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MAGNETORHEOLOGICAL ELASTOMERS: EXPERIMENTS AND MODELING

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Magnetorheological elastomers (MREs) are ferromagnetic particle impregnated rubbers whose mechanical properties are altered by the application of external magnetic fields. Due to their coupled magnetoelastic response, MREs are finding an increasing number of engineering applications. In this work, we present a combined experimental and theoretical study of the macroscopic response of a particular MRE consisting of a rubber matrix phase with spherical carbonyl iron particles. The MRE specimens used in this work are cured in the presence of strong magnetic fields leading to the formation of particle chain structures and thus to an overall transversely isotropic composite. The MRE samples are tested experimentally under uniaxial stresses as well as under simple shear in the absence or in the presence of magnetic fields and for different initial orientations of their particle chains with respect to the mechanical and magnetic loading direction.

Using the theoretical framework for finitely strained MREs introduced earlier by the author, we propose a transversely isotropic energy density function that is able to reproduce the experimentally measured magnetization, magnetostriction and simple shear curves under different prestresses, initial particle chain orientations and magnetic fields. Microscopic mechanisms are also proposed to explain i) the counterintuitive effect of dilation under zero or compressive applied mechanical loads for the magnetostriction experiments and ii) the importance of a finite strain constitutive formulation even at small magnetostrictive strains. The model gives an excellent agreement with experiments for relatively moderate magnetic fields but has also been satisfactorily extended to include magnetic fields near saturation.