Micro-Scale Experiments and Models for Composite Materials with Materials Research

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Numerical models are frequently implemented to study micro-mechanical processes in polymer/fibre composites. To ensure that these models are accurate, the length scale dependent properties of the fibre and polymer matrix have to be taken into account. Most often this is not the case, and material properties acquired at macro-scale are used for micro-mechanical models. This is because material properties at the macro-scale are much more available and the test procedures to obtain them are well defined. The aim of this research was to find methods to extract the micro-mechanical properties of the epoxy resin used in polymer/fibre composites for wind turbine blades combining experimental, numerical, and analytical approaches. Experimentally, in order to mimic the stress state created by a void in a bulk material, test samples with finite root radii were made and subjected to a double cantilever beam test in an environmental scanning electron microscope. Deformation around the notches was measured using a digital image correlation method. Analytically, the experimental results were related to the HRR theory, and the concept of strain energy density was used to find the micro-scale stress-strain relationship and failure strength. In the numerical approach, the experimentally measured strain fields were matched with the numerically predicted strain fields for different power law hardening material models. In addition, this study includes evaluation of the strain gauge accuracy, when devices are applied on polymer and polymer/composite materials.

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