MULTISCALE ANALYSIS OF PIEZOCERAMIC-BATTERY HYBRID COMPOSITES

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Abstract

The multiscale modelling of multifunctional hybrid composites consisting piezoceramic fibers is considered. The piezoceramic fibers allows the composites to be used as both actuators as well as energy harvestors. The flight performance of the UAVs can be improved by using these composites. The essence from the Variational Asymptotic Method(VAM) and Finite Element Method(FEM) are used for modelling the composite. Using VAM, the computational effort for developing the analytical framework reduces to a large extent without reducing the accuracy. The numerical model based on FEM over the analytical framework of the representative volume element ensures modelling complex realistic geometries and material distributions.

The problem is modelled in two length scales- micro electromechanics and macro electro mechanics. The building block used to model the circular cross section Active Fiber Composites is from Hashin Rosen approach. During micromechanical analysis, VAM is used to dimensionally reduce the model and to minimise the Gibbs free energy functional developed and thus to generate the stiffness properties of the reduced model. The electromechanical couplings and the 3D displacement fields of the corresponding unit cell are also generated. The characteristic dimension of the unit cell is smaller than the length making the beam assumption reasonable. VAM is effective in this modelling since the cross sectional dimensions of the piezofiber and battery fiber are of the same order. FEM is used in macro scale modelling which inputs the results from the micro electromechanical modelling. This approach is novel which results in an efficient model for simulating the actual responses. For validation we have used PZT-5A as fiber and epoxy as matrix. The composite model is orthotropic in the principal material direction but can be extended to other class of materials in off principal material planes. The use of Green Lagrange strain which allows large displacements and large strains analysis made the model complex. The model will be asymptotically correct, involves shear terms and resembles like the Timoshenko model without the use of shear correction factors.

In the full length paper, the differential equation governing the multiscale hybrid composite model along with the solutions for the 3D displacements and the force fields will be presented. The graphical results used for validation will also be included.

Keywords: Multiscale modelling, Variational Asymptotic Method, Finite Element Method, Electromechanics, Multifunctional composites.