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Extension-Torsion-Inflation Coupling in Compressible Magnetoelastomeric Tubes with Helical Magnetic Anisotropy

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Abstract : We present an axisymmetric variational formulation for coupled extension-torsion-inflation deformation in magnetoelastomeric thin tubes when both azimuthal and axial magnetic fields are applied. The tube's material is assumed to have a preferred magnetization direction which imparts helical magnetic anisotropy to the tube. We have also derived the expressions of the first derivative of free energy per unit tube's undeformed length with respect to various imposed strain parameters. On applying the thin tube limit, the two nonlinear ordinary differential equations to obtain the in-plane radial displacement and radial component of the Lagrangian magnetic field get converted into a set of three simple algebraic equations. This allows us to obtain simple analytical expressions in terms of the applied magnetic field, magnetization direction, and magnetoelastic constants, which tell us how these parameters can be tuned to generate positive/negative Poisson's effect in such tubes. We consider both torsionally constrained and torsionally relaxed stretching of the tube. The study can be useful in designing magnetoelastic tubular actuators.

Keywords : nonlinear magnetoelasticity, extension-torsion coupling, negative Poisson's effect, helical anisotropy, thin tube
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