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Thermo-mechanical Coupling Analysis of Heat Build-up and Rolling Resistance due to Nonlinear Viscoelasticity for Solid Rubber Tire

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Abstract: The transient temperature and rolling resistance of a solid rubber tire made of natural rubber nanocomposite were analyzed based on the thermo-mechanical coupling approach and nonlinear viscoelastic theory by using finite element method. The thermo-mechanical coupling approach could be divided into three major parts: deformation, dissipation, and thermal transfer modules. In the deformation module, uniaxial, planar, and equibiaxial tensile tests were used to determine the hyperelastic constitutive equation. The 100th-order Fourier sine series was used to approximate the strain amplitude. In the dissipation module, the loss modulus was updated as a function of strain amplitude, temperature and frequency. In the thermal transfer module, the dependence of thermal parameters on temperature was established. A rolling resistance tester was also used to verify the numerical results, which revealed that the proposed analytical method was a reliable approach to predict rolling resistance and transient temperature distribution for tires. At last, the dependence of rolling resistance and heat build-up on thermal conductivity and loss factor was investigated quantitatively by the parametric numerical experiments. The work could provide theoretical guidance and relevant analysis methods for the design of high performance tire.

Key words: natural rubber; nanocomposite; solid rubber tire; finite element analysis; nonlinear viscoelasticity; rolling resistance; thermo-mechanical coupling

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