Aeroelastic Instabilities Analysis of Elastic and Viscoelastic Multi-Layered Panels

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ABSTRACT

Panel flutter is an aeroelastic phenomenon that can cause failure of panels of wings, fuselages and missiles. It happens mostly at supersonic regime even though it can be observed in subsonic ranges. The panel flutter phenomena may appear in space structures during the coasting phase. Some nondestructive aeroelastic phenomena were detected on Saturn V rockets, and analytical and experimental test was carried out as shown by Nichols [1]. During the design of aerospace structures, especially in the case of thin-walled structure, the aeroelastic response have to be considered in order to avoid catastrophic events. In order to avoid the panel flutter phenomena an accurate design of the dynamic response of a structure is required. The possibility to modify the natural frequencies of a structure may move the flutter phenomena out from the critical mission regimes. In this sense, the use of innovative materials could lead to an improvements of the aeroelastic behaviour of a structure.

In this work, the effects on the aeroelastic instabilities of the use of viscoelastic materials in multilayered panels have been investigated. The mechanical properties of the viscoelastic materials depend on the frequencies in which they are vibrating, the dynamic response of a panel could be, therefore, modified with the use of such materials. On the other and the analysis of these materials requires an iterative solution that makes the solution time consuming, the use of efficient numerical models is therefore mandatory. The aeroelastic analysis of elastic and viscoelastic multi-layered panels is performed by using a refined one-dimensional theory based on the Carrera Unified Formulation,CUF [3]. Equivalent Single Layer (ESL) and Layer Wise (LW) models are considered. The use of these structural models provide an accurate solution with a lower computational cost with respect to classical models. The aerodynamic model is based on the linear piston theory [2] therefore only supersonic regimes are considered. The results show that the use of refined structural models is able to provide accurate results in the description of the aeroelastic response of a multi-layered panel. The use of an advanced kinematics approximation, provided by the refined 1D models, through the panel thickness leads to accurate results also when complex multi-layered panels are considered. The introduction of viscoelastic materials is able to modify the response of the panel and can be used to modify the range in which the aeroelastic instabilities appear.

References

[1] Nichols, J., “Final report: Saturn V, S-IVB panel flutter qualification test.” NASA-TN-D-5439, 1969.

[2] Ashley, H. and Zartarian, G., “Piston Theory - A New Aerodynamic Tool for the Aeroelastician,” Composites Structures, 1956, pp. 1109–1118.

[3] Carrera E., Maria C., Petrolo M. and Zappino E., “Finite Element Analysis of Structures through Unified Formulation” John Wiley & Sons Ltd, 2014, pp. 1117–1124.