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OPTIMAL USE OF ULTRA-THIN PLIES IN COMPOSITE STRUCTURES

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Summary: Thermoplastic-based composites offer a large set of advantages over thermoset-based composites: they have higher toughness which is important when impact resistance is required, the time and energy consuming curing process is omitted, reprocessing to correct simple defects is possible and easier, it is possible to weld composite parts together and, therefore avoid the weight, expense and loss of components' resistance that the use of fasteners represents, among others.
To simulate failure in composite materials it is important to take into account:
1. The nonlinear behavior prior to failure that exhibit when loaded in specific directions
2. Pressure dependent yielding
3. Compressibility and dilatation
4. Anisotropic behavior
The material model proposed by M. Vogler [1] has the items mentioned taken into account and it is able to represent the elastic-plastic response of a transversely isotropic material (such as UD composites), i.e., until failure initiates. The yield function proposed is based on the invariant theory and in a non-associated flow rule. To fully define the material behavior, it is necessary to determine:
1. 6 yield parameters (α). Each one is associated with one or two yield stresses and is, as hardening occurs, a function of the equivalent plastic strain.
2. 3 plastic flow parameters (β). These parameters are used to define a non-associated plastic flow function. This function controls the contractibility and dilatancy, but is not a function of the equivalent plastic strain which means that the parameters remain constant during inelastic deformation.
The tests needed to fully characterize the material are sometimes expensive and difficult to perform, hence some assumptions might be done to characterize the material as a first approach.
Vogler proved that this model is able to simulate the mechanical behavior of carbon-epoxy unidirectional composites and, it should be expected that the results obtained when simulating a thermoplastic-based composite are as accurate. This is yet to be proven, but, to do so, experimental data has to be obtained and the simulations have to be performed.
The objective of this paper is to present some relevant aspects of the mechanical behavior of unidirectional thermoplastic-based composites and to discuss the application of Voger's model to high-performance thermoplastic composites.

References:
[1] Matthias Vogler. Anisotropic Material Models for Fiber Reinforced Polymeres. PhD thesis, 2012.