Postdoctoral position

Study on the conformal meshing of 3D woven composites at the mesoscopic scale

The European Commission has established a target of reducing greenhouse gas (GHG) emissions of the European Union by over 80% by 2050, in comparison to 1990 levels. Additionally, the Commission aims to achieve carbon neutrality by that same year. 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 a viable approach to attain these objectives. In the case of the LEAP engine developed by Safran Aircraft Engines, 3D woven composites are used in the manufacturing of blades and fan case.

In the context of the LEAP casing, the composite preform is repetitively wound around an axis before the injection of the polymer resin. Interfaces are thus created between each layer of the composite. These interfaces, essentially made of resin, are critical zones for the initiation and propagation of cracks during the progressive damage of the part.

The characterization and modeling of the phenomena leading to these damages are, therefore, key areas of focus in order to optimize the design of such components.

The objective of this postdoctoral project is to use actual capabilities of a numerical library developed at CEMEF to generate conforming meshes of the composite microstructure at the mesoscale. The mesh will then be used to perform structural mechanical computations.

Numerical modeling

These composite microstructures are inherently complex. However, there are numerical methods that can be used to generate digital representations of such microstructures. These methods allow to capture and model the main features of real composite microstructures and are often used in the material design process.

A digital representation of the microstructure can also be obtained from 3D imaging (X-ray tomography). This experimental techniques allow to obtain 3D images of the real microstructure. Such images can then be merged into a 3D mesh associated with remeshing methods to accurately reproduce interfaces between resin and fibers.

During the design process, numerically generated microstructures can also be used to generate a 3D numerical models of the composite. Such generated microstructures are important to better understand the relationship between microstructure and mechanical behavior. Comparison between generated microstructures meshes and real microstructures ones is important for improving the numerical methods to generate 'synthetic' microstructures.

Once experimental data from X-ray tomography becomes available, an updated version of the microstructure must be generated to achieve a 3D numerical model as realistic as possible. In this iterative process, an automated pipeline is required.

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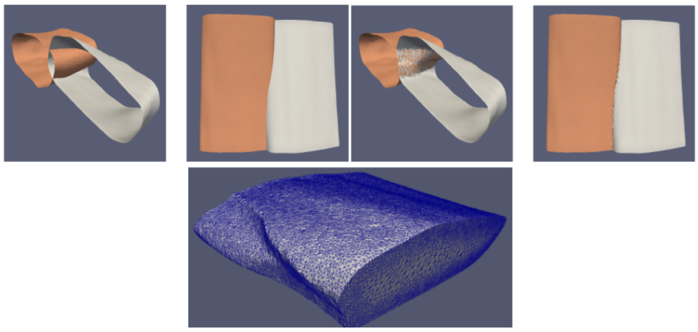
To reach this end, the following steps are required:

- Immersion of the 3D microstructural representation (real or generated microstructure) into the finite elements mesh.
- Volume conserving smoothing of the microstructure.
- Disentangling of the different material phases.
- Computational time optimization.
- Validation and testing.
- Data export for mechanical simulation.

The figure below shows a region containing two fiber strands. These strands, which are initially overlapping, must be disentangled before a conforming mesh could be generated. As for today, this preprocessing is manual and time consuming.



Disentangling and conforming mesh generation

Candidate profile

The candidate must hold PhD degree in computational mechanics, high performance computing, material science, or a closely related field. The candidate should demonstrate a strong interest in numerical modeling and programming within a high-performance modeling environment. Knowledge of mesh generation, mechanics and programming in C++ or Python is required.

Partners

The project is being conducted as part of an ongoing collaboration between Safran and CEMEF with the objective of better understanding and modeling composites at different length scales.