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微纳技术与精密机械

耦合场中小尺寸碳纳米管的组合扭转屈曲行为

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摘要： 针对小尺寸碳纳米管在多物理场耦合作用下的组合扭转屈曲问题，提出了基于非局部理论耦合场作用下的力学模型，并研究了该模型的组合扭转屈曲行为。首先，采用连续弹性壳模型，引进热-电-力多场耦合作用下的本构关系，通过引入非局部弹性理论来考虑小尺寸碳纳米管的尺度效应;然后针对多壁碳纳米管层间范德华力和周边弹性介质的影响，建立了基于非局部理论多场耦合作用下碳纳米管的屈曲控制方程。最后，在轴力组合扭转载荷及温度与电压变化影响的工况下，研究了各因素对碳纳米管组合扭转屈曲行为的影响。得到的结果显示了小尺寸碳纳米管组合扭转屈曲行为在多场耦合作用下的响应，揭示了各物理场与组合扭转屈曲行为的关系；同时指出非局部理论下的屈曲载荷与经典理论下的屈曲载荷比值总小于1，说明经典理论高估了小尺寸碳纳米管的组合扭转屈曲行为。

关键词： 碳纳米管 扭转屈曲 多场耦合 尺度效应

Combined torsional buckling of small size carbon nanotubes in multi-field coupling

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Abstract: For the combining torsional buckling of small size Carbon Nanotubes (CNTs) in the multi-field coupling condition, a mechanical model was established in a couple field based on nonlocal theory and the combining torsional buckling behavior of the model was studied. Firstly, the constitutive relation was introduced under thermo-electro-mechanical loadings by using an elastic shell model of continuum mechanics. Then, the nonlocal elasticity theory was induced to discuss the scale effect of the small size carbon nanotubes, meanwhile, in consideration of the van der Waals forces and the effect of surrounded elastic medium, the generalized governing equation of buckling for CNTs was established in the multi-field coupling based on nonlocal theory. With applied torque and torsion-related axial load, as well as changed temperatures and voltage loads, the influences of different factors on the combining torsional buckling behaviors was calculated numerically. Finally,the conclusion demonstrates the response of the combining torsional buckling of small size carbon nanotubes (CNTs) in the multi-field coupling condition, which reveals the relation between combined torsional buckling of small size CNTs and each field. Moreover, it shows that the ratio of critical buckling load between nonlocal and local theories is always smaller than 1, which indicates that the torsional buckling of small size CNTs is overestimated in classical theory.

Keywords: carbon nanotubes torsional buckling multi-field coupling scale effect

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