Hexcel Chair for *Advanced Numerical Modelling of Composite Structures Infusion-based Processing*

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Numerical approach of Stokes-Darcy flows in low-permeability deforming composite reinforcements for modeling infusion-based processing of aircraft primary structures

Main PhD supervisor : Pr. S. Drapier (SMS div / Mechanics and Materials Processing dept)

Co-supervisors : Dr J. Bruchon, Dr PJ Liotier, Dr N. Moulin

Resin infusion-based processes are promising routes for the production of primary composite structures. However, manufacturing such structures for aeronautics is still a challenge which requires to fill-in further gaps in terms of quality, to reach the 1% max void content targeted in ever increased production rates (60 aircrafts/month in 2020/25 for the next generation of single aisle aircraft). Mandatory developments for setting robust numerical and experimental modelings of the underlying hydro-poro-mechanical phenomena in play are still to be developed. As a world leader in composite materials production for aeronautics, Hexcel is funding a 2 M€ industrial chair at Ecole des Mines in Saint-Etienne, a long time partner, for developing leading edge simulations capabilities for aircraft manufacturers.

Indeed, in the last years a unique holistic framework has been developed at Ecole des Mines to model these processes (see Celle *et al.* Pacquaut *et al.* Abou Orm *et al.*), along with dedicated experimental means to follow the most representative parameters. The bottle neck in modeling properly these processes lays in the **various physical phenomena tightly combined across scales**, namely the **thermo-reactive resin flow** (fluid first, and solid afterwards) **into highly deformable orthotropic preforms undergoing finite strains**.

The aim of the present PhD work is to yield a robust numerical modeling of infusion-based processes at the scale of the preforms, *i.e.* where liquid resin flows take place in - assumed - homogenized equivalent othotropic media. Recent numerical methods, such as ASGS stabilized coupled Stokes-Darcy flows nested with solid finite strain deformations of the very low permeability orthotropic preforms, will be improved and optimized in a high performance computing frame at the process scale, in order to understand and hence control the filling stage of high added value composite structures. A deeper mathematical analysis can eventually be setup to reduce computation costs through model reductions techniques. Alternatively, modeling of industrial structure processing can be achieved, depending on the PhD candidate's ability and motivation.

Partner : Hexcel Corporation.

Profile sought :
1 - mechanics (solid, fluid, porous media),
2 - applied mathematics; computational mechanics
3 - numerical skills. Skills in C++ programming will be a plus.
Applicants should be fluent in English, if not in French.

Funding : 3-years term contract at 1600 € net salary per month (including social insurance).

Recruitment : continuous applications will be examined until proper candidates will be appointed

Applications (CVs+report card+references) should be sent directly to Prof. S. Drapier drapier@emse.fr