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ORIGINAL PAPER

Experimental dynamic analysis of polymer-based nanocomposite beams under low-velocity impact loading

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Abstract An experimental study was performed on low-velocity impact response of nanocomposite beams reinforced with different loadings of nanoclay (0, 3, 5 or 7 wt%). Using two commercially organo-modified nanoclays (Cloisite 30B and Cloisite 15A), as well as two types of manufacturing methods (hand lay-up and vacuum assisted resin transfer molding), a set of composite/nanocomposite beam samples was prepared. To apply identical boundary conditions along the width of the beam, a cylindrical impactor was selected, whose lateral surface was in contact with the beam. The comparative results of the low-velocity impact (LVI) and quasi-static tests for the beam with 3 wt% Cloisite 30B showed that energy absorption capacity of dynamic loading and quasi-static one was equal to 20.75 and 40 J, respectively. Therefore, it was deduced that the energy absorption capacity of an LVI sample was approximately twice as much as that of a quasi-static one. In addition, the smaller after-impact damage to the beams with a higher content of nanoclay was justified as a result of the impermeable nature of nanoclays. Moreover, it was observed that addition of Cloisite 15A significantly increased the energy absorption capacity of the composite than that of the Cloisite 30B. However, increasing the weight percentage of Cloisite 15A had no significant effect on energy absorption capacity of nanocomposite. The reason of the last result has been described in the paper with a precise study of the microstructure of the materials.

Keywords Clay polymer nanocomposite (CPN) · Cloisite 15A · Cloisite 30B · Mechanical properties · Impact behavior · Energy absorption

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Introduction

Since the manufacturing of carbon nanotubes (CNT) and nanoclay/polymer composites began in 1991 [1] and 1993 [2], respectively, nanocomposites have attracted much attention. Compared with the neat polymer or with micro- or macro-reinforced composites, significant improvements in the material properties have been obtained by dispersing nanoparticles in polymers, even at weight percentage as low as 2–5 wt% [3]. Among the various types of nano-reinforced particles, nanoclay has received huge interest not only due to its low cost but also because of its enhancement both in the surface and bulk properties [4]. Nanoclay has unique atomic structure, high cation-exchange capacity, high aspect ratio, and large surface area [5]. Therefore, these features make it a good reinforcement that can be dispersed in polymer-based composites. Among the various properties of clay polymer nanocomposites (CPN) (e.g., high elastic modulus and tensile strength [6–8], reduced moisture and gas permeability [4, 9], flame retardancy, and high fracture toughness [10]), their extremely large surface area is the most attractive feature [11]. In a nanocomposite, the bonding between the matrix and nanoparticles can be improved by creation of such a large interface area [12].

On the other hand, the study of the mechanical behavior of polymer-based composites has been highly interesting in