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Meso-scale modelling of forming textile reinforcements

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Abstract

Textile reinforcements for composite applications exhibit very specific behavior. In order to properly model the textile behavior, simulations at the yarn scale are useful. In the present paper, a simulation method for woven composite fabric deformation at mesoscopic scale is presented together with a specific continuum hypo-elastic constitutive model. X-ray tomography is used to obtain undeformed and deformed 3D geometries of the woven reinforcement. Comparisons between numerical and experimental 3D deformed geometries are shown.

***Key words**: Composite forming, Finite element analysis, X-ray tomography, Meso-scale, Mechanical properties*

1. Introduction

Among the variety of forming processes for composite parts, the Liquid Composite Moulding processes are widely used. They consist in three stages: first, a dry textile reinforcement is formed (pre-forming stage), then the resin is injected within this preform and finally, cured in order to obtain the final composite part. During the first stage, the reinforcement can undergo large deformations, especially when it is doubly curved shaped. In such a case, the reinforcement can be subjected to large in-plane distortions which can reach values up to 40°. These deformations modify the mechanical properties but also the permeability of the reinforcement.

The present contribution presents a method for the simulation of the deformation of a woven composite reinforcement representative unit cell (i.e. at the mesoscopic scale). These simulations enable us to determine the mechanical behavior of dry composite reinforcements (without resin) at finite strain at the macroscopic scale. This information is required in finite element simulations of the pre-forming stage. Besides, knowing the deformed geometry of the woven cell enables us to determine the permeability of the fibrous reinforcement via Stokes (or Stokes-Brinkman) flow simulations within this deformed cell. Finally, the geometry of the deformed reinforcement heavily influences the mechanical behavior of the final composite part.

One way to validate the numerical simulations is to check the local geometry of the reinforcement. Such local geometry can be determined experimentally using X-ray tomography. The advantage of tomography is to give access to local 3D images inside the sample which is not

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