Challenges and Advances in Integrated Self-Healing System Development

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Structural Health Monitoring today has reached a state where we can think beyond Damage Prognosis and focus on Structural Health Management (SHM). Integrated Self-Healing System (ISHS) Development is one of the widely traversed research areas in the domain of SHM. The field is multidisciplinary involving click chemistry, nano-science and technology, MEMS and control system development. In the initial phases of ISHS development, various chemical technologies are developed by which crack initiated polymerizations are designed to take place in composite structure which can modify it's stiffness and strength. These are known as passive self-healing systems. However, passive systems are open-loop in nature and hence, they are generally reactive systems – the healing process occurs once the damage has already taken place. The rate of healing in such systems can not be exactly matched with the rate of damage, as a result there are possibilities of either insufficient healing or loss of healing material due to over-reaction. Extrinsic self-healing systems have been developed based on pressurized vascular networks where the pressure drop due to damage initiates transportation of the healing material. In other applications, fibre optic networks are used for damage sensing and a network of shape memory wires are utilized for stress field modification. Recently, another interesting way of self-healing has been proposed with the help of piezoelectric poly vinylidene fluoride-cohexafluropropylene (PVDF-HFP), zinc oxide and copper nanoparticles to develop a PVDF-HFP solid electrolyte. This solid electrolyte can be triggered to generate copper nano-particle deposition at the damaged site when the stress intensity crosses a threshold level and sensed by the piezoelectric PVDF to initiate voltage generation which can subsequently be used as a control signal to activate the healing process. However, such a system has implementation challenges due to the presence of dead-zones, where signal from the piezoelectric system may become insufficient creating mismatch between the healing and the damage rate. Advanced control system based on sliding mode control integrated with fault detection algorithms may provide useful solutions to this problem. A research collaboration between the University of Sheffield and IIT Kanpur is actively taking place in this direction. Some of the interesting results will be discussed and the future scope of development will be outlined in this direction.

Biodata

Dr. Bishakh Bhattacharya is a Professor of Mechanical Engineering department and Cognitive Science and Technology programmein the Indian Institute of Technology Kanpur (IITK). His area of research includes: Active and Passive Vibration Control, Structural Health Management, Design of Energy Harvesting System, Intelligent System Design and Child-Robot Interaction Design. Based on his work on Shape Memory Actuator, a new technology is developed for shape control of reconfigurable flexible parabolic antenna system for the Indian Space Research Organization (ISRO). Another notable application of his work on Structural Health Management is in developing Energy Harvesting Pipe Health Monitoring robotsfor the Gas Authority of India Limited (GAIL).

Among other activities, he was Head of the Design Programmeat IIT Kanpur from 2011-2013. He is now coordinating the Space Technology Cell of the Institute. He is also coordinating three laboratories: Applied Dynamics and Vibration, Automation and Control and Smart Materials and Systems Laboratory. He is currently Dr. GurmukhD. Mehta and VeenaM. Mehta Chair Professor in the Institute. Dr. Bhattacharya had received best scientist award from the Systems Society of India and recipient of Sakura Fellowship in the area of Brain inspired Robotics. He is in the editorial boards of Jl. of Low frequency Noise and Vibration Control and ISSS Jl. of Micro and Smart Systems.