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WEAKLY COUPLED ELECTRO-MAGNETO-THERMO-MECHANICAL MODEL FOR SHAPE MEMORY POLYMER COMPOSITES EMPLOYING MIXED-FEM

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Shape memory polymer composites (SMPC) are a class of smart composites that under an external stimulus can deform to a temporary shape and return to their original one. SMPC can be synthesized with either electrically conductive fillers or magnetic particles or both embedded in a polymer matrix. Contactless temperature-controlled shape morphing of SMPC structures through losses induced by the high frequency alternating electro-magnetic sources is the focus of this work. Coupled multi-physics such as electro-magnetics (EM) and thermo-mechanics (TM) along with the different timescales of the individual problems increase the complexity for the computational modelling.

A simplified coupled electro-thermo-mechanical model for SMPC without considering the magnetic contributions at low frequencies (f < 1 kHz) was recently developed in [1]. The present work extends the existing E-TM model [2] considering: i) introduction of the magnetic field, thus leading to a strongly coupled dynamic EM-TM model, ii) contactless induction heating at a higher frequency (f >> 1 kHz), iii) individual domains for inductor coil, SMPC and surrounding free space, thus accounting for the contributions from Maxwell stress, and iv) discontinuity of the magnetic field across material interfaces. A mixed-FEM formulation utilizing nodal elements along with Nédélec's edge elements is employed to resolve the coupled dynamic EM fields.

Considering the high frequency of the electro-magnetic source, the timescale of the EM problem is relatively small (μs) compared to the heating and large deformations observed in the SMPC (in s). An efficient weak multi-timescale coupling accounting for the dynamic effects in the TM problem is thus developed and applied in the context of finite deformation of the SMPC domain.

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