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Finite Deformation of a Dielectric Elastomeric Spherical Shell Based on a New Nonlinear Electroelastic Constitutive Theory

Authors : Odunayo Olawuyi Fadodun

Abstract : Dielectric elastomers (DEs) are a type of intelligent materials with salient features like electromechanical coupling, lightweight, fast actuation speed, low cost and high energy density that make them good candidates for numerous engineering applications. This paper adopts a new nonlinear electroelastic constitutive theory to examine radial deformation of a pressurized thick-walled spherical shell of soft dielectric material with compliant electrodes on its inner and outer surfaces. A general formular for the internal pressure, which depends on the deformation and a potential difference between boundary electrodes or uniform surface charge distributions, is obtained in terms of special function. To illustrate the effects of an applied electric field on the mechanical behaviour of the shell, three different energy functions with distinct mechanical properties are employed for numerical purposes. The observed behaviour of the shells is preserved in the presence of an applied electric field, and the influence of the field due to a potential difference declines more slowly with the increasing deformation to that produced by a surface charge. Counterpart results are then presented for the thin-walled shell approximation as a limiting case of a thick-walled shell without restriction on the energy density. In the absence of internal pressure, it is obtained that inflation is caused by the application of an electric field. The resulting numerical solutions of the theory presented in this work are in agreement with those predicted by the generally adopted Dorfmann and Ogden model.

Keywords : constitutive theory, elastic dielectric, electroelasticity, finite deformation, nonlinear response, spherical shell
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