Continuous fiber reinforced composites (CFRP) are increasingly being used in the aerospace [1, 2] and automotive [3] industry to cope with lightweighting challenges and meet high performance standards. Thanks to their unique combination of stiffness, strength and density, CFRP open up new design possibilities to engineers.

The proposed ph. D. work aims to develop and analyze advanced technologies with the objective to manufacture composite preforms or prepregs with complex shapes and defect free. Two technologies will be particularly analyzed:
- Stitching of reinforcement plies
- Blank-holders

These technologies will be analyzed by numerical simulations and by forming experiments. The numerical simulations will be based on the approaches developed in LaMCoS [4-7] but some specific methods will be necessary for modeling the stitches and the blank holders. The experiments will use the forming processes that have been established as benchmarks for composite manufacturing.

Stitching a stack of composite reinforcement plies is a technology specific to composite manufacturing. Stitches are used in NCF (Non Crimp Fabric). It has been shown that the geometry of the stitches influences the forming possibilities of the materials. Stitches in a composite reinforcement modifies the strain field when forming [8, 9]. If the stitches are optimally positioned and oriented they can avoid some wrinkles and some sliding between the yarns during the manufacturing process.

Blank-holders will be the second technology that will be analyzed in order to improve composite forming. The blank-holder create controlled tensions during forming in a preform and modify the stress and strain state [10, 11]. Their main interest is to avoid or decrease wrinkling. Blank-holders are much used in sheet metal forming. In case of composite reinforcement forming their use is less common. The very anisotropic behavior of the composite reinforcement leads to a specific use of blank holders.

They can allow to manufacture complex shape but it must be checked that they don’t lead to loss of cohesion of the yarns during forming.

The possible enhancements brought by the two technologies (stitches and blank-holders) will be analyzed both by numerical simulations and by experiments. The numerical analyses will use the codes developed at LaMCoS [4-8, 11]. Nevertheless some specific development will be necessary to account
for stitching. The blank-holders are already taken into account in the current approaches, but improvement of these modeling will be necessary.

The forming experiments will be performed at INSA Lyon and will be based on the manufacturing benchmarks developed recently: tetrahedron forming [11], double dome [12], cylindrical forming [16]. The numerical simulations will be performed both at macroscopic scale (i.e. the scale of the composite reinforcement) [4, 6, 7, 11, 13] and at the mesoscopic scale (i.e. the scale of the fibrous yarn) [14, 15].
References:


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- Associated Editor of the International Journal of Material Forming (Springer) (IF= 2)
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List of publications at: