ICMAMS 2019
Second International Conference on Mechanics of Advanced Materials and Structures
Nanjing, 19-22 October 2019
www.icmams.com

Virtual Twins of Aeronautic Composite Structures : Innovative Design Methodology, Virtual Manufacturing and Virtual Testing

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Keywords: *Composite, Design Methodology, Virtual manufacturing, Predictive virtual testing*

This plenary will present the issues and recent development made at Institut Clément Ader in design, manufacturing and damage modeling vs testing of aeronautic composite structures.

Concerning the design, the large choice of material compositions (i.e. matrix and fibres combinations), architectures and manufacturing processes makes the design process complex and difficult, as the designers face a hyper-choice of materials and technologies that can be overwhelming. Most of the time, designing composite is understood as, and limited to, the choice of stacking and sizing using the TSAI method or derivative, with or without an optimization scheme. So the GAP composite design methodology (acronym of Geometry, Architecture, Process) which will be presented aims to be a starting point in a composite design process and, in this methodology, we would like to emphasize the importance of creating concepts in sufficient number and variety to tackle the issue of hyper-choice raised above.

Once a design have been selected, to reduce the cost, virtual manufacturing of the complete cycle of an autoclave curing must be develop. A calculation loop including thermo-kinetics, thermo-chemical and thermomechanical implementations has been developped. Refined experimental analysis of the different materials characterics during the cure must be conducted. CFRP stiffened panels are considered with a special focus on the effect on bonding of stiffeners in the distorsion of the cured part.

Aeronautic composite part are certified according to a damage tolerance policy and one main issue is the modeling and the efficiency of testing damaged composite structures. The Discrete Ply Modelling (DPM) is based on a mesh following the orientation of the plies. This complex mesh allows taking into account naturally the coupling between intra and inter laminar damages but also splitting. Moreover, it is based only on 13 "true" parameters. This approach was applied successfully for impact and crash on laminates, CAI, residual dent computation, pull-through, edge impact and impact on tapered laminate. This approach was extended successfully to in-plane issues like open hole tension, scaling effects and recently large notches. So the confidence in this modeling strategy is high and

the next step is to move from the scale of coupon under uniaxial loading to the scale of technological specimens under complex loadings. This investigation was made through the VERTEX research program. A significant step to Predictive Virtual Testing was achieved and a new pyramid of tests for the certification of aeronautic composite structures can be proposed.

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