A SMART MATERIAL BASED APPROACH TO MORPHING

Mr. G. N. Dayananda
Advanced Composites Division
NAL, Bangalore
dayanand@css.nal.res.in

Educational Qualifications:
Master's Degree in Machine Design, University College of Engineering, Bangalore (1987)
Bachelor's Degree in Mechanical Engineering, University College of Engineering, Bangalore (1985)

Professional experience:

» Working in NAL since 1987
» Played an important role in the indigenous development of large state-of-art process equipment required for manufacturing advanced carbon composites for aerospace applications
» Was the project leader for the successful design, fabrication and low speed wind tunnel testing of a smart control surface incorporating shape memory elements (SMA) at NAL
» Is also the project leader for several projects related to the development of shape memory alloy based devices such as smart repair device, deployment mechanisms, energy absorbing systems etc.

Research Interests:

» Composites
» Smart Materials

Awards / Honors received:

» Indian Society for Advanced Materials & Process Engineering (ISAMPE) award for "Design and development of process equipment", 1994
» Sir C.V.Raman Research fellowship to carry out research on shape memory alloys at Catholic University, Belgium in 1999
» ISAMPE award for SMA based smart technologies, 2001 and 2006
» two patents related to SMA based devices
» Fellow of the Institution of Engineers (India)

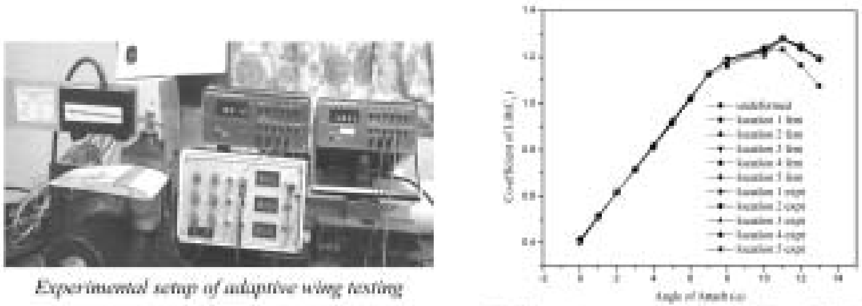
ABSTRACT

G. N. Dayananda, G.M.Kamalakannan, P.Senthil Kumar, S.Jayasankar & Satisha
Advanced Composites Division, NAL, Bangalore; dayanand@css.nal.res.in

This presentation gives an overview of the Shape Memory Alloy (SMA) based approach to the research and development of adaptive/smart/morphing airframe structural technologies at the Advanced Composites Division, NAL. Central to this approach is the efficient integration of thermal NiTi SMA elements with polymeric carbon composites. The SMA elements could be either externally placed or embedded in the polymeric composite. The external connection could be in the form of mechanisms / devices. The various activities related to morphing technologies are briefly discussed below:

A smart control surface having movable part dimensions 600 * 600 mm was built incorporating SMA elements. The movable part consists of two-hinge axis. The SMA elements are connected in an antagonistic fashion about each of these axes. The model was first tested for the static strength and then was taken to the low speed wind tunnel for testing. In the wind tunnel the movable part was tested successfully in the deflected condition[1] (by energizing the SMA elements) up to a maximum speed of 160 km/hr.

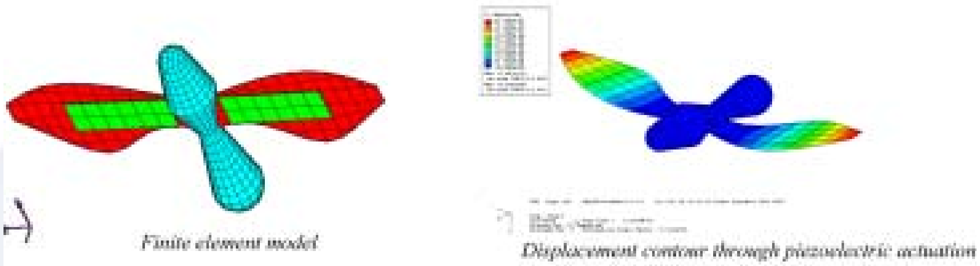
Smart structures technologies using smart materials are not mostly looked into for MAV applications. However, few studies have employed PZT, EAP and SMA materials. Using Eppler 387 airfoil, we have built an adaptive wing for MAV (Figure 1) to demonstrate the use of a piezoelectrically vibrating surface in flow control application. Further, a flapping wing concept (Figure 2) using two stripe actuators is developed and analyzed. Attempts are being made to use MFC/PZT tapes to develop active control surfaces for MAV- Black Kite (Figure 3).



Experimental setup of adaptive wing testing

C_L Vs α (on average deformed shape: FEM and Expt.)

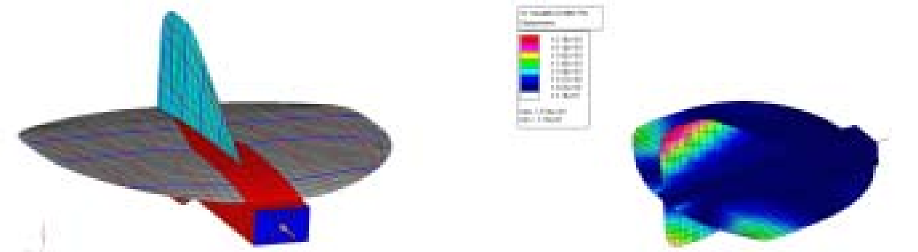
Figure1: Adaptive wing of MAV for flow control application



Finite element model

Displacement contour through piezoelectric actuation

Figure 2: Flapping wing MAV using stripe actuators



Finite Element Model

First Elastic Mode of Black Kite MAV @ 33.0851Hz

Figure 3: Structural Design and Analysis of Black Kite MAV

References

1. Stanford, B., Viieru, D., Albertani, R., Shyy, W. and Ifju, P. (2006), *A Numerical and Experimental Investigation of Flexible Micro Air Vehicle Wing Deformation,*AIAA-2006-440 , 44th AIAA Aerospace Sciences Meeting and Exhibit, Reno, Nevada, Jan. 9-12, 2006.
2. Sathyamoorthy, S., Raja, S. and Stanley, A.J. (2006), *Piezoelectric Based Adaptive Wing for Flow Control*, J. of Aerospace Sciences and Technologies.
3. Imran Shaik (2005), *Design and Implementation of Flapping Wing Actuators for a Micro-Air-Vehicle,* BE Thesis (BITS, PILANI), Structural Technologies Division, NAL, December 2005.
4. Stanford, B., Ifju, P., Albertani, R. and Shyy, W. (2008), *Fixed membrane wings for micro air vehicles: Experimental characterization, numerical modeling, and tailoring*, Progress in Aerospace Sciences, 44(4), pp. 258-294.
5. Sytsma, M., Albertani, R., Viieru, D., Shyy, W., Ifju, P. and Stanford B., (2007), *Static Aeroelastic Model Validation of Membrane Micro Air Vehicle Wings*, AIAA Journal, 45(12), pp. 2828-2837.