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INNOVATIVE VISCOELASTIC DAMPER SELECTION STRATEGY BASED ON DMA AND MINI-SHAKER TESTS FOR SPACECRAFT APPLICATIONS

Abstract

With the increase of payload sensitivity (such as high precision optics for submetric imager), micro-vibrations disturbances generated by spinning actuators, if not controlled, may affect on-board instruments and may worsen the quality of an Earth observation imager. For the last two decades, viscoelastic materials have been gradually used as dampers designed for space applications. Their attractiveness comes from their ability to act as second order passive filters to minimise micro-vibration forces.

In the framework of this study, an innovative viscoelastic damper selection process has been developed in order to assess the mechanical and thermal properties of viscoelastic dampers during early design stages. In order to characterise the viscoelastic dampers, tests have been performed at two levels: At the viscoelastic material level (material characterisation) and at the viscoelastic damper level (Damper characterisation).

The material characterisation, which consists in thermogravimetric analysis (TGA), dynamic mechanical analysis (DMA) and creep tests, have been carried out on five silicon-based and carbon-based viscoelastic materials. Additionally, a mini-shaker experiment has been designed to complete a mechanical characterisation of the damper at ambient temperature. Finally, Kistler© tests have been performed on spinning actuators equipped with viscoelastic dampers to assess the accuracy of the viscoelastic damper selection process.

The main results from the material characterisation (DMA tests) are the storage modulus, loss modulus and tan delta master curves generated for each viscoelastic material. These master curves have been obtained by applying the time temperature superposition (TTS) principle. Key characteristics of these master curves, such as slopes or integrals, have been calculated. Voigt and Maxwell-Voigt models (viscoelastic models based on springs and dashpots) have been implemented to model the experimental transmissibility curves of the different viscoelastic dampers tested with the Mini-shaker experiment. A qualitative and quantitative correlation has been highlighted between the master curves (material characterisation) and the transmissibility curves (damper characterisation). Therefore it is possible to predict the expected damping performances of a viscoelastic material during early design stages of the damper. Indeed, DMA tests, which are cost and time effective, are used as a screening process for material selection:

the viscoelastic material exhibiting the best trade-off between mechanical and thermal stability properties is selected. Moreover, the tests performed on the Kistler© table (With and without the viscoelastic damping system) have been used to demonstrate and validate the innovative correlation.