The carbon nanotube composite simulation by materials point method

H.K. Wang[1], X. Zhang[2*]

[1]School of aerospace, Tsinghua University, Beijing 100084, P. R. China
[2]School of aerospace, Tsinghua University, Beijing 100084, P. R. China
[*]xzhang@tsinghua.edu.cn

Keywords: carbon nanotube composite, material point method, cell effect

The extreme-performance rubber nanocomposite[1] was developed for excavating deep oil resources. The nanocomposite uses multi-wall carbon nanotube as reinforce phase and the nature rubber as matrix. The Young's modulus of the carbon nanotube is almost 1Tpa while the nature rubber is around 3 Mpa, and the composite will be enduring extremely large deformation nearly 300%. Both of the huge difference between the reinforced phase and the matrix and large deformation will challenge the current simulation methods. The traditional finite element method has encountered great difficulties to cope with large deformation.

The material point method (MPM)[2] is an extension of the FLIP particle-in-cell method to solid mechanics. Being a fully Lagrangian particle method, it can solve problems involving extremely large deformation[3] and contact efficiently. In this paper, the materials point method is extend to study the enhancement mechanism of carbon nanotube reinforced composite, which is very helpful for the composite design.

A micromechanical analysis of the representative volume element (RVE) of the composite is carried out with material point method. Both the nanotube and the rubber are presented by particles with different materials properties. Benefit from the material point method, the nanotube interactions effect under large deformations such as hook or cell could be considered. It is shown that the increasement of the Young's modulus of the composite mainly because the volume ratio of the carbon nanotube rather than cell effect.

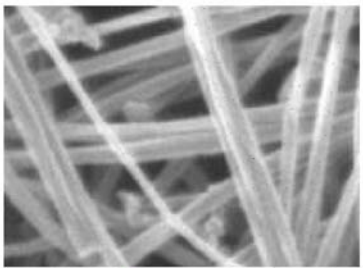

Figure 1: TEM photo

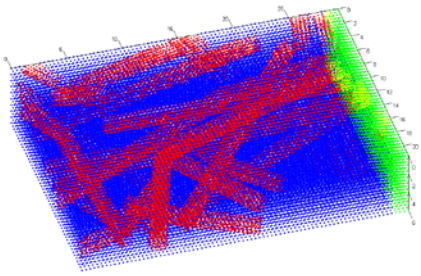

Figure2 MPM Model

References

[1]. M. Endo, T. Noguchi, M. Ito. Extreme-Performance Rubber Nanocomposites for Probing and Excavating Deep Oil Resources Using Multi-Walled Carbon Nanotubes. Advanced Functional Materials. 18(21): 3403 ~ 3409, 2008

[2]. D. Sulsky, Z. Chen, H.L. Schreyer, A Particle Method for History-Dependent Materials. Computer Methods in Applied Mechanics and Engineering. 118(1-2): 179 ~ 196, 1994.

[3]. S. Ma, X. Zhang, YP Lian, et al. Simulation of high explosive explosion using adaptive material point method, CMES: Computer Modeling in Engineering & Sciences. 39(2): 101 ~ 123, 2009.