AVT/ T-121
Application of Smart Materials in the Vibration Control of Aeronautical Structures

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Prof. Dr. Yavuz Yaman (Coordinator)
Department of Aerospace Engineering, Middle East Technical University, Ankara, Turkey
Phone: (90) 312 210 4285, Fax: (90) 312 210 1272, E-mail: yyaman@metu.edu.tr
Tarkan Çaliskan(M.Sc), Middle East Technical University, Ankara, Turkey
Dr. Eswar Prasad, Sensor Technology Limited, Canada
Dr. David Zimcik, Institute for Aerospace Research, NRC, Canada

PURPOSE:

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

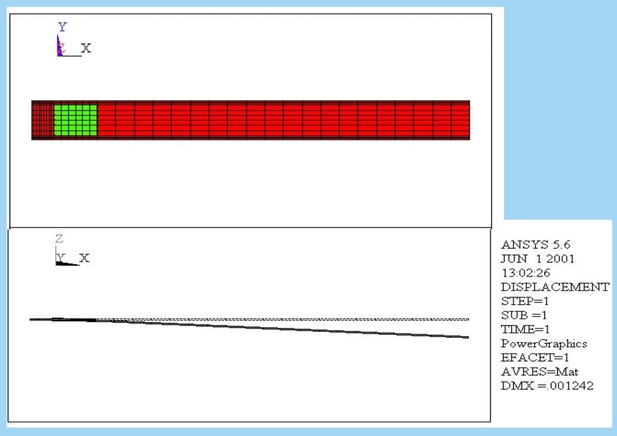
OBJECTIVES:

. Development of structural models of smart beam, smart plate and smart fin.
. Determination of the locations of PZT applications.
. Development of H-infinity control strategy for a smart beam.
. Experimental verifications of the developed structural models.

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

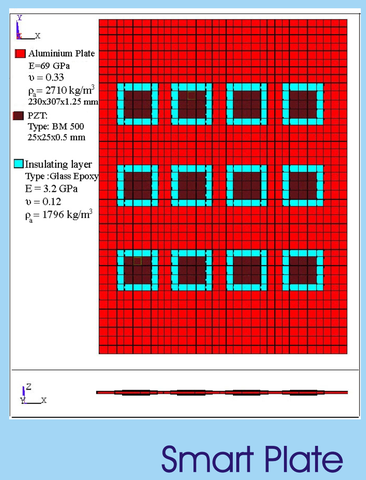
RESULTS:

In the first phase of the project, analytical and numerical modeling of aluminum beam-like structures (smart beams) were studied. 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 modeled as actuators and the strain-gages were assumed to be used as sensors. Modeling of various control strategies such as P, PI, PID, H-infinity control were done. Theoretical verifications of the control models are done through extensive computer simulations by using MATLAB.

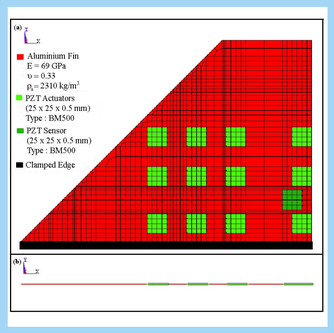


Smart Beam

In the second phase of the project the analytical and numerical modeling 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 modeled 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-infinity control models. The state-space models of the smart beams 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 successfully suppressed in theoretical simulations These control models were also extended to the smart plate models to suppress the first flexural mode of the smart plate. Theoretical verifications of the control models are done through extensive computer simulations by using MATLAB software. The facilities of Sensortech, Collingwood, Canada were visited to conduct extensive open-loop experiments for the smart beam and plate models. The obtained data were used to verify and improve the theoretically developed control models for smart beams and plates.



Smart Plate



Smart Fin

PUBLICATIONS:

The following joint papers were published:

1) Yaman, Y., Çaliskan, T., Nalbantoglu, V., Prasad, E. and Waechter, D., "Active Vibration Control of a Smart Beam", Canada-US CanSmart Workshop on Smart Materials and Structures, Montreal, Canada, 2001

2) Yaman, Y., Çaliskan, T., Nalbantoglu V., Ülker, F., D., Prasad, E., Waechter, D., Yan, B., "Vibration Control of Smart Plates by Using Piezoelectric Actuators", ESDA2002, 6th Biennial Conference on Engineering Systems Design and Analysis, Istanbul, Turkey, 2002

3) Yaman, Y., Çaliskan, T., Nalbantoglu, V., Prasad, E., Waechter, D., "Active Vibration Control of a Smart Plate", ICAS2002, Toronto, Canada, 2002.