NATO/RTO/APPLIED VEHICLE TECHNOLOGY PANEL

PROJECT

T-121

Application of Smart Materials in the Vibration Control of Aeronautical Structures

STARTING DATE: 01 April 2000

COMPLETION DATE: 31 March 2002

1. PURPOSE AND OBJECTIVES

The subject of project T-121 was the application of PZT (Lead-Zirconate-Titanate) ceramics in the vibration control of beam-like (smart beam) and plate-like (smart plate) structures. The aim was the development of various control strategies for the vibration control of aeronautical structures by using the smart structures.

The following goals were achieved in T-121 :
. Determination of the optimum locations of the smart material applications for vibration control of beam-like and plate-like structures.
. Determination of appropriate Finite Element models to be used.
. Development of theoretical structural and control models.
. Development of H_∞ control strategy for a smart beam.
. Experimental verifications of the developed structural models and control strategies.

The theoretical considerations and modelling studies were conducted in METU, Department of Aeronautical Engineering, Turkey. Sensor Technology Limited of Canada provided experimental facilities and acted as consultant. Institute for Aerospace Research of Canada also acted as consultant.

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3. MAJOR RESULTS

1. In the first phase of the project, analytical and numerical modelling of aluminum beam-like structures (smart beams) were completed. Correct FEM models were developed and verified. Determination of the stiffening effects of PZTs on dynamic response were theoretically analyzed by FEM. Determination of the effects of PZT locations on the response were theoretically investigated by FEM. The PZTs were only modelled as actuators and the strain-gages were assumed to be used as sensors. Analysis and implementation of various control strategies such as P,PI,PID, H_∞ control were extensively studied. H_∞ control strategies were developed for beam-like structures (smart beam). Theoretical verifications of the control models are being done through extensive computer simulations by using MATLAB software.

2. In the second phase of the project the analytical and numerical modelling of aluminum plate-like structures (smart plates) were studied in detail. First considered are the effects of PZT characteristics and PZT locations on the plate response. The PZTs were modelled as both sensors and actuators. The strain-gages were also assumed to be used as sensors. The developed control strategies for the smart beams were also improved and the special attention was paid on H_∞ control models. The state-space models of the smart beams and smart plates were obtained from the developed FEM models and they were later reduced to different order models. The vibrations due to first two flexural modes of the smart beams were succesfully suppressed. These control models were also extended to the smart plate models to suppress the first flexural mode of the smart plates. Theoretical verifications of the control models are being done through extensive computer simulations by using MATLAB software. During the experiments single-input and single-output applications were conducted for beam-like structures. For plate-like structures, single input and multi-output experiments were made. The obtained experimental data from visits to Canada were used to verify and improve the theoretically developed control models for smart beams.