Internship proposal for Master 2

Forming Simulations of continuous fiber composite reinforcement

Context

This subject is part of LEME's research activities on the development of Finite Elements (FE) for heterogeneous materials (laminates, sandwiches), in a multi-field environment. Beyond the well-known mass gain when using composite materials compared to metals, the possibility to adapt their mechanical properties to meet design requirements is a second advantage, more difficult to deploy, since it requires to consider the manufacturing process.
This project will therefore focus on the simulation of the forming (draping) of continuous fiber composite reinforcements (Fig. 1) and prepregs. In the first case, a resin is injected into the dry reinforcement after it has been formed (LCM Liquid Composite Molding) [Sozer et al, 2012]. In the case of prepregs, the resin is present in the reinforcement but is not hardened (not polymerized for thermoset resins, or at a temperature above the melting of the matrix for thermoplastics) [Lukaszewicz et al, 2011]. In this second case, the non-hardened matrix modifies the behavior, which, however, still remains controlled by the fibers.
The mechanical behavior of these materials has two peculiarities that make them unique: on the one hand a relative sliding between the fibers is possible, on the other hand the fibers are almost inextensible. These two aspects determine the kinematics of the deformation of fibrous media [Bai et al, 2020]. In addition, these textile reinforcements have a low flexural stiffness, but it has been shown that this stiffness plays an important role during the forming process, in particular for the occurrence of folds [Boisse et al, 2011].
The PlasFib software, an in-house FE code developed at LaMCoS (INSA Lyon) for explicit dynamics, will be used for simulating the forming process. Comparisons with an industrial software such as Abaqus can be carried out.

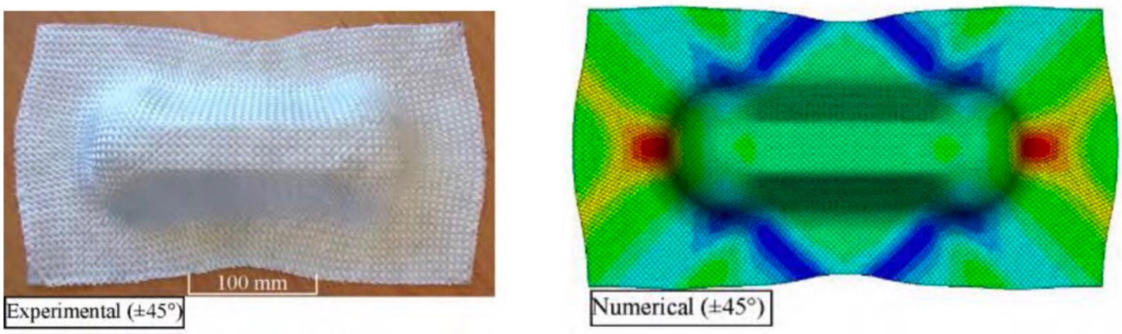

Fig. 1: experimental and numerical comparison at the macroscopic scale

Objectives of the internship

The objectives of this internship are divided into two complementary axes:

1) Bibliography
    used continuous fiber composite reinforcement and resin
    explicit dynamic FE software and PlasFib in particular
    shell FE available in PlasFib for two-dimensional forming simulation [Hamila et al, 2009]

2) Forming simulations with PlasFib
    comprehension of the numerical modeling: explicit scheme, variables update, constitutive law, contact algorithm, …
    perform forming simulations of some classical tests available in the literature

At the end of this internship, a doctoral thesis (ANR funding) may be proposed to continue the work initiated.

Profile and skills required

Profile

The candidate will be in the last year of his Master program (5th year of higher education). Good knowledge of solid mechanics and FE computation are required as well as knowledge of composite materials. Affinity for theoretical and numerical developments (computational mechanics) will be essential.

Skills required

computational mechanics, finite element method, …

solid mechanics, composite materials, …

ability to analyze results, autonomy, accuracy and thoroughness…

Internship application

This internship will be carried out at the LEME-EA4416 laboratory, for a period of 6 months. The internship will start in February / March 2022.

To apply, please send your CV with the acquired academic grades to the email addresses below.

Team direction

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References

Bai R. et al. (2020) A specific 3D shell approach for textile composite reinforcements under large deformation. Compos. Part A Appl. Sci. Manuf., 100, 81-96, 139, 106135. **[link]**

Boisse P. et al. (2011) Simulation of wrinkling during textile composite reinforcement forming. Influence of tensile, in-plane shear and bending stiffnesses. Compos. Sci. Technol., 71(5), 683-692. **[link]**

Hamila N. et al. (2009) Semi-discrete shell finite element for textile composite reinforcement forming simulation. Int. J. Numer. Methods Eng., 79, 1443–1466. **[link]**

Lukaszewicz D.J., Potter K.D. (2011) The internal structure and conformation of prepreg with respect to reliable automated processing. Compos. Part A Appl. Sci. Manuf., 42 (3) :283–92. **[link]**

Software PlasFib (2015), Interdeposit certification, Agency for Protection of Programs, Paris.

Sozer E.M et al. (2012) Resin transfer molding (RTM) in polymer matrix composites. In Manufacturing Techniques for Polymer Matrix Composites (PMCs) Elsevier: Amsterdam, The Netherlands, pp. 245–309. **[link]**