Damping Augmentation of Nanocomposites Using Carbon Nanotube/Epoxy

Naser Kordani*, Abdolhosein Fereidoon, Mohammadreza Ashoori
Department of Mechanical Engineering, Semnan University, P.O.Box: 35195-363, Semnan, Iran, e-mail: naser.kordani@gmail.com, Telephone/fax: +98-0231-3354122

ABSTRACT
In a nanotube-based polymeric composite structure, it is anticipated that high damping can be achieved by taking advantage of the interfacial friction between the nanotubes and the polymer. The purpose of this paper is to investigate the structural damping characteristics of polymeric composites containing carbon nanotubes with various kinds and amounts. The damping characteristics of the specimens with 0, 0.5 wt% nanotube contents were computed experimentally. Through comparing with neat resin specimens, the study shows that one can enhance damping by adding CNT fillers into polymeric resins. Similarly experiment showed that the maximum value of damping ratio was obtained at 0.5 wt%.

Keywords: epoxy; damping; nano composites; nanotubes; polymer

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1. INTRODUCTION

Recently, nanoparticles have been attracting increasing attention in the composite community because they are capable of improving the mechanical and physical properties of traditional fiber-reinforced composites [1-4]. Their nanometer size, which leads to high specific surface areas of up to more than 1000 m²/g, and extra ordinary mechanical, electrical and thermal properties make them unique nano-fillers for structural and multifunctional composites.

Commonly used nanoparticles in nanocomposites include multiwalled carbon nanotubes (MWCNTs), single-walled carbon nanotubes (SWCNTs), carbon nanofibers (CNFs), montmorillonite (MMT) nanoclays, and polyhedral oligomeric silsesquioxanes (POSS). Other nanoparticles, such as SiO₂, Al₂ O₃, TiO₂, and nanosilica are also used in the nanocomposites.

Compared to other particulate additives, carbon nanotubes and carbon nanofibers offer more advantages. The addition of small size and low loading of carbon nanotubes and carbon nanofibers can enhance the matrix-dominated properties of composites, such as stiffness, fracture toughness, and interlaminar shear strength [5-9].

These exceptional properties have been substantiated by a variety of experimental procedures [10-12]. As produced, SWCNTs are found either in parallel bundles referred to as “ropes” or in concentric bundles known as "multi-walled nanotubes" (MWCNTs) [13, 14]. In each bundle arrangement, the SWCNTs are held together with relatively weak van der Waals forces. It has been found that interlayer sliding of MWCNTs is comparable to that of graphene layers in crystalline graphite [14, 15].

New fabrication and purification techniques have enhanced the production of CNTs [16, 17], leading to the possibility that lightweight structural polymers with excellent mechanical properties can be produced using small weight/volume fractions of CNTs as a reinforcing phase. For example, with the addition of only 1% nanotubes by weight, a 36–42% increase in elastic modulus has been observed [18]. Experimental results also demonstrated that the improvement of material properties relies on nanotube dispersion and resin/nanotube interfacial bonding [18-22].

To analyze nano-structures, molecular dynamics (MD) methods are often used [23-25]. However, for large and complex systems, MD simulations require expensive computational facilities as well as extensive computation time.

Most of the research on CNT-based composites has focused on their elastic properties. Relatively little attention has been given to their damping mechanisms and ability. While Koratkar et al. [26, 27] recently observed promising damping ability of a densely packed MWCNT thin film (no matrix); however, damping characteristics of CNT filled composites have not been investigated in any detail.

Previous research has explored the effects of nanoscale particle fillers on the damping properties of polymer composites. For elastomeric materials, it has been found that rod-like aggregates of roughly spherical carbon black particles increase the material damping in the strain range in which the breakdown and reformation of carbon black aggregates occurs [28, 29]. This strain dependent damping enhancement in particle-filled elastomers is known as the Payne Effect. Analogous effects can be expected for composites containing CNT fillers.

Recently, Buldum and Lu [23] investigated the interfacial sliding and rolling of carbon nanotubes using MD methods. It was found that a nanotube first sticks and then slips suddenly when the force exerted on it is sufficiently large.

In this paper, in order to have direct impact to the field of vibration damping, a structure, or system, level approach was used to examine the damping mechanism and characteristics of CNT-based composites.