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Preface: Design, Modelling and Experiments of Adaptive Structures and Smart Systems

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Preface: Design, Modelling and Experiments of Adaptive Structures and Smart Systems

This Special Issue is dedicated to the memory of Professor Liviu Librescu, member of the Advisory Committee of DeMEASS, Great Scientist and Great Man, who left us in an heroic way during the tragic events of Virginia Tech, April 2007.

This special issue of MAMS collects selected papers presented at the International, *non-profit*, Symposium *Design Modelling and Experiments of Adaptive Structures and Smart Systems (DeMEASS I)*, held 10–13 July 2006 in Bardonecchia, Italy.

The collected papers have been grouped in the following three categories: the first 6 papers deal with modelling of smart systems; the further 5 papers are related to design optimization and control; the latter 3 works deal with smart helicopter rotor blades.

Refined models for the analysis of shear mode actuation of piezoelectric plates are analyzed by D'Ottavio et al. in the first paper. The unified formulation is employed to assess classical, refined and mixed theories based on Reissner's theorem. Attention has been restricted to closed form solutions. Variational statements for multi-field thermo-electro-magneto-mechanical (TEMM) problems are discussed in the second article by Carrera et al. for layered structures. A number of interesting variational equations are derived from the generalized TEMM forms of Principle of Virtual Displacement and Ressners' Mixed variational Theorem. First author's Unified Formulation is used to build finite element matrices in terms of a few "undamental nuclei." Numerical results prove the effectiveness of the proposed formulation. The extension of geometrically exact four-node solid-shell element to piezolectric case is given in the third article by Kulikov and Plotnikova. The laminated shell formulation is based on the objective strain-displacement relationships and purely mechanical finite element formulation. The element is free from thickness locking and the element stiffness is evaluated by applying the 3D analytical integration that allows using extremely coarse meshes. The fourth paper by Belouettar et al. presents a shell finite element (FE) formulation with embedded viscoelastic and piezoelectric layers and an integrated active damping control mechanism. A five-layered finite element is derived which uses the first order shear deformation theory in the viscoelastic core and Kirchhof theory for the elastic and piezoelectric layers. Constant velocity and constant displacement feedback control algorithms are used to actively control the dynamic response of the adaptive structure. Boundary element models for magneto-electro-elastic (MEE) bimorph beams analysis is proposed in the subsequent article by Daví et al. BEM formulation is obtained by extension of the reciprocity theorem to MEE problems. A numerical study is made for a better understanding of the link between interlaminar stresses and magnetic induction. A quite cumbersome topic has been treated in last paper by Wallmersperger et al. The attention is focused on computational aspects of the analysis of polymer gels. In this work the chemo-electrical model and the discrete element model are introduced and compared for chemically stimulated polyelectric gels.

The second group of articles starts with a contribution from Krommer et al. on the dynamic displacement tracking of beams. Networks of piezolectric actuators have been used to design an assigned shape. Genetic algorithms are considered in the subsequent paper by Al-Ajmi et al. for optimum design of segmented passive-constrained layer damping treatment. The optimization problem of finding the control voltage applied to a single piezoelectric patch actuator or several such actuators which brings the transient displacements and velocities of all points of a beam or rectangular plate to zero with the least control effort has been treated by Cupial. Damage Detection problem by means of piezoceramic actuators in thin steel structures has been addressed by Dinkler et al. The presented model-updating algorithm adapts the finite element model to the measuring data using an output residual, which is minimized using a least-squares method. The application of special indicators enables the localization and quantification of changes in structural behavior. Active Control of laminated plates using piezoelectric finite elements has been treated by Bruant et al. The usual FSDT theory is combined with a field compatibility methodology to avoid the transverse shear locking for thin plates. A LQR control method including a state observer is used to compute the control. Four examples are presented. The quasi-static correction and the use of collocated sensor/actuators are discussed.

Application of smart structure concepts to helicopter rotor blades design is the subject of the last three articles. The first one by Ghiringhelli et al. proposes an integrated aeroservoelastic analysis for induced strain rotor blades. The induced-strain inclusions can have arbitrary shape and orthotropy. The piezoelectric blade section characterization is detailed; the optimization procedure is illustrated, and relevant results are presented and discussed in view of indications arising from simplified models based on the monocoque theory. Helicopter Rotor Blade is also the subject of the article by Grohmann et al. A new concept is proposed for individual blade control: the Active Trailing Edge (ATE). The aero-servo-elastic optimization of the ATE actuator is based on evolutionary algorithm. The resulting optimal actuator design, the sensitivity of the optimal design to manufacturing and material constraints and Mach-number influence on aerodynamic effectiveness are presented. The paper concludes with a presentation of active helicopter benefit analysis. The last paper by Barkanov et al. deals with optimal design of the active twist for helicopter rotor blades with C-Spar. The structural static analysis with thermal load, static torsion analysis and modal analysis using 3D finite element models have been developed using ANSYS for the optimal design. In this case thermal strain analogy between piezoelectric strains and thermally induced strains is used to model piezoelectric effects. The optimization results have been obtained for four design solutions connected with the application of active materials.

The papers published in this Special Issue discuss only some of the most significant topics on smart systems and their modelling. However, the included articles present significant contribution and promising methods.

We would like to take this opportunity to thank all the authors for their valuable contributions as well as the anonymous reviewers for their comments and suggestions.

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