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Finite element modeling of an interweaved carbon nanotube structure

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Abstract

The behavior of a single-walled carbon nanotube structure, woven in dry-state by individual nanotubes used as yarns, is investigated using finite element modelling. Each nanotube is idealized as a truss-like structure with carbon atoms represented by nodes and interatomic forces, simulated by translational and torsional springs with linear behavior. In the nanoscale there is no real contact between interweaved nanotubes but instead van der Waals forces are those responsible for keeping the nanotextile together. These are also simulated by appropriate nonlinear springs. Numerical tests under various loadings on a single cell of the interweaved nanotube structure, have demonstrated that the overall stiffness depends strongly on nanotube size, increasing with diameter and decreasing with length.

***Key words**: Nanotube, Molecular mechanics, Finite element, Textile, Interweaved*

1. Introduction

At the National Nanotechnology Initiative (NNI), nanotechnology (NT) is defined as the understanding, manipulation, and control of matter at a scale of 1-100 nm, such that the physical, chemical, and biological properties of materials (individual atoms, molecules, and bulk matter) can be engineered, synthesized, or altered to develop the next generations of improved materials, devices, structures, and systems (http://www.nano.gov/). Researchers, during the last few years, have illustrated that the textile industry has a lot to benefit from NT in the form of improvements of various fiber, yarn and fabric properties, such as softness, durability, breathability, water repellency, fire retardancy, antimicrobial properties, etc. Carbon nanotubes (Iijima, 1991) (CNT) have already been used in different ways to increase the strength and performance of fibers to ultra-high levels, as was demonstrated by Jiang et al (Jiang and Li, 2002). They have produced nano-yarns from super-aligned arrays of CNTs, that exhibited a Young modulus in the TPa range, a tensile strength equal to 200 GPa, an elastic strain up to 5% and a breaking strain of 20%. A similar spinning method was followed by Zhang *et al.*, (2004), during which multi-walled nanotubes (MWNTs) of approximately 10 nm in diameter were simultaneously

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