Development of a workflow for the virtual optimization of a nanofiber-interleaved composite laminate subjected to impact loading

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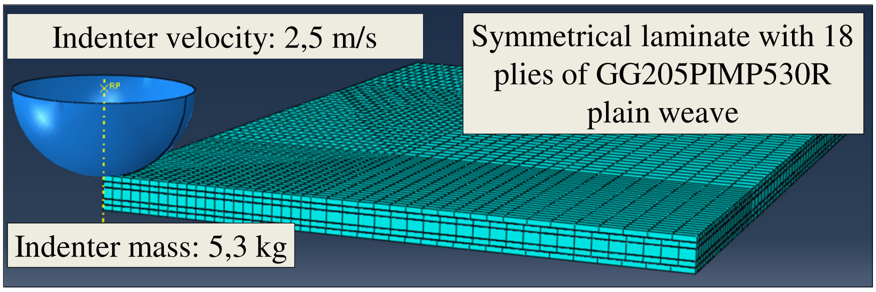
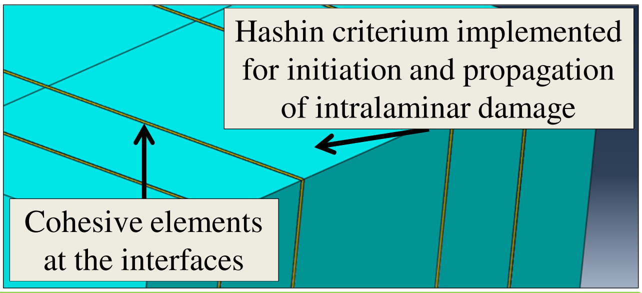
Goals

To identify the configurations of an epoxy/carbon composite laminate with nylon nanomats at the interfaces and subjected to low velocity impact, which optimize the counteracting objectives of maximum energy dissipated by delamination and minimum decrease of laminate stiffness

First step: finite element model





Second step: ESTECO modeFRONTIER^{TM} multi-objective optimization workflow

<u>Input variables:</u>

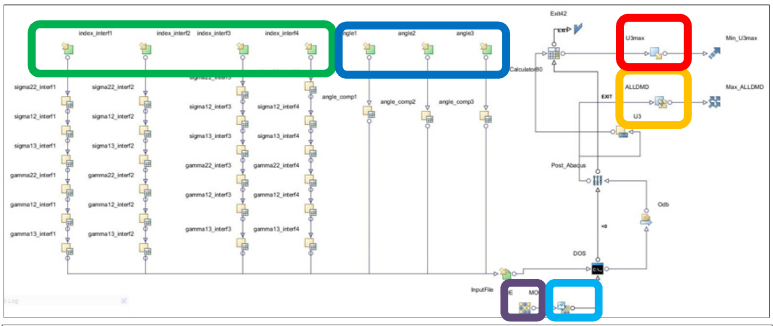
- **Type of interface (virgin, 14RB nanomodified or 25RB nanomodified)**
- **Lamination sequence $[\theta_3/\varphi_3/\chi_3]_S$, where θ, φ, χ can assume the values 0° or 45°**

<u>Output variables:</u>

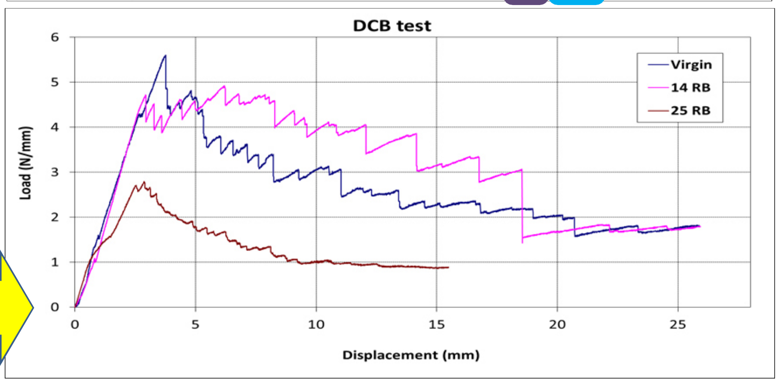
- **Damage-dissipated energy (ALLDMD, to maximize)**
- **Maximum displacement of the impact point (MaxU3, to minimize)**

<u>Optimization techniques:</u>

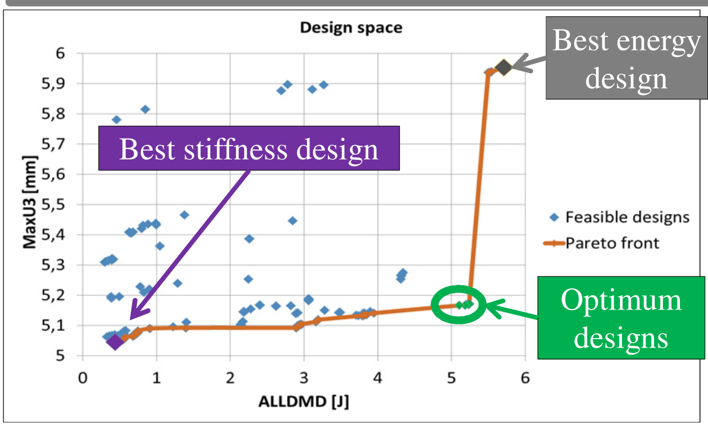
- **DOE technique: SOBOL (quasi-random)**
- **Optimization algorithm: Multi-Objective Genetic Algorithm-II (MOGA-II)**



Depending on the type of interface (nanomats with different thickness), it's possible to gain either a toughening or an embrittlement of the interface itself



Results



Best stiffness design: $[45_3/45_3/0_3]_S$; virgin interfaces

Best energy design: $[45_3/45_3/45_3]_S$; 25 RB nanomodified interfaces

Optimum designs: $[45_3/45_3/0_3]_S$; type of interface (from the top to the bottom):

- **A: 14 RB / 25RB / virgin / virgin**
- **B: virgin / 25RB / virgin / 14RB**
- **C: virgin / 25RB / 14RB / 14RB**
- **D: 14RB / 25RB / 14RB / 14RB**

Conclusions

- The real number of designs simulated by the optimization software is only 164, which produces a time saving of 74% with respect to the case of evaluation of the total theoretical number of designs (648)
- The combined use of DOE+genetic algorithm assures the achievement of a robust solution