Structural Health Monitoring - Web course

COURSE OUTLINE

Materials are evolving today at a rate faster than any other time in the history of civilization. The emergence of new and improved materials, their processing and the development of a newer area of specialization known as Materials Design are stimulating innovation in all the walks of life making new designs for efficient systems and structures. Development and exploitation of new materials like high performance composites, new engineering ceramics, high strength polymers and super-alloys are providing better alternatives in terms of enhanced functionality and energy efficient systems with improved safety and reliability at a competitive price. Advent of smart and intelligent materials together with advances in processing technologies such as tape casting and screen printing, improvement in sensing and actuation technologies and their successful miniaturization and integration to composite structures along with developments in the field of real time data acquisition and information processing is likely to change the scenario in the most dramatic fashion in days to come.

Composites are fast gaining attention as structural materials due to overriding advantages over conventional metallic structures. Owing to their high specific strength and stiffness and very good corrosion and fatigue properties, they are increasingly being used in the design of light weight aerospace, automobile and civil structures. Further, there is an increasing application of advanced composites in varied fields such as marine structures, turbine blades, automobile bodies etc. This increase in usage of composites has raised the necessity for evaluating the in-service performance of such structures.

Due to greater complexity of design, high operational loads and longer lifetime, composite structures are prone to unpredicted failures. Present day non-destructive evaluation (NDE) techniques, such as ultrasonic testing, acoustic emission, eddy current method, radiography and thermography etc., primarily meant for metallic materials, are not always very effective for composites because of inherent micro-mechanical complexities. Further, these methods require specialized equipments and skilled manpower. Many times, in-situ evaluation or evaluation on real time basis is not possible. Anisotropy of composites, conducting properties of the fibers, insulative nature of the matrices and unintentional impact damages beneath the surface which are barely visible (BVID) make the damage prediction still more difficult and challenging in composites. These damages may cause a change in strain / stress state of the structure and hence, its characteristics.

By continuously monitoring one or more response quantities causing these changes, it is possible to assess the condition of the structure for its structural integrity. Such a monitoring of the structure is generally known as Structural Health Monitoring. Health monitoring application has received great deal of attention all over the world due to its signi?cant impact on safety and longevity of the structure. The course will broadly cover the overview of SHM, its interrelationship with smart material and the application of various smart sensors in SHM.

COURSE DETAIL

Modules	LectureTopics and Contents	No of Lectures
1.Introduction to SHM	An Overview of Structural Health Monitoring Structural Health Monitoring and Smart Materials	**15**

NPTEL

http://nptel.iitm.ac.in

Mechanical Engineering

Pre-requisites:

Mechanics of Composite Materials and Introduction to Smart Materials

Additional Reading:

1. Agarwal B D and Broutman L J, *Analysis and Performance of Fiber Composites*, Second Edition, John Wiley & Sons Inc., **1990**
2. Balageas D L, *Structural health monitoring R&D at the European Research Establishments in Aerospace (EREA)*, Aerospace Science and Technology, 6(**3**), p159-70, **2002**
3. Bunk W G J, **Advanced Structural and Functional Materials**, Springer-Verlag, **1991**
4. Crawley E F, *Intelligent structures for aerospace: A technology overview and assessment*, AIIAA

	Structural Health Monitoring versus Non Destructive Evaluation A broad Overview of Smart Materials Emerging SHM Technologies using Piezo Sensors SHM using Magnetostrictive Sensors SHM using Optical Fibres and other sensors Overview of Application Potential of SHM Notable Applications of SHM – Aerospace and Civil Applications Underground Structures and Other Applications Understanding Piezoelectric Material Understanding Magnetostrictive Material Optical Fibre and Lambwave method Solution Domain for SHM Other Damage Indices		Journal, 32(8), p1689-99, **1994** **Coordinators:** **Prof. Anand Kumar** Mechanical EngineeringHBTI Kanpur **Prof. Bishakh Bhattacharya** Department of Mechanical EngineeringIIT Kanpur
2.Vibration Control for SHM	Vibration Control using SHM – introduction to FE formulation Constitutive Relationship Element Stiffness Matrix for High Precision Finite Element Element Mass Matrix for High Precision Finite Element Developing Actuator and Sensor Influence Matrix Estimating Sensor Voltage Active Control of Damping A Case study of Performance Estimation for Different Patches SHM of Ribbon Reinforced Composite Laminate	**9**	
3.SHM using Piezo and Magnteostrictive Layers	Delamination Sensing using Piezo Sensory Layer	**11**	

	Voltage Response from Piezopatch Electrical Impedance Method basic theory A Case Study: Results and Discussions SHM using Magnetostrictive Sensory Layer Basics of Magnetization and Hysteresis Delamination Sensing using Magnetostrictive Sensory Layer Constitutive relationship with composite relationship MS Layer in symmetric Laminate MS Layer Away from the Mid-plane in Asymmetric Laminate Case Studies related to MS Layer based SHM	
4.SHM using LDV	Experimental Modal Analysis using LDV - introduction What is LDV? Velocity and Displacement Measurement using LDV Case Study for Symmetric Laminate Case Study for Cross-ply	**5**
	Total no of Lectures	**41**

References:

1. Smart Materials and Structures, Gandhi and Thompson
2. Structural Health Monitoring: Current Status and Perspectives, Fu Ko Chang
3. Journal Papers on this subject