ABSTRACT

ACTIVE FLUTTER SUPPRESSION OF A SMART FIN

Karadal, Fatih Mutlu
M.S., Department of Aerospace Engineering
Supervisor: Prof. Dr. Yavuz Yaman

September 2008, 112 pages

This study presents the theoretical analysis of an active flutter suppression methodology applied to a smart fin. The smart fin consists of a cantilever aluminum plate-like structure with surface bonded piezoelectric (PZT, Lead- Zirconate-Titanate) patches.

A thermal analogy method for the purpose of modeling of piezoelectric actuators in MSC®/NASTRAN based on the analogy between thermal strains and piezoelectric strains was presented. The results obtained by the thermal analogy were compared with the reference results and very good agreement was observed.

The unsteady aerodynamic loads acting on the structure were calculated by using a linear two-dimensional Doublet-Lattice Method available in MSC®/NASTRAN. These aerodynamic loads were approximated as rational functions of the Laplace variable by using one of the aerodynamic approximation schemes, Roger's approximation, with least-squares method. These approximated aerodynamic loads together with the structural matrices obtained by the finite element method were used to develop the aeroelastic equations of motion of the smart fin in state-space form.

The H∞ robust controllers were then designed for the state-space aeroelastic model of the smart fin by considering both SISO (Single-Input Single-Output) and MIMO (Multi-Input Multi-Output) system models. The verification studies of the controllers showed satisfactory flutter suppression performance around the flutter point and a significant improvement in the flutter speed of the smart fin was also observed.

Keywords: Flutter suppression, thermal analogy method, unsteady aerodynamic modeling, H∞ controller design, smart structures.