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Thermo-electro-mechanical modeling of electro-active polymers

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Due to the unique micro-mechanical structure of polymers, which enables chains slippage, rotations and alterations under different environmental conditions, there is a need to predict the thermal effects on EAPs behavior. Most works studied the behavior of EAPs actuators assuming constant temperature during their performance. However, few researches considered the temperature changes during the operation of EAPs, i.e., discussed the temperature changes as a function of time.

Referring to the literature, a finite-deformation fully coupled thermo-electro-elastic continuum model has been presented in [1]. In particular, the model has been suited for the control of solid-state transduction devices based on electrostrictive elastomers. Lately, [2] used the entropy-temperature or electric displacement-electric field plane to describe the temperature change and entropy change of dielectric elastomer undergoing large electrostriction deformation. With the influence of temperature, they developed a temperature and deformation coupling thermodynamical free energy model to calculate the electric field induced variation of temperature and entropy in dielectric elastomers. A more comprehensive model, which introduces the temperature, viscoelasticity and current leakage into energy conversion, has been established in [3]. In this work, the relation between the temperature and the shear modulus has not been discussed or taken into account.

Due to the aforementioned, there is a need to develop an extended mathematical model, including the thermo-electro-mechanical coupling nature of EAPs. Such a model should account for the material parameters changes within the temperature fluctuations. In this paper, a fully coupled thermo-electro-mechanical model, which accounts for the time-dependent nature of EAPs Will be introduced.

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