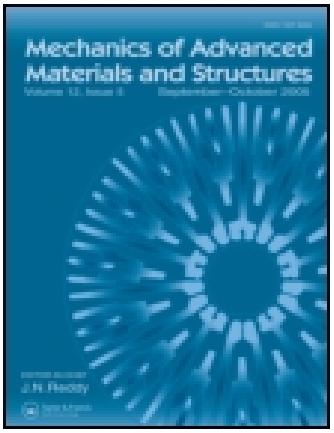

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Guest Editorial of MAMS Special Issue on Modeling and Analysis of Smart Structures

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Guest Editorial of *MAMS* Special Issue on Modeling and Analysis of Smart Structures

This special issue of *MAMS* collects selected papers presented at the "6th ECCOMAS Thematic Conference on Smart Structures and Materials (SMART2013)," held on June 24–26, 2013, at Politecnico di Torino, Torino, Italy.

The collected papers have been grouped in the following two categories: the first eight papers deal with modeling of smart structures; the remaining three papers are related to health-monitoring.

Several one-dimensional finite elements for the static analysis of shear actuated piezoelectric three-dimensional beams are discussed by Koutsawa et al. in the first paper. Stiffness and mass matrices are obtained through a Unified Formulation and a layer-wise approximation above the cross-section via Lagrange's polynomials which are used for the displacement components and the electric potential. Several mechanical boundary conditions are investigated and both sensor and actuator configurations are considered. Results are assessed towards three-dimensional finite elements solutions and it is demonstrated that the proposed class of finite elements is able to yield very good accuracy. In the second work, Krommer and Zehetner present the mathematical analysis of a specific realization of piezoelectric torsion transducers based on the piezoelectric d_{36}effect. The analysis follows closely the Saint-Venant torsion theory, but additionally takes the electrical field into account. Within the presented theory, a representation of the exact solution for the stress function, the electric potential, and the warping function of the electromechanically coupled problem in the cross section is derived, which is then solved numerically using finite differences. The transducer can be used as either an actuator or a sensor. The study of harmonic vibrations of a cantilevered transducer completes the paper. The third article by Kulikov and Plotnikova focuses on the use of the method of sampling surfaces (SaS) to exact three-dimensional (3D) solutions of the steady-state problem of thermoelectroelasticity for piezoelectric laminated plates subjected to thermal loading. The SaS method is based on selecting inside the *n*th layer I_n not equally spaced SaS parallel to the middle surface of the plate in order to choose temperatures, electric potentials, and displacements of these surfaces as basic plate variables. The SaS are located inside each layer at Chebyshev polynomial nodes that improves the convergence of the SaS method significantly. Then, Miglioretti and Carrera propose a complex application of a refined electro-mechanical beam formulation in the fourth article. Lagrange-type polynomials are used to interpolate the unknowns over the beam cross section and three (L3), four (L4), and nine-point (L9) polynomials are considered. With the application of Carrera Unified Formulation (CUF), the finite element matrices are expressed in terms of "fundamental nuclei," not depending on the assumption made (L3, L4, or L9). Complex three-dimensional geometries have been studied in order to demonstrate the capabilities of the present formulation. In the fifth paper, Cinefra et al. consider the linear static analysis of both composite plate and cylindrical shell structures embedding piezoelectric layers by means of a shell finite element with variable through-the-thickness kinematic. The refined models used are grouped in the Unified Formulation by Carrera and they permit the distribution of displacements, stresses, and electric variables along the thickness to be accurately described. Various thickness ratios are considered and both sensor and actuator configurations are analyzed. The results are compared with both the elasticity solutions from the literature and the analytical solutions obtained using Navier's method. The sixth article by Cinefra et al. is devoted to the evaluation of refined theories for the static analysis of piezoelectric plates. Also, in this case, the CUF is employed to generate the refined plate models. The axiomatic/asymptotic technique is applied in order to evaluate the relevance of each term in the model by measuring the error introduced with its deactivation with respect to a reference solution. Sensor versus actuator configurations and isotropic versus orthotropic materials are analyzed and compared. 'Best' models are proposed for the different problems and the stress/displacement components and electric potential distributions are evaluated by means of these reduced models. Humer and Krommer investigate a novel approach for the constitutive modeling of piezoelectric continua subjected to large deformation and strong electric fields in the seventh work. This approach is based on a multiplicative decomposition of the deformation gradient tensor and the notion of a stress-free intermediate configuration is introduced. The behavior of piezoelectric materials, according to Voigt's linear theory, is generalized to the nonlinear case. For this purpose, the piezoelectric part of the deformation gradient is identified by comparing the corresponding nonlinear strain measures with the electrically induced strains in the linear theory of piezoelectricity. The implications of the choice of different strain tensors on the material response are discussed. The last work, by Akoussan et al., deals with the vibration of orthotropic multilayers sandwich structures with viscoelastic orthotropic core using the finite element method. The finite element model is derived from a classical zig-zag model with shear deformation in the viscoelastic layer. The free vibration problem is solved by coupling the asymptotic numerical method and the automatic differentiation. The aim of this work is to establish numerical models and develop numerical tools to design multilayer composite structures with high damping properties.

The second group of articles starts with a contribution from Rauter and Lammering on impact damage detection in composite structures. New methods are developed to detect fiber/matrix cracks and delaminations. The acoustical nonlinearity parameter is used to detect micro-structural damages like plasticity in metal and fatigue damages in metal and composites. Here, the second harmonic generation is used to analyze composite specimens for impact damages. Therefore, Lamb waves are launched and detected by a piezoelectric actuator and sensor, respectively, at a certain frequency to generate cumulative second harmonic modes. The results of the relative acoustical nonlinearity parameter are compared to the development of the group velocity due to impact damages. The second paper by Carrara and Ruzzene deals with the design of a novel class of transducers for structural health monitoring and strain sensing, designed using a Fourier-based approach. The design procedure formulates the problem considering an arbitrarily shaped distribution of the sensing surface. Interrogation of the sensors is based on the generation of guided and surface acoustic waves generated in the region surrounding the transducers. The representation of the distribution of the sensing material is analyzed and designed in the spatial Fourier domain, where the emission characteristics of the transducer in relation to the interrogating wave can be tailored to a specific application. The paper illustrates the commonalities of the design procedure, which leads to novel Lamb wave and strain transducers, and suggests the potential integration of the two sensing modalities as a single device for health and usage monitoring of structural components. The last paper by Bucchi et al. is devoted to the thermal effects on the torque of a magnetorheological clutch. An experimental campaign was carried out on a test bench equipped with a caulk over heating up to 80°C. The torque characteristics were measured and both the fluid and the clutch case temperature were monitored at the beginning and at the end of each test. Torque data were processed and well fitted by a formula where the temperature dependence is expressed by Arrhenius law, taking into account the temperature variation during the test. In particular, a loss of transmitted torque for increasing temperature was found. An approximate dependence of the magnetorheological fluid shear stress on temperature was also obtained on the basis of some simplifying assumptions; such dependence may be used to estimate the effect of temperature on similar devices.

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

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

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