11th. World Congress on Computational Mechanics (WCCM XI)
5th. European Conference on Computational Mechanics (ECCM V)
6th. European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

ON CONSTITUTIVE RELATIONSHIPS AND DESIGN OPTIMIZATION OF ELECTROACTIVE POLYMERS

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Key words: *dielectric electroactive actuator, optimization, FE analysis, active electromechanical media, Helmholtz free energy, finite deformations, active deformations, Maxwell stress*

Due to the rising demand in dynamics and control new actuators based on electroactive polymers have gained attention. The potential of this technology is shown here exemplarily by investigating a dielectric Electroactive Polymer (EAP) actuator employed to regulate a water valve. The diaphragm EAP actuator is analyzed using finite element analyzes accompanied by experimental studies. To this end an accurate and efficient finite-element model had to be developed.

In this contribution we present the general theoretical framework for the formulation of constitutive equations of electromechanical active media. The approach is based on the additive decomposition of the Helmholtz free energy in elastic and inelastic parts and on the multiplicative decomposition of the deformation gradient in passive and active parts. We describe a thermodynamically sound scenario that accounts for geometric and material nonlinearities, and specialize the general approach to a typical EAP material. Thus we account for finite deformation with large values of eigenstrains and viscous effects as well as for the electromagnetic Maxwell stress induced by electric fields.

The fully coupled problem is solved for the specific geometry of a diaphragm EAP actuator. Since within valve applications a low voltage must be observed, the actuator design needs to be optimized with a maximum voltage of 1000 Volts. Accounting for this constraint, the effect of different design parameters on the the mechanical output variable stroke have been studied. The computational results are verified by an appropriate EAP test bench.