A hyperelastic damage model for continuous fiber reinforced thermoplastic composites: formulation and numerical simulations

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In this work an orthotropic hyperelastic damage model is presented for modeling and simulation of continuous fiber reinforced thermoplastic composites behavior. For this purpose, the free energy function is additively decomposed into three components: 1) a component taking into account the matrix response; 2) a component taking account of the fibers behaviors and 3) a component describing the matrix-fibers interactions. A continuum damage formulation is used by associating to each free energy function component an isotropic internal variable describing the irreversible aspect of the damage evolution of the material constituent considered. Thus, the response of a reinforced thermoplastic composite is obtained through the response of each constituent with its damage evolution for the matrix and the fibers separately, and for the matrix-fibers interactions. Parameters laws were obtained by inverse identification from experimental results of uniaxial tractions and cyclic loading performed at 0 and 45 degrees of Twintex fiber directions, a woven thermoplastic composite, and at a temperature higher than the matrix fusion temperature. A user material subroutine VUMAT for an explicit dynamic analysis has been developed and implemented in Abaqus software. In order to evaluate the constitutive law predictive capability, finite element simulations of thermostamping process of a woven thermoplastic composite were performed with the four nodes S4R thick shell element. Results show that the model provides interesting physical responses compared to an orthotropic hyperelastic model without damage. This constitutes a first step before making a benchmark with experimental results that will be performed.