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# Torsional vibration of carbon nanotube with axial velocity and velocity gradient effect

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**Abstract**

New torsional models of carbon nanotube in which axial velocity and the velocity gradient effect are separately considered on the basis of newly proposed nonlocal strain gradient theory are presented in this study. The nonlocal strain gradient theory developed from nonlocal theory contains additional strain gradient scale parameter representing the effect of high-order strain gradient besides the nonlocal scale parameter depicting interactions of neighboring particles. For torsional vibration of carbon nanotube considering axial velocity, the influence of axial velocity is included in kinetic energy. For that in view of velocity gradient effect, additional kinematic component which represents material particles in micro/nano-scale distinguishing those in macro-scale is involved in the kinetic energy. The governing equations are derived by Hamilton's principle and the high-order boundary conditions are also deduced simultaneously. As study case, fixed-fixed boundary condition is considered. The two scale parameters impacting on torsional frequencies are discussed in detail, meanwhile, comparisons of current model with other high-order non-classical and classical models, and the relations between axial velocity and torsional frequencies are shown in this paper. The relations between critical velocity and two scale parameters are also illustrated. Ultimately, the influences of velocity gradient effect on torsional frequencies are presented.

Keywords: torsional vibration; carbon nanotube; axial velocity; velocity gradient effect; nonlocal strain gradient theory.