OPTIMIZATION OF HYBRID COMPOSITES IN UNIAXIAL TRACTION INTRODUCING A PSEUDO-DUCTILE RESPONSE

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Keywords: Hybrid Composites · Pseudo-ductility · Analytical Modelling · Multi-objective Optimization · Genetic Algorithm.

Abstract

Composite materials have met increased interest in the industry, especially in lightweight construction (for example, in automotive and aerospace applications) due to their unique properties compared to the more conventional structural materials. However, they are characterized by having a brittle failure, i.e., typically they have no ductility, which may limit their usage. A ductile failure of a composite material is desired, like in metallic materials, which present yielding after the elastic region followed by strength increasing. Hybridization is a key factor to introduce a so-called pseudo-ductile behavior in the fiber reinforced composite material. The hybridization here consists in the use of two different types of fibers (with different failure strains or strengths) embedded in a polymer matrix, with the goal of improving overall composite properties and performance. The present work analyzes and optimizes this hybrid fiber reinforced composite based on failure analytical models. Ultimately one discovers the optimal mix of fiber materials which produces an "optimal" ductile behavior in the composite material when it is subjected to a tensile load.

To predict the failure of composite materials, two different analytical models previously developed were coupled with optimization algorithms. The first model considers a bundle composed of two different types of fiber, without matrix, named as hybrid tows. To account for the presence of the matrix, a second analytical model is used, based on the multiple fiber fragmentations.

Despite the simplicity of these failure models, they are very useful to work on a correct parameterization of the response curve of the hybrid composite when subjected to uniaxial traction. A parameterization of that response is necessary for its control and consequent optimization to achieve the desired pseudo-ductile response. One proposes here four parameters which fully characterize the response. These parameters are included in the optimization problem. The problem is formulated here either as a multi-objective problem or as single objective one using a weighted sum of objective functions. The optimizations are performed using the Genetic Algorithm (GA). The final goal is to identify the optimal mix of the base constituents in the hybrid composite.