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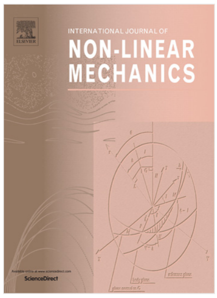

Panel flutter suppression with nonlinear energy sinks: Numerical modeling and analysis

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Panel flutter suppression with nonlinear energy sinks: Numerical modeling and analysis

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Abstract

High-speed flight can cause aircraft skin to exhibit an aeroelastic instability typically called panel flutter. Due to the risk of fatigue failure imposed by this undesired phenomenon, several techniques have been proposed over the years to passively or actively control such aeroelastic vibrations. One relatively new method that has been proven effective for controlling various aeroelastic phenomena is the use of nonlinear energy sinks (NES). Here, for the first time, this technique is employed for suppressing panel flutter and reducing the intensity of limit cycle oscillations (LCOs). The present work consists of a comprehensive study on the numerical modeling of a NES, its coupling to an aeroelastic finite element plate model, and several solutions attained through the resulting system. In order to simulate LCOs, a geometrically nonlinear plate model is employed. The supersonic aerodynamic loads are modeled by piston theory, and the final aeroelastic equations of motion are solved directly in time by an implicit integrator. The energy dissipated by the NES and the energy injected in the panel by the flow are obtained numerically as a function of time. This provides important insights on the mechanism through which a NES can either suppress flutter or mitigate LCOs by partially balancing the aerodynamic work. The performance of the NES is tested in three regimes: At the pre-flutter regime, the NES leads the panel to a faster return to equilibrium after a perturbation; at higher speeds, the NES is still able to suppress flutter, whereas an uncontrolled panel would exhibit LCOs; at even higher speeds, the NES is no longer able to completely suppress the motion but can pump enough energy to reduce the amplitude of the LCOs. In any of these scenarios, the practical outcome would be a longer lifespan for the skin structure. Furthermore, a parametric study is conducted to assess how different NES parameters such as damping coefficient and nonlinear stiffness affect the aeroelastic response. The results reveal that a NES can be used as a lightweight device for passively controlling panel flutter, and that such technique is suitable for optimization-driven design.

1. Introduction

Panel flutter is an aeroelastic instability that affects the skin structure of aerospace vehicles, normally in supersonic flight. It caught the attention of the scientific community in the 1950's due to structural failures in fighter planes and rockets [1, 2, 3]. Differently

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