Exploiting global dynamics to investigate the effects of thermomechanical coupling in laminated plates

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Abstract

Thermoelastic analysis of composite plates is of interest in mechanical, aerospace and civil engineering, where they may have a variety of applications. Partial or full thermomechanical coupling of composite plates and shells has been addressed in the literature through models of different order and richness, and mostly finite element-based approaches, in statics as well as linear or nonlinear dynamics. In contrast, few works have referred to low-order models to numerically investigate the effects of actual coupling on the plate dynamical behavior. In the framework of the 2D modelling of geometrically nonlinear laminated plates, reduced order models of thermomechanical coupled plates, with different levels of refinement as concerns shear deformability and temperature distribution along the plate thickness, have been recently proposed [1,2]. Their reduced formulation, with one mechanical and two thermal time-dependent variables/equations, has shown to preserve the main nonlinear dynamic features of the underlying continuum formulation though furnishing few, manageable, equations, crucial to enable a comprehensive description of their dynamics [3]. Yet, when dealing with multiphysics problems, characterized by contemporary presence of slow and fast dynamics, the classical numerical tools used for investigating the nonlinear dynamical response of a system, i.e. bifurcation diagrams and stability charts, prove to be inadequate to grasp its actual behavior, since they neglect the possible decisive effects of the transient dynamics. Conversely, global dynamics analysis, carried out by constructing properly selected 2D cross-sections of the 4D basins of attraction able to reliably representing/describing the multidimensional scenario of nonlinear dynamic response, allows to obtain a comprehensive description and understanding of the response behavior of the system. In fact, despite the computationally demanding effort required, global investigations succeed in detecting conditions under which the long thermal transient of the coupled system meaningfully affects its steady dynamics, both when the coupling interactions entail a solely dragged, i.e. passive, presence of thermal phenomena within the system overall response, and, more evidently, when entailing an actually active role of the coupled thermal dynamics. In the latter case, thermomechanical coupling proves to crucially affect the actual onset of buckled responses, with strong differences with respect to what obtained from the uncoupled mechanical system directly subjected to steady thermal excitation.

Keywords: **laminated plates, thermomechanical coupling, global dynamics**

References

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