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From macro to meso-scale modelling of forming textile reinforcements

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Abstract

Composite textile reinforcement draping simulations allow the conditions for a successful process to be determined and, most importantly, the positions of the fibres after forming to be known. This last point is essential for the structural computations of the composite part and for resin injection analyses in the case of Liquid Composite Moulding processes as well as for final part resistance prediction. Because textile composite reinforcements are multiscale materials, continuous (macro) approaches and discrete (meso) approaches have been developed. The present paper deals with both scales and gives an example of how to go from macro to meso-scale simulations and build a simulation suite.

***Key words**: Textile composites, Woven fabric, Triangular shell element, X-ray tomography, Finite element simulations*

1. Introduction

Modelling the mechanical properties of woven textile reinforcements has been an objective for many years, but until recently, numerical tools able to simulate their forming were less developed than for other materials. This is now changing with the strong need of simulation tools in some strategic industries like aeronautics.

Textile materials are definitely multi-scale materials. They are made up of interlacing of warp and weft tows, themselves made up of thousands of fibres (Kam *et al.*, 2008). The main consequence of this internal structure is the possible relative motions between fibres and between yarns that lead to a very specific mechanical behaviour: the only high stiffness is the tensile stiffness in the fibre direction. All the other rigidities (shear, bending, and transverse compaction) are much weaker.

To be exhaustive, simulation tools must be able to simulate a forming process at various scales.

At a macroscopic scale, that is to say at the whole component level, a woven reinforcement can be seen as a continuous material with a specific behaviour capable of taking into account its great anisotropy and its high ability to exhibit very large shearing and bending deformations. That scale of investigation is the most popular one for preforming simulations as it allows modelling large mechanical components. Unfortunately, there is no widely accepted model that accurately describes all the aspects of

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