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

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Numerical approach of local Stokes-Darcy and capillary flows in fibrous preforms for modeling infusion-based processing of composite 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 model, at local scales, the resin flows in the fibrous network of the preforms, where wettability issues are assumed to play a great role, either in assisting or in delaying resin infusion, as well as in porosity formation and transport. First, at the fibre scale (micron), the resin flow in impervious fibre systems will be characterized and modeled. Then, flows inside and around fibre tows, containing thousands of individual fibres, will be studied relying on some specific ASGS stabilized numerical methods able to deal with coupled Stokes-Darcy flows in low permeability orthotropic media. Capillary and viscous dominated flows competing at this scale will be used to scale-up 'rules' for flows at the process scale. Studying the post-filling stage in infusion-based processes, where pressure equilibration takes place over time, is also an issue of this PhD work. All these appraoches will be improved and optimized in a high performance computing frame, in order to understand and hence control both filling and post-filling stages of high added value composite. Physical analyses of the surface-tension driven capillary and wettability issues will be a part of this approach.

Partner : Hexcel Corporation.

Profile sought :
1 - mechanics (solid, fluid, porous media),
2 - numerical skills, experimental sense.
Skills in C++ programming and physical characterization 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