NUMERICAL SIMULATION OF COMPOSITE MATERIALS REINFORCED WITH CARBON NANOTUBES

RESAM MAKVANDI

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering (Mechanical Engineering)

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

JUNE 2013

To my parents for their enormous financial and emotional support throughout my study.

ACKNOWLEDGEMENT

Foremost, I would like to express my sincere gratitude to my supervisor Professor Andreas Öchsner for the continuous support of my study and research, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my Master study.

Besides, I would also like to thank my parents and two elder brothers. They were always supporting me and encouraging me with their best wishes.

Finally, I would like to thank my dear friend Mr. Siamak Fereidooni for all his support and encouragement throughout my study in Malaysia.

ABSTRACT

The application of carbon nanotubes (CNTs) in innumerable areas of industry is increasing day-to-day. One of their most important applications is in composite materials as the reinforcing phase. Many researchers studied the behavior of composite materials reinforced with short fibers. This paper examines the effect of the position of short fibers on the total stiffness of a composite material reinforced with carbon nanotubes for various volume fractions. Three different situations have been suggested for the position of a CNT fiber with respect to the other fibers in the composite: completely separated fibers, fibers with overlap, and fibers connected through a shared node (long fibers). Three different cases including a case when just overlaps are allowed, a case when just long fibers are allowed and a case when both overlaps and long fibers are allowed have been investigated. It has been shown that the effect of these cases on the Young's modulus of the composite is significant and that they should be considered for a better understanding of the reinforced composites behavior. In addition, it is shown that the effect of the investigated cases is more remarkable at higher numbers of randomness values.

ABSTRAK

Penggunaan nanotube karbon (CNTs) di kawasan begitu banyak industri semakin meningkat dari hari ke hari. Salah satu aplikasi yang paling penting mereka adalah dalam bahan komposit sebagai fasa memperkukuh. Ramai penyelidik mengkaji tingkah laku bahan komposit diperkukuhkan dengan gentian pendek. Karya ini mengkaji kesan kedudukan gentian pendek kepada jumlah kekukuhan bahan komposit diperkukuhkan dengan nanotube karbon untuk pelbagai pecahan kelantangan. Tiga situasi yang berbeza telah dicadangkan untuk jawatan serat CNT berkenaan dengan gentian lain dalam rencam: serat sepenuhnya dipisahkan, gentian dengan pertindihan, dan serat berhubung melalui nod yang dikongsi (serat panjang). Tiga kes yang berbeza termasuk kes di mana hanya bertindih dibenarkan, kes apabila hanya serat panjang yang dibenarkan dan kes di mana kedua-dua pertindihan dan serat panjang dibenarkan telah disiasat. Ia telah menunjukkan bahawa kesan daripada kes-kes pada modulus Young rencam adalah penting dan mereka perlu dipertimbangkan untuk pemahaman yang lebih baik daripada tingkah laku komposit bertetulang. Di samping itu, ia menunjukkan bahawa kesan daripada kes yang disiasat adalah lebih luar biasa pada nombor yang lebih tinggi nilai-nilai rawak.