Abstract

A constituent-based analysis of the fatigue performance and damage initiation of unidirectional reinforced composites is an approach drastically limiting the number of variables to three, but simultaneously ignores other important aspects. Still, the constituent level is the basis for a better understanding of the main mechanisms driving early stages of fatigue damage. This is essential for a high flexibility in the choice of processing methods and the constituents themselves and allows for a targeted testing campaign including associated cost savings. This work investigates how variations in the matrix polymer's properties affect the fatigue performance under transverse tension-tension and on-axis compression-compression loading. Since it is acknowledged that the fiber-matrix level will only include part of the real composite, a multi-scale approach is perused both experimentally and by Finite Element modelling. Carbon and glass fiber reinforced epoxy and carbon fiber reinforced polycarbonate are investigated. The results identify the relative stiffness and time-dependence as main polymer properties affecting fatigue damage, whereas plastic yielding has a limited influence. As essential additional factors in controlling damage initiation, residual stresses and interface failure could be identified. The concept of an in-situ S-N curve could be developed and showed that local variations in fiber-distribution need to be considered to get the intrinsic fatigue strength of any system. Similarly, polymer characterization needs to account for the local stress state within a composite, i.e., constrained conditions and loading sequence.