8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

ANALYSIS OF LOCALIZED EFFECT IN VICINITY OF PIEZOELECTRIC PATCHES IN SMART PLATES

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Key Words: *Smart Structures, Multi-physics Problems, Advanced Plate Theories, Finite Element, Carrera Unified Formulation*

ABSTRACT

Smart systems are the candidate for next generation structures of aerospace vehicles as well as for some advanced products of automotive and ship industries. Piezoelectric materials are extensively used in that framework. These materials are characterized by the so called 'direct' and 'inverse effect': an applied mechanical stresses induces electrical potential and vice-versa. Such an electro-mechanical coupling permits one to build up closed-loop control systems in which piezo-materials play the role of both actuators and sensors. An intelligent structure can be therefore built in which, for instance, deformations or vibrations are reduced by appropriate control laws.
A number of theoretical and practical problems arise in the applications, whose solution would play a crucial role in the future development of smart structures [1]. Piezoelectric panels mostly appear as multilayered structures. The piezoelectric parts of the structures consist of embedded continuous layers and/or discretize patches [3]. Many works are available in the case of piezoelectric layers [2]. A few papers [3] are known in which accurate evaluation of mechanical and electrical are variables is made However, an appropriate use these piezo-electric materials, requires an accurate description of electrical and mechanical fields in the constitutive layers to prevent failure mechanisms at th interfaces as well as to furnish a reliable estimation of electric charges and/or voltages which are essential in the control loop.
Since almost one decade the first author and co-workers have contributed to the application of Reissner Mixed Variational Theorem (RMVT) to FE analysis of piezoelectric plates/shells [2]. Results have shown that RMVT consists of a very suitable tool to provide quasi-3D description of stresses, strains and electric fields in multilayered structures embedding piezoelectric layers. RMVT was employed in the framework of Carrera Unified Formulation (CUF) which has been detailed in [4]. As main feature the UF permits one to formulated both ESLM and LW models in terms of a few fundamental nuclei whose form does not depend on the order of expansion N in the thickness plate directions (that have been used for the description of electrical and mechanical various variables) neither by the number of the node of element N_n. Classical formulation based on Principle of Virtual Displacements (PVD) were developed for comparison purpose. Various forms of RMVT and PVD for their application to Multifield problems have been recently discussed in [5].

The present work extends the UF and some of the variational statements quoted in [5], including canonical forms of PVD and RMVT, to make a FE analysis of electrical and mechanical fields in vicinity of piezoelectric patches. The aim is duplicate: to provide a FE models able to furnish accurate stresses, strains, electric displacements and voltages in vicinity of not continuous fields due to patches; to establish the accuracy of various simplified models that are usually used in smart structures applications. Discussion of computational techniques that are able to merge various kinematics will be considered in future works.

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