Paper ID: 10417
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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures - Dynamics and Microdynamics (3)

Author: Dr. Andreas Rittweger
Astrium Space Transportation, Germany, andreas.rittweger@dlr.de

Mr. Stephane Muller
Astrium Space Transportation, France, stephane.muller@airbus.com
Mr. Jean-Francois Durand
Astrium Space Transportation, France, jean-francois.durand@airbus.com

THE NEW APPOACH FOR DAMPING MODELLING IN THE COUPLED DYNAMIC LOAD ANALYSIS FOR THE ARIANE 5 ACOUSTIC BOOSTER MODE LOAD CASES

Abstract

The Ariane 5 launcher is configurated with large solid propellant booster. As all launcher which are using large solid propellant booster there can be severe dynamic excitation due to pressure oscillations in the motor case. These excitations appear at certain flight time for frequencies related to the acoustic modes in the motor case, for Ariane5 around 20 Hz (1st acoustic booster mode) and 40 Hz (2nd acoustic booster mode). For the prediction of the dynamic responses the knowledge of the damping is here essential because the acoustic booster mode load cases are harmonic like load cases. The damping modelling which is used for Ariane 5 is based on damping measurements of typical elements (e.g. damping devices), reconstruction of launcher modal damping from flight measurement and measurement of damping from subsystem tests (e.g. stage or upper composite modal and vibration tests).

Typically the launcher model is assembled by substructures (components) with different component damping. An essential source of damping knowledge is the measurement of the modal damping from subsystem test which are performed under certain boundary conditions. The new introduced approach is based on structural damping and is called Equivalent Structural Damping (ESD, equilvalent means here: equivalent to the modal damping of the component modes under certain boundary conditions). A direct way is to build the condensed substructure models including ESD with component modes corresponding to the test boundary condition. If the condensed models are based on different boundary conditions compared to the test, a transformation of the damping is possible with help of the ESD. By the reverse process of condensation, the condensed model representing the test conditions can be blown up to the physical degrees of freedom and new boundary conditions as desired can be introduced with a following new condensation. Anyhow, condensation techniques including damping for arbitrary boundary conditions of the component modes are necessary, for instance the Craig-Bampton method for clamped modes test condition, the mixed boundary method for test conditions with clamped and free interfaces, or the flexible boundary method for elastic interfaces.

The new approach for damping overcomes physical unrealistic behaviour and inconsistencies in case of different component damping known from classical approaches based on damping forces proportional to velocity.

The simulations performed with the new methodology proved to be much closer to the flight results and ensured as well a complete mathematic consistency in the damping modelling process.