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Author: Dr. Enrico Zappino
Politecnico di Torino, Italy

Dr. Matteo Filippi
Politecnico di Torino, Italy
Prof. Erasmo Carrera
Politecnico di Torino, Italy

REFINED MODELS FOR THE LIMIT-CYCLE OSCILLATIONS PREDICTION OF VAT COMPOSITE PANELS IN SUPERSONIC FLOW

Abstract

Launch vehicle design and analysis is a crucial problem in space engineering. The large range of external conditions and the complexity of space vehicles make the solution of the problem really challenging. Even if the launch phase may take only a few minutes, the structures undergo high mechanical, aeroelastic and thermal loads during the atmospheric flight. The stability of the outer spacecraft panels can be an issue when they are subject to supersonic flow. Panel flutter is an aeroelastic phenomenon that appears at supersonic regimes. Panel flutter does not always lead to a catastrophic failure, but a limit-cycle oscillation (LCO) usually appears. This phenomenon creates severe mechanical stresses in the components that may results in early failure due to fatigue phenomena. LCO has been largely investigated in the last decades, and many numerical models were developed to predict the stability of light-weight panels. The use of advanced materials, such as classical laminates or variable angle tow composites, may lead to a reduction of the aeroelastic phenomena if a proper lamination is used but the design of such structures requires accurate numerical models. The present paper presents a refined kinematic finite element model for the prediction of the LCO in advanced composite structures exposed to supersonic flows. The Carrera Unified Formulation has been used to derive a class of refined one- dimensional elements able to deal with advanced materials. A geometrically non-linear formulation has been employed to predict the LCO phenomenon. A classical aerodynamic model, the piston theory, has been used to describe the flow field, that is, only supersonic regimes have been considered. The results show that the use of refined models is mandatory when advanced materials are considered. Nevertheless, the use of one-dimensional elements permits to reduce the computational costs that are relevant when non-linear solution have to be obtained, while, the use of refined kinematics lead to an accurate three-dimensional stress field evaluation.