Computational modelling of fracture and healing in self-healing materials

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Summary

Self-healing materials are a class of materials which possess the capability of autonomously or under minimal external stimulus healing the 'damage' incurred in the material. Research in this field gained significant attention in the last decade owing to its promise of enhanced durability of the material/structural components in engineering applications. Though the research has led to several promising applications, extensive experimental tests were often required for a successful demonstration. Further, for real-time engineering applications with self-healing materials, arriving at an optimal design of the self-healing system is a crucial challenge. In this context, modelling techniques in combination with a limited number of experimental tests are potentially more efficient than an experiment-driven trial and error design process. With this motivation, the research aims to develop a modelling framework to analyse and understand the fracture mechanisms and the healing behaviour of self-healing material systems using finite element modelling. In particular, a crack healing constitutive model capable of simulating multiple cracking and healing events is developed for which cohesive zone-based fracture mechanics in combination with cohesive elements is utilised. The end application considered in this research is a Thermal Barrier Coating (TBC) system for gas turbine engines. The applicability of the developed framework will be demonstrated through lifetime simulations of a self-healing TBC system. The overall objective is to provide certain guidelines and suggestions for material scientists and engineers in terms of selection and design of healing particles and a computational tool to understand and quantify the cracking and healing behaviour of self-healing material systems.

About the Presenter

Dr Sathiskumar Anusuya Ponnusami joined as a Lecturer in Structural Mechanics at City, University of London in October 2018. His research interests encompass computational modelling of damage and failure in heterogeneous materials while his ongoing research exploits utilising machine learning tools for solid mechanics problems. Prior to City, he worked as a postdoctoral researcher in Solid Mechanics Group at University of Oxford, UK, where he continues to be a visiting academic. As a part of a Rolls-Royce and Innovate UK project and in collaboration with Imperial College and University of Bristol, his research focused on an integrated computational-experimental approach to investigate high strain-rate failure behaviour of fibre composites under impact loading. He conducted his doctoral research on self-healing materials in the Department of Aerospace Structures and Materials at Delft University of Technology (TU Delft) Netherlands. In parallel to his PhD research, he formed and led an international team, MultiFun which won the €30,000 Airbus-UNESCO Global Innovation Challenge, Fly Your Ideas 2015 among 500 teams from over 100 countries for a project on multifunctional composite structure for next-gen aircraft. He is the recipient of NLF Dutch Aerospace Award 2015 (€5000) for the best aerospace engineering student at university level in the Netherlands, ITMA Future Materials Award 2015, Italy, Young Scientist Award (€5000) at International Conference on Self-Healing Materials 2013, Belgium and Outstanding Performance Award in Mahindra Aerospace Young Engineer Awards 2010, India.