Curriculum Vitae

Name: Mr. G. N. Dayananda

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)

A Smart Material based approach to Morphing

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.

The fore plane or mousche has been identified as an additional aerodynamic control surface to be attached to the fore body of a typical combat aircraft for deck landing. This is deployed only during landing to improve the landing characteristics of the aircraft. In this connection a geared drive relay mechanism using banks of SMA actuators[2] is being built and will be tested for full load. A state-of-the-art electronics and control system has been employed to drive the SMA banks. The mechanism developed has adequate redundancy built into the system.

Aircraft parts like wings, tail units, control surfaces get damaged during service for a variety of reasons. Since they are part of aerofoils, their smooth surface contours should not get affected due to repair. For example, when the damaged portion of the wing skin is removed, it forms a cut out in the skin. If the cut out is patched in the usual repair method, it leaves a projection on the skin, which is not desirable from the aerodynamic point of view. Hence, bonding a flush repair patch is desirable. In order to bond a flush patch it is necessary to first bond an annular ring shaped patch inside the skin. Taking the support of the bonded annular ring a flush patch can be bonded. Bonding the annular ring inside (to the inner surface of the damaged skin) requires special gadgets / mechanical devices which are cumbersome to use. These gadgets also do not apply uniform heat and pressure on the annular ring during bonding. Applying uniform external heat and pressure during bonding is a primary requirement. A programmable smart repair kit has been developed based on the innovation, which overcomes the limitations of the conventional devices. The unique SMA property wherein the SMA element attains a pre-set shape due to a thermal transformation from martensite to austenite is exploited. The SMA device is inserted in the cold state through the damaged hole. After insertion it is electrically heated (in a controlled manner) due to which it opens out like a flower (in the process memorizing the hot shape) exerting uniform force on the annular ring patch area while at the same time heating the resin system required for curing the polymer as a bonding agent. A closed loop temperature controller for maintaining the desired temperature profile (in the bonding region) for the given resin system is designed and developed for bonding both annular ring and patch.

Large controlled shape changes of thin SMA embedded beams have been realized by innovatively configuring the SMA elements inside the fibre reinforced plastic beams[3]. The large controlled shape changes are necessary to obtain the morphing of aircraft structures. By achieving large controlled elastic deformations of thin beams it is possible to realize smart / adaptive features in the aircraft structure such as the wing. With this large shape change it is possible to generate a local adaptive bump on the wing. The adaptive bump is a smart feature, which enables reduction of drag arising due to the shock wave. For a given aerofoil, in a certain range of speeds and in a certain range of angle of attack a strong supersonic area is formed on the upper side of the wing. The supersonic area ends in a shock (shock wave) leading to high energy losses and considerable drag. One of the ways of reducing the drag is by providing a local bump in the area of shock, using smart / adaptive concepts. The SMA wires were successfully embedded in an innovative manner and the large controlled elastic deformations were demonstrated when the SMA wires are energized. The beam returned to the original position when the SMA was de-energized. The deflected beam was also tested under a uniformly distributed load of 27 Kg/mm^2.

The possibility of incorporating SMA based morphing schemes discussed above for Micro Air Vehicles is being currently examined.

References

1. G.N. Dayananda and V. Shankar, M. Subba Rao and M.A. Farook, “ Active Shape Control of an Airfoil using Shape Memory Alloys “ Proceedings of Third International conference on “Advances in Composites” ADCOMP-2000,Bangalore, India (2000), Pg.392-399.
2. G.N. Dayananda, P. Senthil Kumar and M. Subba Rao “Development of an SMA based actuator mechanisms for deployment of control surfaces” Proceedings of Fourth International conference on Smart Materials, Structures and Systems, Bangalore, India (2005), Paper No. SB-19, Pg.SB-131 to 138.
3. S. Jayasankar, G.N. Dayananda, M. Subba Rao, “Hybrid Composites for Morphing Applications’’ XV NASAS Conference, Coimbatore, India (2007).