nanoparticles is a promising method to improve the flexural properties of grid-stiffened fibrous composite structures.

Keywords : grid-stiffened composite structures, nanocomposite, three point flexural test , energy absorption
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