MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Interactive Session on Materials and Structures (9)

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SENSING CAPABILITIES OF MULTIFUNCTIONAL COMPOSITE MATERIALS USING CARBON NANOTUBES

Abstract

Multifunctional composite materials are a rising trend of the last years in the aerospace world, as they can offer mass reduction to the final design. Nanotechnology, on the other hand, has helped significantly towards the development of such materials by providing nano-scale materials with exceptional property combinations (e.g. carbon nano-tubes); when incorporated inside a composite material, they can greatly affect their macro-scale properties and enable new functionalities. Use of carbon nanotubes (CNT) enhances composites properties with the most important being increased electrical conductivity of previously conductive materials. Additionally it leads to the switch of non-conductive materials to conductive. These advancements have helped to increase the sensitivity or enable techniques which use electrical conductivity as an index of the material's state (e.g. health). Such sensing strategies applied until now in conductive composites have been able to address issues related to the existence of the damage. A remaining challenge is the localization of damage and the evaluation of its shape and extent. To address this limitation,this study proposes the use of the Electric Resistance Tomography (ERT) technique. ERT works by making measurements on the boundary of the material and by using mathematical methods try to estimate the conductivity distribution inside the material. The resulting conductivity map provides indications of the material's state. To implement this technique, we developed an ERT system for the measurement of voltage distribution at multiple locations of the materials. In this work, the technique was applied to CNT reinforced Glass Fiber Reinforced Polymers (GFRP), which are conductive due to the presence of the CNT. Different loading conditions were imposed to the materials under investigation. ERT measurements were collected during the test and used for the extraction of conductivity maps. A correlation between the resulting conductivity maps, as derived from the inversion of the ERT data, the loading and the response was attempted. The sensitivity of the technique requires further assessment to define its limitations and identify further potential applications.