Asociación Argentina
de Mecánica Computacional

Mecánica Computacional Vol XXXIII, págs. 1683-1683 (resumen)
Graciela Bertolino, Mariano Cantero, Mario Storti y Federico Teruel (Eds.)
San Carlos de Bariloche, 23-26 Setiembre 2014

ANALYSIS OF NONLINEAR VIBRATIONS IN BEAMS MADE OF FUNCTIONALLY GRADED MATERIAL (FGM) WITH PIEZOELECTRIC ACTUATORS

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Abstract. The Functionally Graded Materials (FGM) have been studied for several years due to their constructive features. Unlike laminated composite materials, the FGM are a class of composites that change their constitution smoothly and continuously from one surface to other following a particular law of distribution. The piezoelectric materials are a branch of the smart materials with a lot of applications in engineering designs, also with a growing importance in control of deformations and vibrations and used for actuators and sensors as well. FGM and piezoelectric structures that combine both characteristics are constructed for several industrial purposes. These structures consist of layers of FGM with piezoelectric plates embedded in the structure or bonded in the surface or both.

In this paper a nonlinear model for a curved beam constructed with FGM and piezoelectric materials is introduced. The model considers different types of gradation laws, temperature aspects among others of importance. The motion equations are deduced in the context of classical variational principles considering nonlinear strain-displacement relations. The non linear model can be reduced to other models by dropping all or some non linear terms.

For the analysis of the non-linear dynamics of the curved beam two different approaches are employed and compared. Firstly, the Method of Multiple Scales is employed to tackle directly the non linear equations in order to characterize the nonlinear dynamics of curved FGM beams with piezo actuation. Also, the motion equations for different problems are analyzed by means of finite element approaches and the studies of transient dynamics are tackled with reduced models developed employing the Karhunen-Lóeve decomposition or proper orthogonal decomposition. A number of studies are carried out in order to characterize different aspects of the dynamics of curved beams with piezo-FGM. The effect of the electric charge and the FGM constitution on the non-lineal vibrations and dynamic stability is discussed.