The role of numerical tools on the development of a new generation of polymer composite materials

P.P. Camanho[1]

[1] DEMec/INEGI, University of Porto, Rua Dr. Roberto Frias, 4200-465
Porto, Portugal - pcamanho@fe.up.pt

The stringent guidelines on emissions combined with the strong competition between aerospace companies motivate the development of a new generation of polymer composite materials. New requirements, ranging from lightness, multi-functionality, recyclability, structural health monitoring, and faster manufacturing processes are imposed by the market. However, the time frame from material development to implementation is currently too high (up to 20 years) [1], and product innovation based on new materials is particularly fraught with risk and uncertainty. The use of computational mechanics mitigates these risks and uncertainties: not only the development of new materials is faster due to the reduced number of physical tests, but also increased knowledge on the material performance is obtained at early stages of material development.

This work addresses the role of Computational Fracture Mechanics on the development of a new generation of non-conventional polymer composite materials based on ultra-thin plies [2], fibre hybridisation [3], and carbon-nanotubes [4]. The analysis models that support the development of the non-conventional polymer composite materials are based on computational micro-mechanics, cohesive zone models, and continuum damage mechanics. The models developed represent the mechanics of non-linear deformation and fracture of the new material systems proposed. Furthermore, the models are able to explain the reasons why the new materials have an improved performance over conventional materials with respect to the main failure mechanisms of polymer composite laminates, such as delamination, matrix cracking, and fibre fracture.

The work presented corresponds to one of the building-blocks required for the effective optimisation of the micro-structure of composite materials with respect to a set of design drivers.

References

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