PhD position

3D crack propagation in a CMO/CMO interface at the mesoscopic scale

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The European Commission has set itself the objective of reducing the European Union's greenhouse gas (GHG) emissions by more than 80% by 2050, compared with 1990 levels, and even aiming for carbon neutrality by that date. In the aeronautics industry, one of the ways to achieve these objectives is to reduce the weight of structures, thereby reducing fuel consumption.

The use of composite materials to manufacture structural parts is one way to achieve this. On the LEAP engine developed by Safran Aircraft Engines, 3D woven composites (CMOT3D) are used to manufacture the blades and fan case.

In the case of the LEAP casing, the composite preform is wound several times around an axis before the polymer resin is injected. Interfaces are thus created between each ply of the composite. These interfaces, essentially made of resin, are the privileged zones for the initiation and propagation of cracks during the damage of the part.

The characterization and modeling of the phenomena leading to these damages are therefore major development axes to optimize the dimensioning of such parts.

The goal of this thesis is to study and simulate the 3D crack propagation in a CMO/CMO interface, to feed a macroscopic behavior law of the composite delamination. This multi-scale approach to damage, presented in Figure 1, requires achieving several objectives.

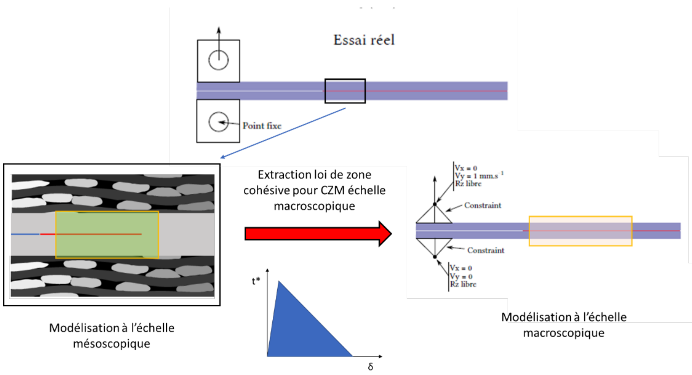
Experimental part

First, an experimental protocol to characterize the crack propagation in the CMO/CMO interface will be defined. This protocol will cover the characterization of mode I, mode II and mixed mode delamination, in the warp and weft directions, for several substrate thicknesses and for different levels of wet aging of the composite. These tests will be instrumented in situ and/or post-mortem to allow the description of the damage kinetics in the CMO/CMO interface. In addition, some specimens will be analyzed by tomography before and after the tests, in order to extract the mesostructure numerically.

Numerical modeling

The next objective will be to simulate crack propagation in the CMO/CMO interface. To do so, tomography images will be used to generate a Representative Elemental Volume (REV) of the CMO/CMO interface. Based on previous work conducted by CEMEF, this part will consist in obtaining a representative mesh of the topology of the 3D woven composite substrates mesostructure and their interface. By test/calculation comparison, the cohesive law(s) at the mesoscopic scale will be identified on the characterization tests, according to the material directions and the type of solicitation.

Based on the mesoscopic scale modeling, a multi-scale crack propagation simulation strategy will be defined, implemented, and validated from the available experimental data. This work will include the transfer of the mesoscopic cohesive law to a macroscopic delamination law also using the cohesive zone elements.



Approach proposed in the study

Candidate profile

The candidate must have a strong interest forboth experimental testing and numerical modeling of complex phenomena. Knowledge of material testing, mechanics and programming in C++ or Python are requriedand.

Partners

The project takes place within an ongoing collaboration between Safran and CEMEF aiming at understanding and modeling the fracture of CMO/CMO interfaces at different scales.