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Smart structures and their applications on active vibration control: Studies in the Department of Aerospace Engineering, METU

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Abstract This work presents the theoretical and experimental studies conducted in Aerospace Engineering Department of Middle East Technical University on smart structures with particular attention given to the structural modelling characteristics and active suppression of in-vacuo vibrations. The smart structures considered in these analyses are finite and flat aluminium cantilever beam-like (called as smart beam) and plate-like (called as smart fin) structures with surface bonded lead–zirconate–titanate patches. Finite element models of smart beam and smart fin are obtained. Then the experimental studies regarding open loop behaviour of the structures are performed by using strain gauges and laser displacement sensor to determine the system models. Further studies are carried out to obtain H_∞ and μ-synthesis controllers which are intended to be used in the suppression of free and forced vibrations of the smart structures. It is observed that satisfactory attenuation levels are achieved and robust performance of the systems in the presence of uncertainties is ensured. In that respect a comparative study involving H_∞ and sliding mode controls is also conducted. Recently, the studies involving aerodynamic loading are also gathering pace.

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1 Introduction

The developments in piezoelectric materials have motivated many researchers to work in the field of smart structures. A smart structure can be defined as the structure that can sense external disturbance and respond to that with active control in real time to maintain the mission requirements. Smart structures consist of highly distributed active devices which are primarily sensors and actuators either embedded or attached to an existing passive structure with integrated processor networks. Depending on the characteristics of the smart structures involved and the expected operating conditions, the selection of sensors and actuators vary considerably. The typical smart structure sensors used in discrete or distributed locations to measure the performance of the system comprise fibre optics, piezoelectric ceramics and piezoelectric polymers. The actuators used in the smart materials technologies include applications of piezoelectric ceramics, piezoelectric polymers, electrostrictive, magnetostrictive materials and piezofibres. Their reliability, nearly linear response with applied voltage, showing excellent response to the applied electric field over very large range of frequencies and their low cost make piezoelectric materials [lead–zirconate–titanate (PZT)] the most widely preferred one as collocated sensor and actuator pair. Therefore our work mainly considers the application of PZT patches to smart beam-like and smart plate-like structures for the purpose of active vibration control. Structural models and controller models so far developed and implemented were for in-vacuo vibrations where the effects of aerodynamics