Multi-Scale Asymptotic Computations of Axisymmetric Piezoelectric Problem for Composite Structures

Qiang Ma[1,*], Junzhi Cui[2] and Xue Jang[3]

[1]School of Mathematics, Sichuan University, Chengdu, 610043, China.

[2]LSEC, ICMSEC, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, 100190, Beijing, China.

[3]Beijing University of Posts and Telecommunications, School of Science, Beijing, 100876, China.

[*]Corresponding Author: Qiang Ma. Email: maqiang809@scu.edu.cn, maqiang@lsec.cc.ac.cn.

Abstract: A new second-order two-scale (SOTS) asymptotic coupled piezoelectric models are developed for the axisymmetric composites. The governing piezoelectric equations are compactly formulated in cylindrical coordinates, and the composite domains are assumed to be periodically occupied by the representative cells. The multi-scale asymptotic expansions for the displacement and the electric potential are formally defined and the effective elastic, piezoelectric, and dielectric coefficients are expressed in terms of the microscopic functions defined on the cell domain. Particularly, the cell solutions and the homogenized solutions for the plane axisymmetric problem are derived analytically. The corresponding SOTS finite element procedure is proposed, in which the Newmark algorithm is applied to construct the computational scheme in the temporal domain. Numerical experiments are carried out to simulate both the static and dynamic asymptotic behavior of the space axisymmetric and the one-dimensional plane axisymmetric structures. It is validated from the numerical examples that the asymptotic models proposed in the current work are effective to capture the macroscopic performance of the piezoelectric structures and the second-order expansions of the solutions is essential for obtaining the correct distributions of the stress and electric displacement.

DOI:10.32604/icces.2019.04487 www.techscience.com/icces