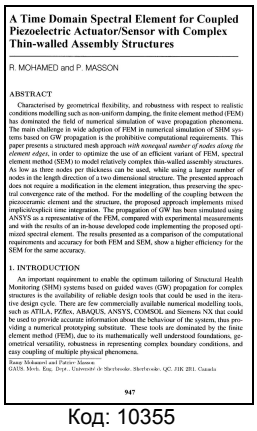

A Time Domain Spectral Element for Coupled Piezoelectric Actuator/Sensor with Complex Thin-walled Assembly Structures

R. MOHAMED and P. MASSON

ABSTRACT

Characterised by geometrical flexibility, and robustness with respect to realistic conditions modelling such as non-uniform damping, the finite element method (FEM) has dominated the field of numerical simulation of wave propagation phenomena. The main challenge in wide adoption of FEM in numerical simulation of SHM systems based on GW propagation is the prohibitive computational requirements. This paper presents a structured mesh approach *with nonequal number of nodes along the element edges*, in order to optimize the use of an efficient variant of FEM, spectral element method (SEM) to model relatively complex thin-walled assembly structures. As low as three nodes per thickness can be used, while using a larger number of nodes in the length direction of a two dimensional structure. The presented approach does not require a modification in the element integration, thus preserving the spectral convergence rate of the method. For the modelling of the coupling between the piezoceramic element and the structure, the proposed approach implements mixed implicit/explicit time integration. The propagation of GW has been simulated using ANSYS as a representative of the FEM, compared with experimental measurements and with the results of an in-house developed code implementing the proposed optimized spectral element. The results presented as a comparison of the computational requirements and accuracy for both FEM and SEM, show a higher efficiency for the SEM for the same accuracy.

1. INTRODUCTION

An important requirement to enable the optimum tailoring of Structural Health Monitoring (SHM) systems based on guided waves (GW) propagation for complex structures is the availability of reliable design tools that could be used in the iterative design cycle. There are few commercially available numerical modelling tools, such as ATILA, PZflex, ABAQUS, ANSYS, COMSOL and Siemens NX that could be used to provide accurate information about the behaviour of the system, thus providing a numerical prototyping substitute. These tools are dominated by the finite element method (FEM), due to its mathematically well understood foundations, geometrical versatility, robustness in representing complex boundary conditions, and easy coupling of multiple physical phenomena.

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947

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Ключевые слова:

Содержание.

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