The application of the energy dissipation arc-length solver for the simulation of damage in composite materials

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Abstract

Failure of composite materials is often a combination of multiple failure mechanisms, such as fibre breakage, matrix failure and delamination. These phenomena can be simulated on a meso-scopic level of observation using the finite element method. Here, the individual layers of the material are modelled using solid-like shell elements[1], which can be equipped with a continuum damage law to capture the intralaminar damage mechanisms. The solid-like shell elements are based on a non-linear kinematic relation which allows for the simulation of (local) buckling. Delamination is modelled by means of interface elements, which have a mixed-mode damage constitutive law [2] and are placed between the solid-like shell elements. The combination of several failure mechanisms and a non-linear kinematic relation has a negative effect on the stability of the solution algorithm. Conventional techniques to solve the system of equations in a quasi-static manner, such as the arc-length method, often fails to converge at the onset of damage in the model. An alternative is the energy dissipation based arc-length method, in which the constraint equation is based on the amount of energy that is dissipated in the model [3]. In this research, we combine the energy dissipation based arc-length method and the geometrically non-linear solid-like shell element [4]. The robustness of the developed solver will be demonstrated via the simulation of delamination growth in composite materials.

References