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”PACO#2 - Nonlinear damper approaches to flutter mitigation in highly-flexible wings”

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The High-Altitude, Long Endurance (HALE) aircraft is an innovative concept with great potential in telecommunications and surveillance applications due to its ability to function as a “pseudo-satellite” within the stratosphere. Its unique features are accomplished in practice through numerous design requirements that ensure maximal efficiency. Regarding the airframe in particular, these lead to light wings with extremely high aspect ratios. The resulting -very flexible- structure is consequently sensitive to dynamic instabilities emerging from aeroelastic effects (i.e., flutter), which produce large-amplitude oscillations and drastically diminish the aircraft’s flight envelope. Hence, accurate prediction of flutter and the ability to mitigate it are crucial to enable reliable HALE aircraft design and operation. In the present work, we explore passive control strategies for flexible wing flutter through the nonlinear effects introduced by an added damper system. To this end, an original aeroelastic model of the wing is introduced, whose structural component provides a degree of accuracy and complexity that lies at a midpoint between linear and geometrically-exact nonlinear beam models. The damper is modelled as a single-degree-of-freedom secondary subsystem attached to the wing through a linear spring, and the equations of motion of the full system are implemented numerically. Mitigation performance is assessed with regard to flutter speed, instability range and vibration amplitude. Parametric studies are conducted for varying stiffness, span-wise location and dissipation mechanism of the damper. The latter of these aspects is given special attention, and the respective performances of viscous and nonlinear damping are compared. Overall, our results show that dynamic stability of the wing can definitely be improved through the use of a well-tuned damper. However, the choice of design parameters leading to optimal performance is far from obvious. Furthermore, the simplistic mechanism proposed herein is subjected to evident practical limitations, and thus this work concludes with a discussion on potential extentions and considerations for implementation.

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