Structural Health Monitoring for Advanced Composite Structures

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Editors

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Preface

Structural health monitoring (SHM) is a modern technology with the potential to significantly improve damage detection in composites and therefore act as a viable alternative to the commonly utilized non-destructive inspection (NDI). The industry's quest for high efficiency and performance with reduced weight has resulted in the extensive use of composite materials. However, composite materials are sensitive to in-service impact damage and with today's NDI technologies, inspections are frequent and costly due to the fact that it can only be carried out if access to the area to be inspected exists or is provided during maintenance checks.

The basis of SHM is the application of permanent fixed sensors on the structure combined with the necessity of a minimum of manual intervention to monitor the structural integrity. This enables a continuous monitoring of the structure, and thus a detection of the defect at a very early stage to move away from planned maintenance and towards condition-based maintenance.

This book, for the first time, provides an overview of prominent SHM techniques for damage detection and localization utilizing ultrasonic-guided waves in composites. It covers not only the fundamental concepts in the SHM piezoelectric and fiber optic sensor philosophy but also the state-of-the-art on passive and active sensing methodologies.

Chapter 1 initially provides a comprehensive review of guided wave damage detection techniques, before presenting some of the key aspects required for establishing an effective SHM system for large complex composites structures such as optimization of sensor positioning and influence of changes in environmental conditions on damage detection algorithms. Chapters 2 and 3 present efficient and accurate numerical

modeling techniques for wave propagation and their interaction with damage in composites. Electro-mechanical impedance and guided wave propagation methodologies based on special signal processing techniques that allow identification of signal anomalies caused by structure degradation are the subject of Chapter 4. In Chapter 5, constructive interference via beamforming is developed to increase the reliability of the SHM system with a phased array configuration. Chapter 6 presents the fiber optic (FO) sensors as effective sensors for strain monitoring due to their high sensitivity to strain measurement, light weight and immunity from electro-mechanical interference. Finally, in Chapter 7, application of SHM to in-service monitoring of impact events is presented through passive sensing algorithms. Particular attention is paid to data-driven methods using machine learning algorithm for determination of impact location and energy. A Bayesian-based optimization is presented for determining the optimal sensor configuration in complex structures.

About the Editors

M. H. Ferri Aliabadi is a Professor or Aerostructures and Zaharoff Professor of Aviation. He has been the Head of Aeronautics Department at Imperial College, London, since 2008. Prior to joining Imperial College in 2005, he was Professor of Computational Mechanics and the Director of Aerospace Engineering at Queen Mary, University of London (1997–2004) and Reader and Head of Damage Tolerance Division at WIT, Southampton (1987–1997). Since 2004 he is the head of the Department of Aeronautics at Imperial College, London.

Ferri's main research interests are computational methods and mathematical modeling, aerospace materials and structures, composites and material innovations and structural health monitoring. He has published more than 250 journal papers and authored and edited over 50 books.

Zahra Sharif Khodaei is a Senior Lecturer in Aerostructures. She obtained her PhD from Czech Technical University in Prague in numerical modeling of functionally graded materials in 2008. Prior to her lectureship post in 2014, she was a Research Associate at the Department of Aeronautics, Imperial College, London, since 2009 where she conducted research in fatigue modeling and analysis of metallic and fiber metallic laminates (FMLs) and more significantly in developments of technologies and methodologies for structural health monitoring (SHM) of composite structures. Her main areas of research are structural integrity and health monitoring of structures in particular composites. She has authored more than 30 journal publications including book chapters.

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